AN INVESTIGATION OF PHASE TRANSFORMATION MECHANISMS FOR NICKEL-TITANIUM ROTARY ENDODONTIC INSTRUMENTS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for

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By

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ABSTRACT

The concern of nickel-titanium instrument separation is still a challenge confronting every manufacturer and endodontist, and such separation often seems to happen without any prior signs of permanent deformation. Nickel-titanium instruments based upon the equiatomic intermetallic compound NiTi have gained considerable popularity among endodontists because of their very low modulus of elasticity, which enables these instruments to negotiate curved root canals during conventional root canal therapy. NiTi exists in two major microstructural phases: austenite, the high-temperature and low-stress form, and martensite, the low-temperature and high-stress form. An intermediate R–phase is also sometimes observed for the transformation between austenite and martensite. The structural transformations in NiTi occur rapidly by twinning on the atomic level and are reversible for stresses below the onset of permanent deformation.

The nickel-titanium rotary instruments are intentionally manufactured in the superelastic condition, which provides the capability of extensive elastic strain without fracture under clinical conditions associated with root canal therapy. The microstructural phases present in the NiTi rotary instruments were studied by Micro x-ray diffraction (Micro-XRD) and temperature-modulated differential scanning calorimetry (TMDSC). The latter analytical technique provided information about the variations in proportions of the phases with temperature.

The overall objective of this study was to gain new insight into the microstructural phases and their transformations that would provide the basis for improved clinical performance of NiTi rotary instruments. The phases present were identified by Micro-XRD and TMDSC, using the clinically popular ProFile GT and ProTaper nickel-titanium rotary instruments, which have two different cross-sectional designs. Instruments were analyzed in the as-received condition and after clinical use, as well as following elevated-temperature heat treatments. The *first* null hypothesis for this research was that microstructural phases and phase transformations do not have an impact on clinical performance and instrument failure. The *second* null hypothesis was that appropriate heat treatments previously used for orthodontic wires will not result in beneficial changes in microstructural phases that may significantly affect the clinical life of these instruments. Based upon this research and complimentary previous studies by this investigator, both null hypotheses were rejected. Information obtained from this research should be of importance for the future development of improved instruments with reduced likelihood of failure during clinical use.

DEDICATION

This study is dedicated to my family, parents and friends who have provided me unwavering love, support, and motivation throughout my life.

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