New Taipei Journal of
Medicine

Original

Acoustic Emissions During Soldering of Base Metals and the Resultant Structures and Strengths

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Key Words
Base metal
Soldering temperature
Acoustic emission
Tensile strength

ABSTRACT

Based on the acoustic emission (AE) technique, the present study evaluates interactions among soldering temperature, flux treatment, the resultant ultimate tensile strength (UTS), and fracture surfaces of solder joints of a dental prosthesis. Specimens were cast from a removable partial denture alloy and placed in a jig with a gap distance of 1.0 mm. A high-frequency soldering machine with an optical pyrometer was used for soldering at 1150 and 1200 °C, respectively. The flux concentrations used were 67%, 75%, and 100% (pure powder). During soldering, AE signals were collected by a model R-30 sensor and processed by a MISTRA version 2001 system for further analysis, which served as a non-invasive means to detect possible fracture types and reveal subtle changes in soldered structures under different soldering conditions. The soldered specimens were also subjected to tensile testing and were examined by scanning electron microscopy (SEM); the results were analyzed statistically by ANOVA and Tukey's HSD. For pure powder flux during soldering, 4 distinct phases of acoustic activity were observed: background, heating, isothermal, and cooling periods, which correspond to different soldering stages. Heating and isothermal periods were characterized by burst-type high-count and high-energy acoustic activities, while high-amplitude AE signals appeared during the cooling period only at the 27^{th}, 29^{th}, and 82^{nd} s after the onset of soldering power. The mechanical results of UTS values showed no significant differences at different temperatures. But in the 1200 °C group, UTS values showed significant differences ($p < 0.05$) at different flux concentrations. SEM showed that the 1200 °C group had a better dendritic crystal structure than did the 1150 °C group. In the 1200 °C group, specimens with 67% flux had fewer flux inclusion bodies and dendritic crystals than did specimens with 75% flux. Acoustic emissions and tensile strength of the soldered specimens appear to depend on flux concentration and the resultant metallurgical structures but not soldering temperature.

(N. Taipei J. Med. 2001; 3:193-202)

Received: April 10, 2001
Accepted: August 16, 2001

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