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COMPARISON OF THE METALLURGICAL PROPERTIES AND SURFACE CHARACTERISTICS OF DIFFERENT ORTHODONTIC ARCHWIRES ALLOYS

Anna Zięty[1*], Victoria Hoppe[2], Dominika Grygier[3], Jerzy Detyna[1]

[1] Wrocław University of Science and Technology, Department of Mechanics, Material Science and Engineering, Smoluchowskiego str 25, Wrocław 50-360, Poland. *e-mail: anna.ziety@pwr.edu.pl

[2] Wrocław University of Science and Technology, Student Scientific Circle of Material Science named doc. Rudolf Haimann

[3] Wrocław University of Science and Technology, Department of Materials Science, Strength and Welding, Smoluchowskiego str 25, Wrocław 50-360, Poland

1. Introduction

There are lots of properties which describe an ideal orthodontic archwire. Unfortunately, this kind of alloy does not exist. This is because of different requirements of each stage of orthodontic treatment. In the first stage, where the initial teeth rotation and alignment are needed, archwire should provide a large range of forces with low, constant values. At this stage, use of Ni-Ti alloys is crucial. [1], [2], [3] These shape memory wires are characterized by a high resilience and high elastic limit. Nowadays, there are lots of types of NiTi orthodontic archwires from conventional, I generation (55% of nickel and 45% of titanium) to newer one, e.g. CuNiTi alloy which are superelastic and thermoelastic. [4], [5], [6]
At the last stadium, a small, but still constant movement of teeth is required. A stainless steel, the 18:8 austenitic type (18% chromium and 8% nickel), due to its high stiffness (about 200 MPa) and a low springiness, is ideal for it. What is more, it is characterized by high resistant to corrosion (thanks to coherent oxide layer and passivation process) and a very high strength (R_m=2,1 GPa). [3], [7].

According to this, for the correct use of orthodontic appliance one must have a thorough knowledge of these materials. [2] The aim of the present paper is to compare and evaluate metallurgical properties and surface characteristics of three widely used archwires materials, which are applied to various stage of orthodontic treatment.

2. Material and methods

To investigate metallurgical and surface properties of selected materials, structural analysis by light microscopy (MA200 model / *Nikon* company) and scanning electron microscopy (*Phenom ProX Desktop SEM*) were performed. Furthermore, SEM was also applied to do roughness tests. The sample hardness measurement was carried out on a Vickers 1A VH-1000B microhardness tester.

Mentioned experiments were carried out on each of three different materials: Ni-Ti (I generation), Ni-Ti Copper and stainless steel (SS 18:8). All of them are in conventional use. Their manufacture characteristics, sizes and brand names are presented in a table 1.

Sample Material	Brand	Cross-section	Size
Ni-Ti	*Swiss Dental Specialties*	rectangle	0.16x0.22”
Ni-Ti Copper	*Ormco Corporation*	rectangle	0.16x0.22”
Stainless Steel	*G&H Orthodontics*	rectangle	0.16x0.22”

Tab. 1. Types of materials used in the investigation

Brand new archwires were randomly chosen from the one batch and divided on three sections (two sides of archwires – left, right and the centre of it). It is shown on figure 1. Next, they were rinsed with acetone in ultrasonic washer.

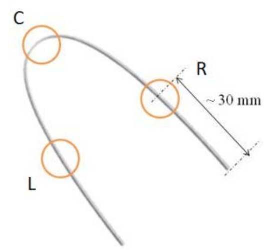

Fig. 1. Three measuring points which were chosen to do research: L, R – a straight wire, C – a bent section of a wire

3. Results

The surface topography of each archwires, as observed by SEM, had its own characteristic surface structure. The differences were noted among studied materials, but also inside one material between a straight wire (L, R) and a bent section of a wire (C). NiTi family wires showed more grooves, especially in the centre measuring place, which were parallel to the long axis of the archwire. Conventional NiTi alloy exhibited some irregularities, but not such depth as NiTi with a copper. Both of them have lots of peaks, while stainless steel mostly has a smooth surface with a few areas of valleys.

The roughness tests confirmed the microscopic observations. As it is seen on figure 2, values of roughness average of a surfaces (Ra) are similar for NiTi family and higher than steel SS.

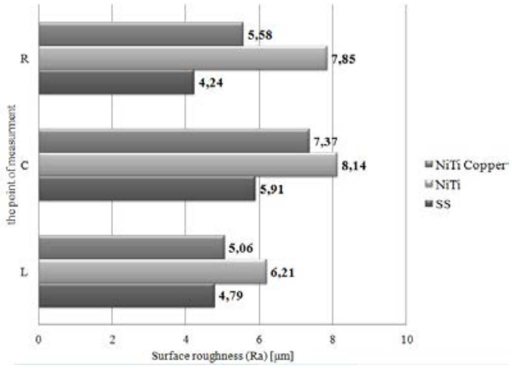

Fig. 2. The mean surface roughness of the wires studied

Obtained results of surface roughness also showed irregularities inside one material, especially between the straight elements and curved parts of archwire. The value of Ra coefficient for C places is higher for each studied material. Microhardness tests demonstrated similar trend as roughness research.

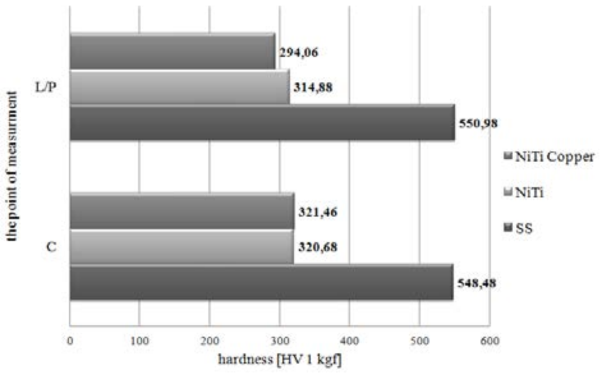

Fig. 3. The mean surface microhardness of the wires studied, where L/R – straight section of wire, C – bent section

Figure 3 presented results of hardness [HV 1] for all three biomaterials and points of measuring too. There are higher values for bent parts of archwires than R and L points. Furthermore, these experiments proved that stainless steel has the highest hardness than both Ni-Ti alloys along the entire length of the wire.

4. Conclusions

Summarizing, it is clearly seen that the NiTi archwires have more defects than the SS archwires. It is related to the chemical composition of each material, but also to the various material structure and existence of a large number of non-metallic inclusions.

It is observed that NiTi alloys (I generation and alloy with copper) have similar values of both tests (roughness and hardness). What is more, these biomaterials showed the same tendency during surface observation: lots of peaks and depth grooves. The SS has higher hardness, so that its surface is smoother (the smallest value of Ra)

Archwires are first pulled and straighten during drawing process. After that, they are bent. These activities generate strengthening mechanism near C places. This is a confirmation of obtained differences in values for C and R/L points of measuring.

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