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## Rotary Instruments in Nickel Titanium

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Over the last few years endodontics has undergone a complete revolution with the introduction of the NiTi alloy for the manufacture of initially manual and then rotary endodontic instruments. The extraordinary characteristics of superelasticity and strength of the NiTi alloy<sup>83,84</sup> have made it possible to manufacture rotary instruments with double, triple and quadruple taper compared to the traditional manual instruments (Fig. 18.1).<sup>26</sup>

This has made it possible to achieve perfect shaping with the use of very few instruments<sup>22,58</sup> in a short period of time and without the need for above average skills on the part of the operator.

**CHARACTERISTICS OF NITI ALLOY**

The NiTi alloy came to the fore when used at the beginning of the 60's by W. H. Buehler in a spa-

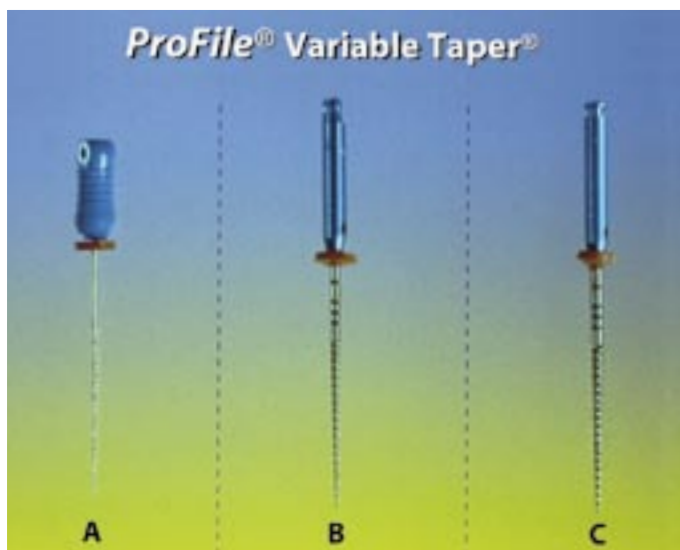


Fig. 18.1. **A.** ProFile hand file .02 taper. **B.** ProFile rotary instruments .04 taper. **C.** ProFile rotary instruments .06 taper

ce program of the Naval Ordnance Laboratory at Silversprings, Maryland, USA.<sup>18</sup>

The alloy was called Nitinol, an acronym for the elements from which the material was composed: ni for nickel, ti for Titanium and nol from the Naval Ordnance Laboratory.

It was introduced into dentistry in 1971 by Andreasen et al.<sup>1-3</sup> in order to create orthodontic wires.

The NiTi alloy belongs to the family of the Nickel and Titanium intermetallic alloys, characterized by two properties which distinguish them, the memory of shape and superelasticity.<sup>17</sup>

**Shape Memory**

By shape memory we mean the capacity of NiTi alloys to reacquire its initial shape through heating after strain.<sup>18</sup> This property is utilized in orthodontics but not in endodontics.

**Superelasticity**

We define elasticity as the property of bodies to deform by the action of external forces and once these external forces cease the ability to return to the original state. There is a limit which is defined "elastic limit", beyond which there is a component of plastic strain which can no longer be recouped by the elimination of external forces. For example if we compare two wires of equal cross section, one in stainless steel and one in NiTi, we can better understand the extraordinary property of superelasticity which NiTi has. If we apply a moment of force to a stainless steel wire that is able to produce an angular deformation of 80°, when the moment ends a permanent angular deformation of 60° will

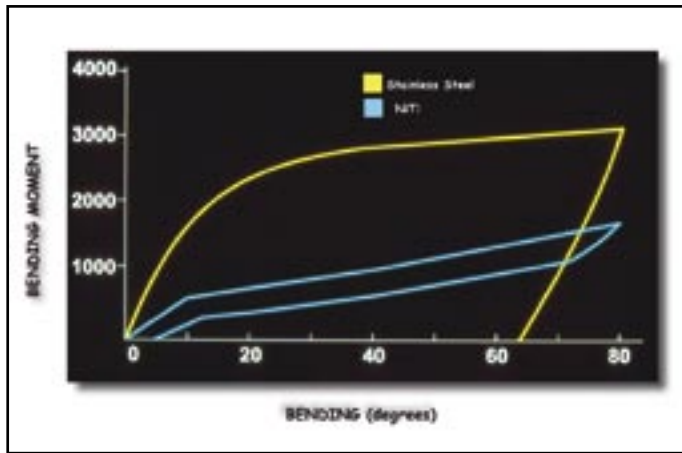


Fig. 18.2. Strain-stress diagram.

remain (Fig. 18.2). It can be deduced that the stainless steel wire has an elastic deformation limit of 20° above which every deformation becomes permanent.

If we apply a bending moment which is able to produce a deformation of 80° to a NiTi alloy wire of equal cross section, when the moment ends a permanent angular deformation of less than 5° will remain. The wire in NiTi will undergo deformation which is almost completely elastic, leaving a minimum permanent deformation (Fig. 18.2).<sup>44,70,83</sup>

This characteristic (superelasticity) is particularly evident when for example, using a finger, we try to bend two identical endodontic instruments, one in stainless steel, the other in NiTi. The stainless steel endodontic instrument presents a higher stiffness while the NiTi instrument is particularly compliant. The

use of endodontic instruments in NiTi is particularly advantageous for shaping the canal system in harmony with the original anatomy.

### Strength

Walia et al.<sup>83</sup> and Camps et al.<sup>20</sup> have demonstrated that files in NiTi were much more resistant to clockwise and counter-clockwise torsional stress compared with files of equal size but in stainless steel. This elevated strength of the NiTi alloy has made it possible to manufacture rotary instruments that have greatly simplified the shaping of the root canal system.

### Metallurgy of nickel-titanium alloys

The NiTi alloy used in root canal treatment contains approximately 56% (in weight) of Nickel and 44% (in weight) of Titanium. In some NiTi alloys, a small percentage (<2% in weight) of Nickel can be substituted by cobalt.<sup>48</sup> The resultant combination is a one-to-one atomic ratio (equiatomic) of the major components (Ni and Ti). This alloy has proved to be among the most biocompatible materials and it is extremely resistant to corrosion.<sup>72</sup> As we have previously said, NiTi belongs to the family of inter-metallic alloys. This means that NiTi alloy can exist in various crystallographic forms, with distinct phases and different mechanical properties: austenitic, transformation and martensitic (Fig. 18.3).<sup>85</sup>

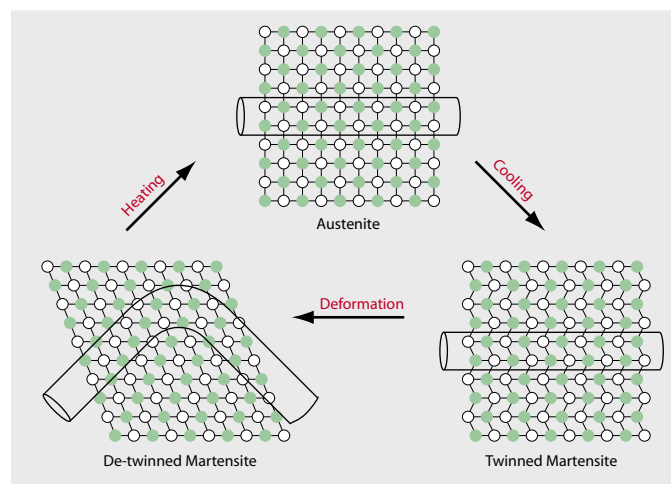


Fig. 18.3. Diagrammatic illustration of the martensitic transformation and shape memory effects of NiTi alloy (By Thompson S.A.; *Int. Endod. J.* 33:297, 2000).