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

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Satish B. Alapati, BDS, MS

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The Ohio State University

2006

Dissertation Committee	
Dr. William A. Brantley, Adviser	Approved by
Dr. John M. Nusstein	
Dr. William M. Johnston	
	Adviser
	College of Dentistry



ABSTRACT

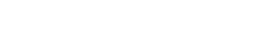
The concern of nickel-titanium instrument separation is still a challenge confronting every manufacturer and endodontist, and such separation often seems to happen without any prior signs of permanent deformation. Nickel-titanium instruments based upon the equiatomic intermetallic compound NiTi have 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.

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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.





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DEDICATION

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





ACKNOWLEDGMENTS

I would like to express sincere appreciation to my advisor, Dr. William A. Brantley, for the ubiquitous role he has had in all aspects of my academic program and dissertation work. I would also like to thank Dr. John M Nusstein and Dr. William Johnston, for their unswerving willingness to actively participate in my committee and also for their encouragement and challenge throughout my academic program. I am also highly appreciative to Dr. Rudy Melfi for expert advice on dental hard tissues and pulp biology. I am also highly appreciative to Dr. Robert Seghi and to the entire faculty in the Section of Restorative and Prosthetic Dentistry for their support throughout my academic program. My sincere appreciation goes to Dr. Glenn Daehn in the Department of Materials Science and Engineering for his valuable guidance and motivation over the years. It is highly important for me to acknowledge my early mentor at the Northwestern University Dental School, Dr. James Bahcall, who constantly provided me great moral support when I needed it the most at very early stages. Lastly, sincere thanks to Dr. Scott Schricker for allowing me use of his laboratory facilities to perform the Temperature-Modulated Differential Scanning Calorimetric experiments and to Dr. Masahiro Iijima at the Hokkaido Health Sciences University in Japan for performing the Micro-X-Ray Diffraction experiments.

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