MECHANICAL PERFORMANCE OF DIFFERENT NICKEL-TITANIUM ARCHWIRES USED IN DENTISTRY

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Keywords: NiTi, mechanical properties, bending

Abstract

The mechanical properties of superelastic (SE) and heat activated (HA) .014 inch NiTi orthodontic wires were evaluated and compared. A total of 132 wires were divided in 22 groups (n=6) according to six commercial brands, two lots from each wire, and SE or HA properties. Three-point bending test were conducted up to 3.1 mm at 36±1oC. Stress-deflection diagrams were determined and different mechanical properties were compared by analysis of variance and Tukey test (P=.05).HA wires showed a lower load (LMS) unload (UMS) mean stress, total (TR) and potential (PR) resilience than SE wires. However, HA wires demonstrated a higher hysteresis resilience (HR) and mechanical hysteresis (MH) than SE wires. According to comparisons between different lots from the same manufacturer and wire types, four groups matched in LMS, UMS, TR and PR (P>.05).These conclusions could lead clinicians in choosing archwires which exhibit similar performance, however are commercial offered at different costs.

Introduction

Shape memory alloys (SMAs) used in orthodontic archwires are of two kinds: superelastic and thermoactivated. Superelastic alloys regain the original shape at room temperature after unloading, while thermoactivated have to be heated. The main advantage of these alloys for orthodontic applications is that they have small elastic constants, even for large deformations, as required to allow tooth movement.

Materials and Methods

In the present study NiTi archwires from three companies (3M – St Paul Minneapolis, MN, USA; GAC –Bohemia, NY, USA; and Morelli, Sorocaba, SP, Brazil) were tested. They were of the superelastic (SE) kind. Archwires 0.014-inches in diameter were subjected to a *three-point bend test* according to ISO 15841:2006. The distance between the supports was 10 mm. The machine speed was 6.0 mm/minute and the fulcrum and cutlass radii were 0,1 mm (Figure 1) The tests were performed in a universal testing machine EMIC DL 10000,with the cutlass in the center. All samples were cut at the straighter section of the arch and were 30 mm long. A total of 30 specimens were tested in flexion until the had a deflection of 3,1 mm at 37ºC. The heating was provided by lamps controlled by rheostats. The strength (N) versus deflection (mm) curves from the tests were analyzed and compared. For purposes of comparative analysis of the behavior of archwires from different lots and manufacturers, the stress-deformation curves were compared on unloading from a deflection of 2,5 mm (from point D to point G on figure 1).

Results and Discussion

Table 1 shows the values of the stress determined on the unloading plateau. The stress was computed using the equation

$$\sigma = \frac{2.55FL}{d^3}$$

where **σ** is the stress, **F** is the maximum strength, **L** is the distance between the supports and **d** is the wire diameter.

We compared the behavior of archwires from different lots by the same manufacturer and the variation ofmechanical resistance between lots and manufacturers. The most significant differences between lots by the samemanufacturer on unloading were between archwires by 3M (about 17%). The archwires by 3M presented thegreatest dispersion of results between wires from the same lot. The company that had greater homogeneity between wires from different lots was Morelli. An important result was is the large variation, up to 28%, of the behavior in flexion of archwires theoretically identical. This demonstrates the lack of standardization of methods of thermomechanical treatment between manufacturers. The intensity and rate of application of strength on unloading are mechanical factors that affect the physiological tooth movement. For each type of archwire there will be an amount of tooth movement and an amount of root resorption. It is important to determine the best pattern of behavior on mechanical tests so that manufacturers can offer archwires with better mechanical properties and orthodontists can have predictable results. To analyze their efficiency, it is necessary to determine a zone of stress ideal for tooth movement. Results in the literature show that there is a tendency of considering that the ideal strength for tooth movement must be as low as possible, which depends on the tooth, on the root/bone area of contact and on the mechanical properties of the local bone [1-6]. The literature [3-6] shows that light forces (25 g) are more effective than heavy forces (225 g). However, theterm “light force” is not meaningful if one ignores the anatomy of the tooth root and the properties of the adjacent bone. Table 2 shows the equivalence between the g values and the values of the stress measured in three-point mechanical flexion tests. For example, considering that the ideal strength to move a premolar is 25 g, none of the archwires tested were able to release this strength on the unloading baseline. Considering the latest works on ideal orthodontic strength, these baselines could be considered as being of intermediate strength [3,5,6].

Conclusions

Variations were observed on the behavior in flexion of up to 31% between archwires with same dimension and designation by different manufacturers. Variations of up to 14% were observed between lots of archwires with same dimension and designation by the same manufacturer.

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