Heat treatment of endodontic files

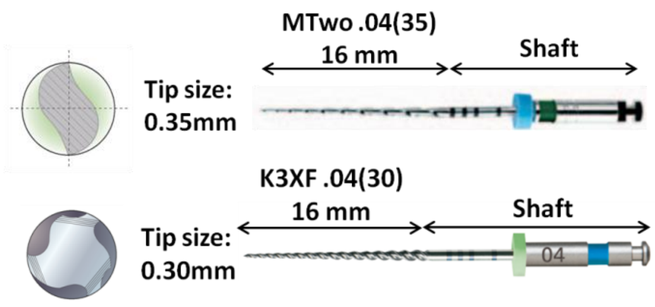
F. M. Braz Fernandes[1*], Ana Rita Alves[1], A. Machado[1], J. P. Oliveira[1]
[1]CENIMAT-I3N, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Portugal
Universidade Nova de Lisboa, Caparica, Portugal
* fbf@fct.unl.pt

Workshop on Shape Memory Alloys
Processing, Properties and Applications
CENIMAT, FCT/UNL, 19/02/2020

ABSTRACT

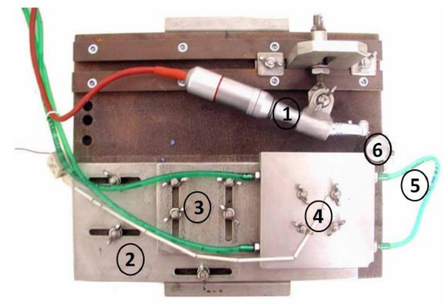
Three brands of rotary nickel-titanium endodontic instruments with some comparable geometric features but with different cross-section (similar tip size and same taper of .04) were selected for this study: MTwo .04(35) (VDW GmbH, Germany), K3 .04(30) (SybronEndo, Mexico) and K3XF .04(30) (SybronEndo, Mexico). K3XF is made from novel R-phase heat-treated metal alloy while all other files were made from traditional Ni-Ti alloy. The instruments were analyzed under the following conditions: i) as-received (AR), ii) heat treated at 350ºC, iii) heat treated at 400ºC. The transformation temperatures were determined by differential scanning calorimeter (DSC). Compared to conventionally K3 and Mtwo files, R-phase heat treatment K3XF file showed higher transformation temperatures. These results also showed that heat treatments increase the transformation temperatures.

MATERIALS AND METHODS

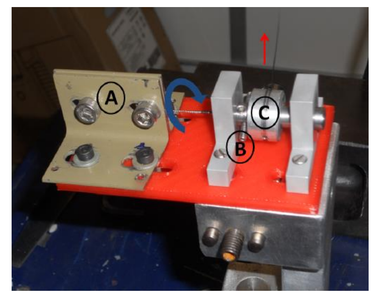


Three brands of rotary Ni-Ti endodontic instruments with some comparable geometric features (similar tip size and same taper of .04) but with different cross-section were selected for this study:
Mtwo .04(35) (VDW GmbH, Germany),
K3 .04(30) and K3XF .04(30) (SybronEndo, Mexico).

K3XF is made from novel R-phase heat-treated metal alloy, while the other files were made from traditional Ni-Ti alloy.



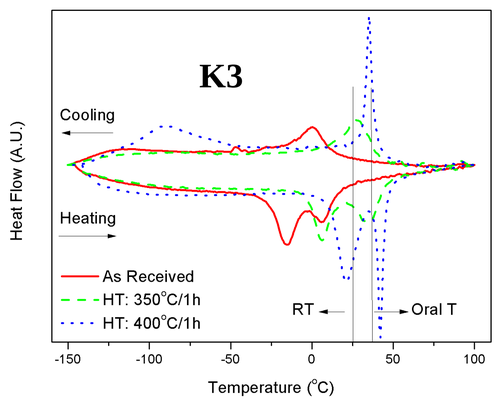
Rotation/flexion device [1-2]

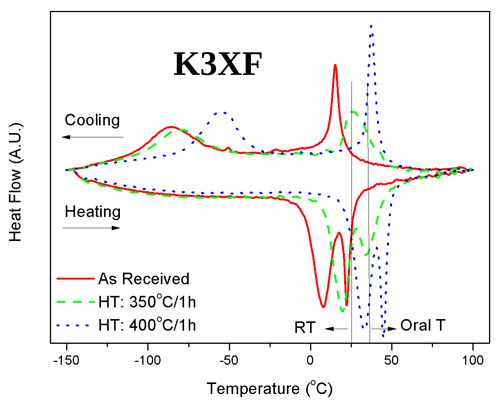


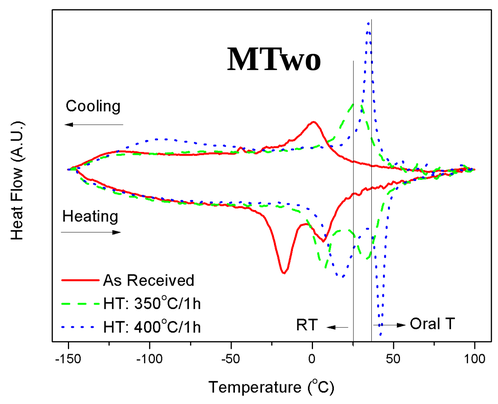
Torsion testing device [3]

RESULTS AND DISCUSSION

DSC Tests
[3]



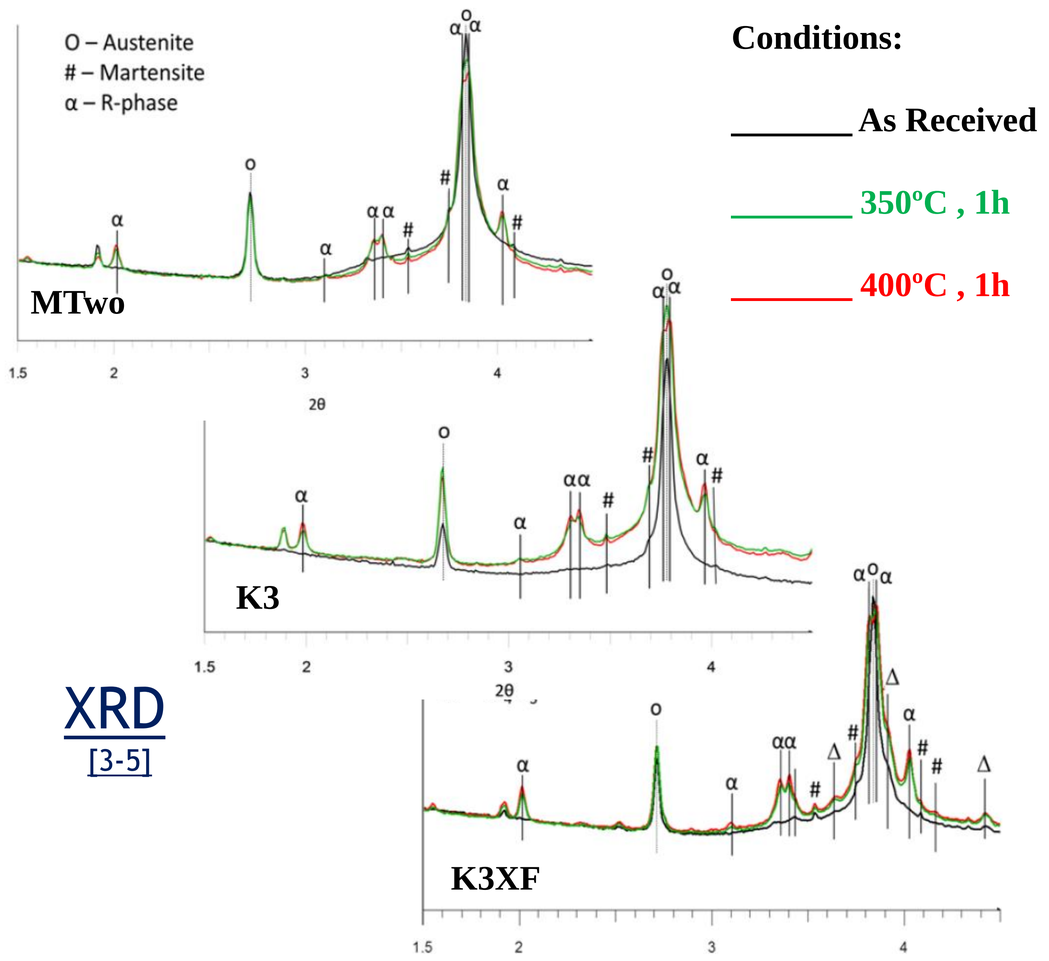


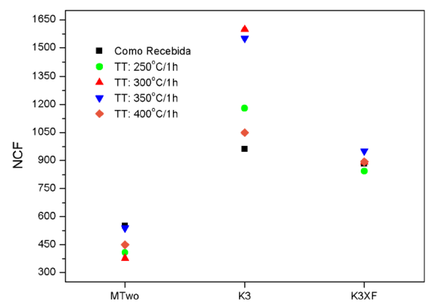


		Cooling		Heating	
	HT	R_s	R_f	A_s	A_f
MTwo	AR	16.1	-17.3	-8.8	16.0
	350ºC/1h	40.0	8.5	11.5	47.0
	400ºC/1h	42.1	25.1	31.6	48.0
K3	AR	14.1	-17.4	-4.9	16.6
	350ºC/1h	41.0	5.0	7.8	46.0
	400ºC/1h	47.1	27.6	30.1	47.6
K3XF	AR	22.6	2.6	13.6	31.1
	350ºC/1h	42.6	15.1	24.6	46.1
	400ºC/1h	45.1	30.1	36.1	49.6

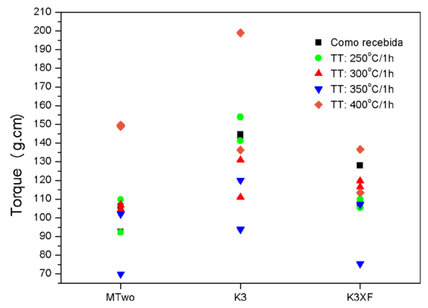
Transformation temperatures for diferente conditions (as-received, heat treated at 350ºC and 400ºC for 1h)

XRD
[3-5]





Number of cycles to fracture (rotation / flexion)



Maximum torque at fracture (under torsion)

for diferente conditions (as-received, heat treated at 350ºC and 400ºC for 1h)
[5-6]

CONCLUSIONS

- Heat treatments increased the transformation temperatures, which is more notorious for higher heat treatment temperatures.
- K3XF is the file which shows the highest transformation temperatures, thus confirming that this file had a previous heat treatment; this appears not to be the case for MTwo and K3 files.
- The DSC results showed that both direct and reverse transformations are taking place in two steps B2 → R-phase → B19'.
- These observations indicate that an improvement in flexibility should be expected after heat treatment, as a consequence of the presence of R-phase. In order to obtain transformation temperatures between room temperature and the oral temperature, the heat treatments for these files should be performed below 350ºC.

REFERENCES

[1] S. Vilaverde Correia. “Estudo do Comportamento em Serviço de Limas Endodônticas Superelásticas de Ni-Ti”. PhD thesis. Faculdade de Medicina Dentária, Universidade de Lisboa, 2009.
[2] S. Vilaverde Correia, M.T. Nogueira, R.J.C. Silva, L. Pires Lopes, F. M. Braz Fernandes, “Phase Transformations in NiTi Endodontic Files and Fatigue Resistance”, ESOMAT 2009, 07004 (2009).
[3] Ana Rita Alves. “Estudo do efeito de tratamentos térmicos nas propriedades térmicas e mecânicas de três limas endodônticas: MTwo, K3 e K3XF”. MSc thesis in Materials Engineering, Faculdade de Ciências e Tecnologia, UNL, 16/12/2015.
[4] F. M. Braz Fernandes, Ana Rita Alves, João Pedro Oliveira. “Assessing the influence of heat treatment on endodontic files”. Oral communication (Sessão 4.2) presented (by FMBF) at 21st European Conference on Fracture (ECF21), Catania, Italy, 20-24 June 2016.
[5] F.M. Braz Fernandes, J.P. Oliveira, A. Machado, Norbert Schell. “XRD Study of NiTi Endodontic Files Using Synchrotron Radiation”. Journal of Materials Engineering and Performance, 23-7 (2014) pp. 2477-2481.
[6] F.M. Braz Fernandes, J.P. Oliveira, A.M. Machado, A.R. Alves, N. Schell. “Effect of heat treatment on K3, K3XF and MTwo endodontic files”. MATEC Web of Conferences 33 (2015) 03016-p.1/6. Proceedings ESOMAT 2015 – 10th European Symposium on Martensitic Transformations. Antwerp, Belgium, September 14-18, 2015. N. Schryvers and J. Van Humbeeck (Eds.).

ACKNOWLEDGMENTS

DESY
FIBR3D
CENIMAT
provides expertise facilities, infrastructure and teaming environments to enable and facilitate interdisciplinary research in Materials Science and Engineering.
UNIVERSIDADE NOVA DE LISBOA
i3N
INSTITUTE FOR NANOSTRUCTURES, NANOMODELLING AND NANOFABRICATION
RESEARCH, INNOVATION AND ENGINEERING APPLICATIONS
FCT
FACULDADE DE CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE NOVA DE LISBOA

www.cenimat.fct.unl.pt