Effect of heat treatments to endodontic files

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Introduction

Nickel-titanium (Ni-Ti) endodontic files are used for over three decades, replacing stainless steel ones, as they show greater resistance to rotation/flexion and torsion[1] associated with a greater recovery of deformation. Until this day, NiTi endodontic files have been subject of studies in order to improve the fatigue performance of these medical devices [1-5]. The main problem of using these alloys as endodontic instruments, relates to the fact that they present a high risk of fracture. It is important to note that the existing NiTi endodontic files, have several distinct characteristics, such as composition, design and manufacture, that may influence the performance of the file [4,5,6]. The objective of this study is to obtain a better performance of these components (at mechanical level) by heat treatments by modifying the phase transformation temperatures.

Materials and Methods

Material

Mtwo.05(30)(VDWGmbH, Germany)

K3.04(30)(SybronEndo, Mexico)

K3XF.04(30)(SybronEndo, Mexico)

Heat Treatments

The heat treatments at a conventional furnace (250, 300, 350, 400ºC, 1 hour) were followed by quenching.
Simulated heat treatments (250, 300ºC, 1 hour) using DSC were also performed.

Tests

•DSC thermal analysis (DSC 204 F1 Phoenix from NETZSCH)

•Torsion Testing (Shimadzu AG 50 N)

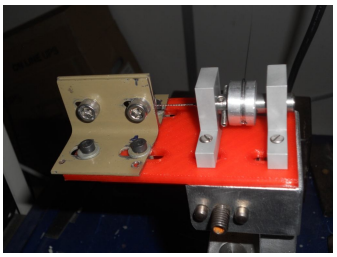
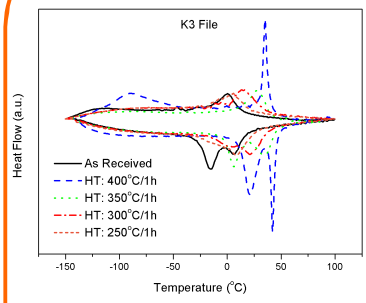
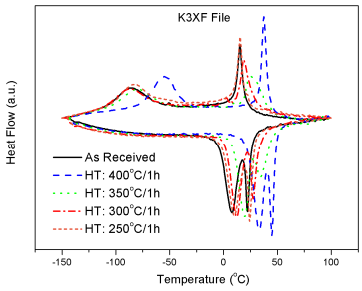


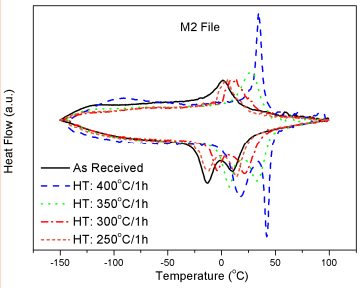
Fig.1- Experimental set up for torsion tests

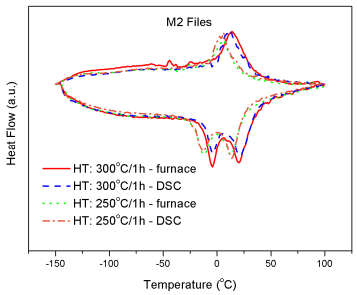
Results

DSC Analysis



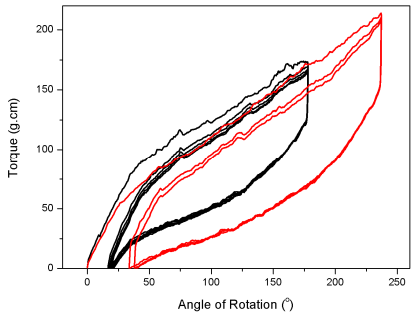






Mechanical Test

Torsion test
Stroke speed:
100 mm/min



Conclusions

•The heat treatments increased the transformation temperatures. R-phase is present in both direct and inverse transformations.
•As the objective is a superelastic behaviour at the oral temperature, the advantageous heat treatments should be performed between 250 and 300 ºC for 1 hour.
•We can also see that the heat treatment for the MTwo file in the furnace or in the DSC equipment show no major differences.
•The mechanical behaviour shows that the file recovers almost all the deformation at 180º; for a higher angle of rotation some irrecoverable plastic deformation is observed.

References

[1] H. Walia, W. a. Brantley, and H. Gerstein, "An initial investigation of the bending and torsional properties of nitinol root canal files," *Journal of Endodontics*, vol. 14, no. 7, pp. 346–351, 1988.
[2] S. B. Correia, "Estudo do comportamento em serviço de limas endodônticas superelásticas de Ni-Ti". PhD thesis, Faculdade de Medicina Dentária da Universidade de Lisboa, 2009.
[3] Y. Yahata, T. Yoneyama, Y. Hayashi, a. Ebihara, H. Doi, T. Hanawa, and H. Suda, "Effect of heat treatment on transformation temperatures and bending properties of nickel-titanium endodontic instruments," *International Endodontic Journal*, vol. 42, pp. 621–626, 2009.
[4] Y. Shen, H. M. Zhou, Y. F. Zheng, B. Peng, and M. Haapasalo, "Current challenges and concepts of the thermomechanical treatment of nickel-titanium instruments," *Journal of Endodontics*, vol. 39, no. 2, pp. 163–172, 2013.
[5] K. Miyara, Y. Yahata, Y. Hayashi, Y. Tsutsumi, A. Ebihara, T. Hanawa, and H. Suda, "The influence of heat treatment on the mechanical properties of Ni-Ti file materials." *Dental materials journal*, vol. 33, no. 1, pp. 27–31, 2014.
[6] F. Braz Fernandes, J. Oliveira, A. Machado e N. Schell. "XRD Study of NiTi Endodontic Files Using Synchrotron Radiation". *Journal of Materials Engineering and Performance vol* 23, nº7, pp. 2477–2481, 2014

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