INTRODUCTION

To fabricate prostheses of high accuracy and durability, soldering techniques have been introduced to clinical dentistry. Here the soldering technique generally refers to the combine action of 2 metal parts to form a solid structure through the use of a medium made of metal or alloy, with the soldering temperature kept below the solidus temperature of the test metal. Such procedures as long-span fixed partial denture repair of clasps and framework, addition of wrought wire clasps to removable prostheses, and the superstructures of dental implants all require soldering with improved the accuracy. However, these prostheses mostly fail at the solder joints.

Soldering can heat the solder metal up almost immediately and cause a plastic deformation in the target material. However, there are many variables and complex interactions involved during the soldering process which make it very difficult to a precisely control soldering quality. Numerous researchers have investigated and compared factors affecting alignment accuracy and joint strength of soldered prostheses. The deciding factors include the accuracy of the index material,[1-3] the effects of gap distance,[4-6] different heat sources on soldering strengths,[7-13] and comparison of pre-solder and post-solder mechanical strengths.[14-16] Stresses on soldered prostheses in the oral cavity are quite complex and dynamic, thus fatigue tests have been conducted to simulate actual pressures on soldered prostheses in order to determine endurance limits.[17-20] Several researchers have also proposed that temperature has a crucial effect on soldering strength.[21-23] Overheating or heating for too long may cause (1) evaporation of the solder and base metal components in alloys, resulting in porosity; (2) oxidation of the solder and parental alloy, resulting in an unstable connection between the two; and (3) formation of ion-diffusion or heat-affected zones, and even changes in the microstructure of the alloy. All these effects in turn have certain impacts on solder strength. Although wavelength dispersive x-ray spectroscopy[22-23] and metallography[21,23] have been utilized to detect variations in post- soldered metals, it is difficult, if not impossible, to gain insights into the cracking phenomena produced during the soldering process. The properties of metallic materials are greatly affected by their crystalline structure, or lattice size and condition.[24-25] Soldering strength is closely tied to micro structural changes resulting from temperature changes of the solder, the flux, and parental metal alloys, as well as the initiation and propagation of soldering cracks. To date, most research and literature on soldering techniques and changes in their processes have not been able to explain the above mechanisms.

Due to the rapid development of acoustic transducers and high-speed data acquisition systems, the non-destructive acoustic emission (AE) technique is now available for the detection of internal conditions of a material under external stress. The AE technique uses a piezoelectric sensor to detect a release of energy and subsequent production of elastic waves along with frequency vibrations, caused by deformations or fractures due to internal stresses of a material. These vibrations can be transformed into an electrical signal and can be recorded and analyzed afterwards.

AE differs from other methods, such as optical surface examinations or ultrasonic inspection, due to the fact that AE reflects the integrity failure itself during the initiation and propagation of defects. Thus, it can be used to detect inter-crystal fractures, crack extensions, and impurity fractures, but also twinning, phase transformations, dislocations, and displacements.[26-27] AE phenomena can be identified during metal melting and solidifying.[28] If no acoustic signals are detected through the process of soldering, including heating-up and cooling-down, then the products should be of excellent quality.[29]

Various characteristics of AE signals used for monitoring structural integrity a shown below.[30] (1) Information representing energy and time duration of an AE signal induced the AE pattern, maximum peak amplitude and frequency content. (2) Structural information such as microfracture and deformation includes the emission rate and energy distribution of AE signals detected by a transducer. (3) Information which leads to the identification of a detected area includes the relative signal arrival time from several transducers.

The current study used a high-frequency soldering