Revista Odontológica Mexicana
Vol. 20, No. 3 ● July-September 2016
pp e162-e169

Facultad de Odontología

ORIGINAL RESEARCH

Clinical importance of austenitic final point in the selection of nickel-titanium alloys for application in orthodontic-use arches

Importancia clínica del punto austenítico final en la selección de las aleaciones de níquel-titanio para su aplicación en arcos utilizados en Ortodoncia

Aberto Teramoto Ohara*

ABSTRACT

There are many nickel-titanium alloy wires available in the market. Nevertheless not all of them possess the ideal characteristics of shape memory and super-elasticity to be used in orthodontic treatment. The aim of the present study was to find austenitic final temperature of these archwires so as to determine the transformation phase in order to better use them in orthodontics. **Methods:** Eleven nickel-titanium orthodontic wires were selected. Transformation phase was assessed using differential scanning calorimetry method. **Conclusions:** The present study illustrates how some orthodontic Ni-Ti wires elicit results contrary to those advertised.

RESUMEN

Existe en el mercado una gran cantidad de alambres de aleaciones de níquel-titanio; sin embargo, no todos poseen las características ideales de memoria de forma y superelasticidad para ser utilizados en ortodoncia. El objetivo de este estudio fue encontrar la temperatura austenitica final de estos arcos con la finalidad de determinar la fase de transformación para su mejor uso clínico en Ortodoncia. **Métodos:** Se estudiaron once alambres de níquel-titanio más utilizados en Ortodoncia y se evaluó la fase de transformación utilizando la prueba de calorimetría de barrido diferencial. **Conclusiones:** Este estudio muestra cómo algunos arcos de NiTi en Ortodoncia presentan resultados contrarios a los que promocionan.

Key words: Austenitic final point, nickel-titanium alloys, phase transformation, differential scanning, calorimetry.
Palabras clave: Punto austenítico final, aleaciones de níquel-titanio, fase de transformación, calorimetría de barrido diferencial.

INTRODUCTION

At the beginning of the 1970's Andreasen[1,2] introduced the first nickel-titanium (Ni-Ti) wire in orthodontics. This can be attributed to William F Buehler[3,4] who discovered this alloy. He named this wire NITINOL, as acronym of the two most important elements composing the alloy: nickel (Ni), titanium (Ti) and NOL for Naval Ordnances Laboratory in Silver Springs, Maryland, USA where the alloy was discovered.

According to Miura[5-8] Ni-Ti alloys possess two main characteristics that render them unique in orthodontics: shape memory and super-elasticity. Shape memory refers to the ability of the material to return to its original shape through temperature transformation phases. Super-elasticity means the possibility of generating constant forces for a long period of time; tension being the force to cause this property.

Transformation phases

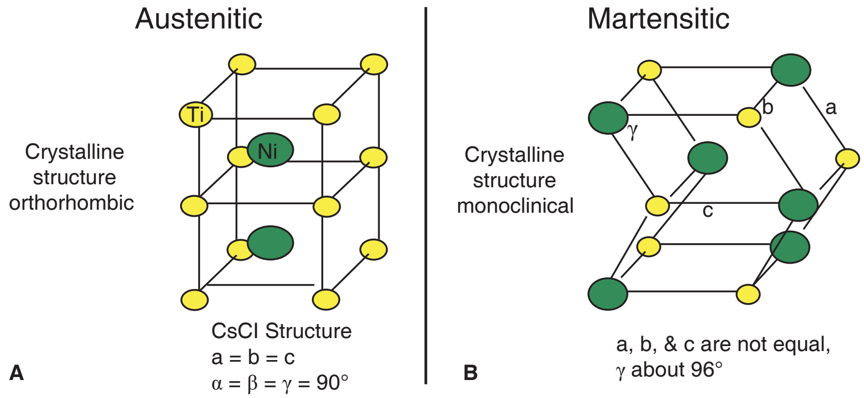
The unique characteristics exhibited by Ni-Ti alloys are mainly due to the transformation phases they undergo. The first one is the high temperature phase, also called austenitic phase, the other low temperature phase is called martensitic phase *(Figures 1 A-B)*, these phases do not appear at a given temperature, rather, they possess different temperatures where these changes gradually appear. Ni-Ti alterations apparent in austenitic and martensitic phases are basically at three temperatures: initial, peak and

* Faculty of Health Sciences, School of Dentistry. Orthodontics Department, Mexico Technological University.

Received: August 2015. Accepted: October 2015.

This article can be read in its full version in the following page: http://**www.medigraphic.com/facultadodontologiaunam**

See related content at doi:
http://dx.doi.org/10.1016/j.rodmex.2016.08.012



Figures 1 A-B.

A) Austenitic phase: shape of orthorhombic crystal, angles exhibit 90° angle, **B)** Martensitic phase: shape of monoclinic crystal, angles displace braking their original 90°.

final. Depending on the final application for which the product manufactured with this alloy is intended, it will be important to determine transformation temperature. This can be clearly observed in the graphs known as thermograms which are generated during the differential scanning calorimetry test *(Figure 2)*. Austenite final (AF) is the most important temperature to determine from the clinical and manufacturer´s point of view. It is considered the most important since, at this phase, the alloy is stable and exhibits the final, work-suitable shape.

Ni-Ti alloys classification

Kusy[9] made up a classification by dividing these orthodontic alloys in three main groups: the first one is passive (passive martensitic) the other two are active (austenitic and martensitic). All of them are practically composed of 50% Ni and 50% Ti (with small composition variants). They possess the unique characteristic of returning to their original shape (shape memory). Differences between them mainly lie in two aspects: the first one is that active forces generate constant load during the phases, and the second difference, also found between active forces lies in the temperature at which this transformation phase is generated.

According to Kusi, the first alloy to be used in orthodontics was martensitic passive. This alloy possessed the shape memory property only in name. This was due to the fact that errors incurred upon during manufacturing process when stretching the material to shape it caused incapacity to generate continuous forces, only preserving the ability to return to its original shape. Nevertheless, forces generated by these alloys when compared to other archwires such as stainless steel, were lesser by one fifth. In 1971 this alloy appeared for the first time in Orthodontics with the commercial name of NITINOL (UNITEK Co) *(Figure 3)*.

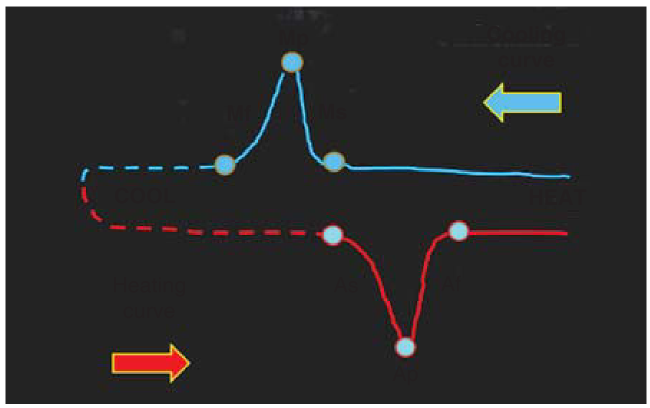


Figure 2. Transformation phases of NiTi alloys in heating and cooling curves represented in the thermograms.

With time, a second generation of nickel titanium was generated, under the name of active austenitic. When describing this material, Kusi mentioned as its main characteristic the fact that, differing from passive martensitic, the wire did not only generate mild force, it also presented the unique characteristic of generating continuous forces at both the activation and deactivation phases., and this was mainly due to the performance they exhibited at the austenitic phase (high temperature phase) and the martensitic phase (low temperature phase) in the process of mechanical transformation between both phases.

In this austenitic-active alloy both phases can be clearly observed: the beginning is with a lineal force three times greater than the force generated by a passive martensitic archwire. This linear force disappears and brings about a curve where the archwire generates a continuous force for a long period of time; this is known as the activation phase *(Figure 4 A-B)*. The archwire experiences a transformation from martensitic phase to austenitic phase; once this latter is completed, the archwire once more experiences