MATERIAL CHARACTERISTICS OF THE ORTHODONTIC ARCHWIRES

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Abstract *Our aim was to investigate the mechanical properties of coated superelastic archwires from different producers and to compare them with the characteristics of conventional archwires. A bending test was used in order to evaluate the elastic properties of the investigated samples. Experimental results were statistically processed in order to emphasize the average values, the amplitude (R) and the mean square deviation (S).Results showed that the esthetic coated archwires produced lower values in loading and unloading compared with uncoated wires of same nominal size.*

Keywords: *orthodontics archwires, elasticity, friction, nitinol, biomechanics*

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1. Introduction

Historically, according to Angle, the first type of fixed orthodontic appliance was the bow of ‘Fauchard of France’ in 1728. This arch wire was flat piece of metal scalloped out for the ideal position of the teeth. Magill, was according to Angle, first to use a plain band cemented to tooth, with oxychloride of zinc cement. Nowadays, the types and materials used in orthodontics are varying from the common metal brackets and wires to ultraesthetic spahire brackets and coated wires.

The elastic behavior of any material is defined in terms of its stress-strain response to an external load. Both stress and strain refer to the internal state of the material being studied. Stress is the internal distribution of the load, defined as stress per unit area, whereas strain is the internal distortion produced by the load, defined as deflection per unit length.

Orthodontic archwires are included in any type of device, fixed or mobile, are actually elastic wires through which apply orthodontic forces on teeth.

Classification of orthodontic archwires(Kumar):
A) According to material used:
a. Gold archwires
b. Stainless steel archwires
c. Chrom-cobalt archwires
d. Nickel-Titanium archwire
i. Martensitic
ii. Austenitic
1. Superelastic
2. Japanese NiTi
3. Chinese NiTi
4. Alpha NiTi
5. Reverse curve NiTi
6. Copper NiTi
Titaniumβe. TMA -
f. Ceramic coated / optiflex archwires
B) According to cross-section
a. Round
b. Rectangular
c. Rounded rectangular
d. Square
e. Braided
f. Stranded.

The NiTi archwires have gained significant use in orthodontics. The respective alloys are employed in two different structural states resulted from heat processing. The structural state is correlated to the functional scope. The use of intelligent materials such as the shape memory alloys in the medical field ensures the possibility of designing and practical achievement of certain cosmetic dentistry works with special advantages regarding the enhanced biocompatibility, superelasticity, the effect of the shape memory, resistance against corrosion and wear, etc., which leads to very favourable functional and aesthetic effects.

Fig.1. Orthodontic metal brackets and visible wires.

Fig.2. Orthodontic sapphire brackets and esthetic coated wires.

The social impact of the orthodontic appliances upon the numerous patients with malocclusion is extremely high. The intelligent materials have physical and mechanical characteristics which can be modified via metallurgical factors, respectively through the design of the tensioning device, being explicitly included in the primary mathematical models which describe the materials mentioned. The shape memory alloys, such as the Ni-Ti alloys, have the characteristic of superelasticity which is around significant higher than that of stainless steel. Superelasticity refers to an unusual characteristic of certain metals of resisting to a high plastic deformation.

Another important finding is that some wires showed different levels of resistance according to the test that they were submitted. This study allows a direct comparison of different archwires to assist the choice to choose the one with lowest level in regard to bending resistance.

Since the introduction of the superelastic archwires the use based on the theory of applying light continuous force has been indicate. Frecvent had use the rectangular superelastic archwire since the initial phases of the treatment. Tridimensional control of the teeth could be range but also, using wires with circular cross sections would delivery optimum forces of resistance to sliding.

The bracket – wire high friction is due to the roughness of the bracket interface which slows the sliding of the archwire through the bracket. This clinical problem can be managed by using coated superelastic archwires brackets with smoother slot surfaces i.e. A high variety of products is now available on the market, using this particular design feature.

Orthodontic wire coating Teflon layer significantly reduces the coefficient of friction between wire and bracket. Depending on the physical and mechanical thickness of the deposited layer that is expected to some stiffening of the wire.

Use of NiTi wires has gained ground because of the significant benefits, compared with stainless steel wires, or ferrous alloys:

- high initial shape memory up to 8%
- very good shape memory / features superelastice after thermomechanical treatment,high ductility (60% possibility of cold work)
- excellent performance against corrosion and friction,
- relatively high electrical resistance,
- biomedical compatibility.

Since, for the clinician, sometimes it is very difficult to select the proper orthodontic wires, the purpose of our study was to review the material elastic properties of the wires used in orthodontic practice.

Our aim was to investigate the mechanical properties of coated superelastic archwires from different producers and to compare them with the characteristics of conventional archwires.

2. Materials and methods

This study took place in the Politechnica University of Timisoara, Faculty of Mechanics. The wires taken in this study were selected from different producers(Ormco, Forestadent, Leone). Experimental study aimed NiTi wire material: uncoated state (one) with a diameter of 0.387 mm and coated with Teflon (two variants) with a diameter of 0.403 mm. The initial length of a complete orthodontic arch was 115 mm.

The wires used in the experimental program are consistent with current orthodontic specifications.

The experimental study was aimed at highlighting the dependencies between displacements and forces for five types of requests associated with bending, chosen as the most common practical applications (Figure 1) simple bending (1), closing semi-round (2), the opening spring (3), closing spring (4), lateral bending and torsion (5).

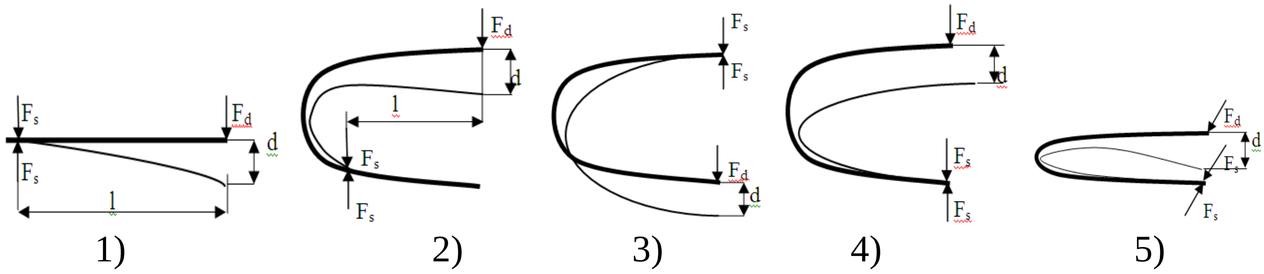

Fig. 3. Common practical applications: simple bending (1), closing semi-round (2), opening spring (3), closing spring (4), lateral bending and torsion (5).

Forces acting on the wire restraining analyzed by clamping (Fs), and that was the input parameter of deformation (DF). This was ensured by direct application of mass bran. Free length of the call for simple bending (a) was l = 45 mm. Every type of wire analyzed groups was measured displacement (d). Results movements (d) measured on each of the 10 components of each type of wire (three types) were statistically processed in order to emphasize the average values, the amplitude (R) and the mean square deviation (S).

3. Results and discussion.

The graphical representation emphasizes for the five groups of samples almost linear dependencies between the deformation induced by the load.

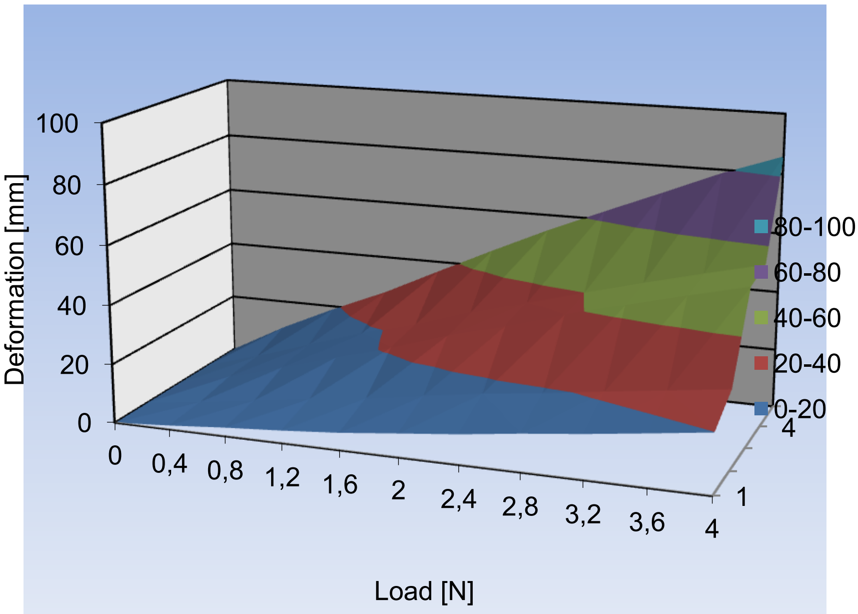

Fig. 4. Dependence of deflection under load for the set of uncoated state wires

The results of measurements of displacements / deformations for two sets of wires protected are presented in figures 5 and 6, in conjunction with the arrangements for application in Figure 1.

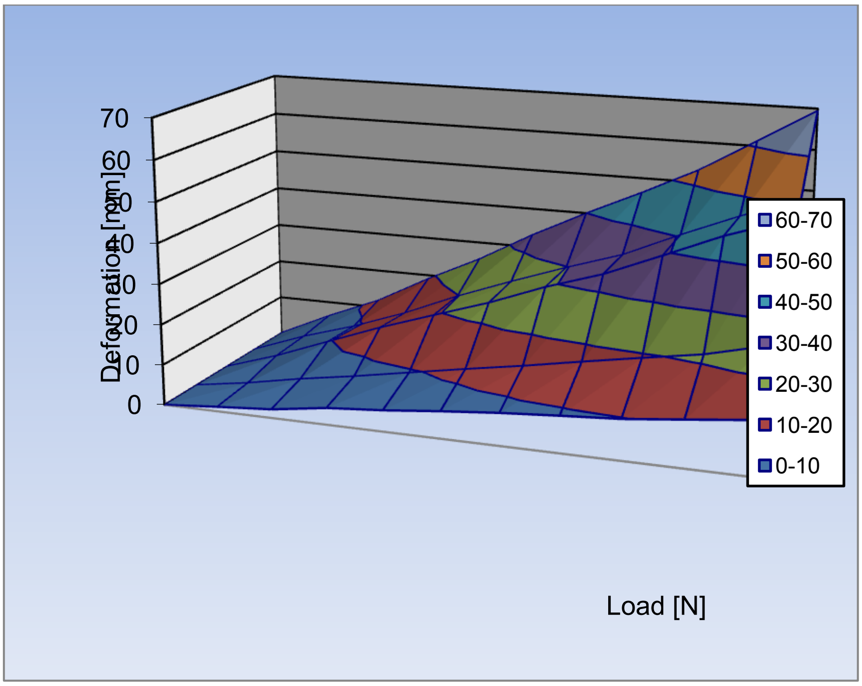

Fig. 5. Dependence of deflection under load for the set (a) of uncoated state wires

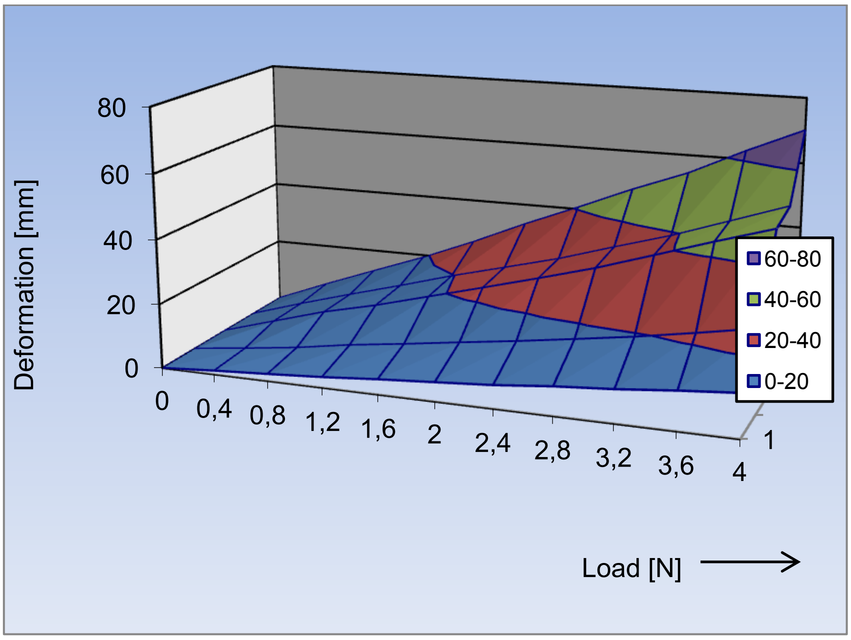

Fig. 6. Dependence of deflection under load for the set (a) of uncoated state wires

It is noteworthy elastic behavior of wire analyzed based on the linearity of the dependence between the forces and displacements induced demand. The results mean elasticity, amplitude and mean square deviation are shown on the application fields applied (Table 1).

The previous graphs show the significant dependencies depending on how the application of orthodontic arch, and the slope of the straight lines is conclusive proof in this regard. The wires were analyzed according to the most rigid application of simple bending (item 1, Figure 1). Wire elasticity subject to requests 3 and 4 (see Figure 1) is similar, in fact bow closure request was submitted, that opening in elastic behavior.

Nr..	Type of wire	Load (fig. 1)	Elasti-city, E /mm/N/	Ampli-tude R /N/mm/	Medium deviationS
1	*Non-coated*	1	421	44	3,60
2		2	654	56	6,50
3		3	1326	49	11.80
4		4	1429	62	16.60
5		5	2302	66	21.17
6	*Coated*	1	314	32	3.18
7		2	583	40	6.18
8		3	1189	59	11.14
9		4	1248	49	13,19
10		5	1651	56	17,19
11	*Coated*	1	292	27	3,21
12		2	579	47	6,19
13		3	1199	57	11.19
14		4	1245	49	12,52
15		5	1699	53	17,99

Tab. 1. Values of elasticity, amplitude and medium deviation of the esthetic/classic orthodontic wires.

Horizontal positioning of orthodontic arch at one end of the consolidation and application request from the other end of the generated bending and torsion (requesting 5 in Figure 1). Behavior proved curved wire having the highest elasticity.

Average values of elasticity analysis shows the effect of strengthening due to the deposit layer of teflon. The set of wires protected with additional layers had an average elasticity of about 81% of the set of bare wires.

Amplitude (R) stands at about 10% to characterize the scattering of individual strains under the applied effects of wire. However, the standard deviation (S) stands at about 1% of reading. An overall analysis of statistical parameters indicate that lots of wires subjected to experiments are homogeneous in terms of assessing elasticity.

3. Conclusions

a) Orthodontic wires are included in any type of device, fixed or mobile, and can be coated with white plastic materials for esthetic reasons,

b) Our experimental study was focused on three sets of standard wires. The elastic properties of uncoated wires were superior to those from the esthetic coated orthodontic wires.

c) The statistical parameters (amplitude R, the standard deviation S) had reduced determined values, showing that lots of wires subjected to experiments are homogeneous in terms of elasticity.

4. Acknowledgements

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