

Abstract of the PhD thesis:
Influence of archwires mechanical properties and surface characteristics in
orthodontic biomechanics

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The principle of fixed orthodontic therapy is based on tooth movement, generated by light and continuous forces. Orthodontic archwires are key elements in producing such forces and their clinical selection should take into consideration both mechanical properties and surface characteristics. The complexity of factors an intraorally used archwire undergoes, may modify the wires mechanical properties and, in consequence, the archwires biomechanical behaviour. The present work is aimed to bring new information in the field of orthodontic biomechanics, by a comprehensive description and characterization of the archwires. Besides, one of the main objectives was to evaluate the archwires mechanical properties alteration due to numerous variables.

The general part of the thesis includes the description of the principles governing the tooth movement, both from a biological and a biomechanical point of view.

Chapter 1 evaluates the main types of physiologic and orthodontic tooth movements and the initiating forces.

Chapter 2 focuses on the atomic and interatomic structures of the orthodontic alloys and the different testing procedures used to evaluate their mechanical and structural properties. The main mechanical tests are described as well as their advantages and disadvantages. Because terminology is sometimes confusing in literature, this chapter also includes a thorough definition of the biomechanical terminology and its clinical importance.

Chapter 3 includes the classification of the orthodontic archwires based on different criteria. It also contains detailed specifications of their advantages and disadvantages, as well as their clinical selection criteria.

The personal contribution of the work includes three clinical and experimental studies and a chapter of clinical cases.

Regarding the great variety of orthodontic archwires on the market, evaluation of clinician's choices in archwire selection during different stages of the fixed orthodontic therapy was necessary. The study from Chapter 4 is a questionnaire based-study and the results were guidelines in selecting the archwires for the next two studies. The results showed that the majority of clinicians use the SS and NiTi wires in their fixed orthodontic treatments, very few use β -Ti, Co-NiTi and aesthetic archwires.

The study included in Chapter 5 evaluated the morphological characteristics of four types of orthodontic archwires : SS, NiTi, β -Ti and coated aesthetic NiTi. It was also aimed to observe the surface characteristics for evidence of corrosion and alteration of as-received, retrieved

and immersed archwires. Immersion solutions included a topical fluoride agent and a soft drink. On the as-received archwires (especially on the SS wires) SEM analysis revealed surface irregularities caused by manufacturer process and handling during orthodontic treatment. The aesthetic archwires exhibited a porous coating. Following immersion in topical fluoride agent, corrosion changes were more obvious on the NiTi and β -Ti wires surface and less obvious on the SS wires. In vivo used archwires showed different types of surface changes: corrosion on the alloy and major delamination of the coated wires.

Experimental studies described in Chapter 6 included two types of mechanical testings (tension and three point bending tests) performed on a total number of 495 wires, of different cross-sections and diameter. The main objective was to compare the mechanical parameters of the as-received, immersed (in topical fluoride agent and Coca Cola™ solutions) and as-retrieved archwires (intraorally used for 4 to 6 weeks and more than 6 weeks). The investigated mechanical properties included: ultimate tensile strength (UTS), yield strength (YS), modulus of elasticity (E) and the load deflection characteristics (activation and deactivation forces) of the orthodontic wire. It was evident from the data that stainless steel had the highest values for UTS and elastic modulus, while the aesthetic wires exhibited significantly lower values compared to the metallic archwires of the same cross-dimension. Immersion produced greater loading and unloading forces of the deflected wires. The elevated values of the deflection forces could be explained by the increased frictional resistance at the bracket-archwire interface. Intraoral use resulted in significant alteration of the wires mechanical properties, especially the SS and coated aesthetic wires.

GENERAL CONCLUSIONS

1. Three types of orthodontic archwires are currently used by clinicians from the N-V Romania: SS, Niti and β -Ti, while newly introduced alloys and aesthetic wires are not popular.
2. During intraoral use, numerous disadvantages were observed by the clinicians, the most frequent were the unwanted bendings.
3. The presence of surface irregularities caused by manufacture process of the orthodontic wires was obvious.
4. Changes in wires surface topography caused alteration in the load deflection characteristics due to the increased surface rugosity and frictional forces.
5. Immersion in fluoride solutions mostly affects the Ti containing wires. Further investigations including differential scanning calorimetry are required in order to elucidate the mechanism of fluor interference with the austenitic and martensitic transformation at interatomic level.
6. Both surface and mechanical properties are modified during intraoral use of the wires.
7. Clinically observed low efficiency of the coated wires was confirmed by the mechanical tests.

8. The correlation between alteration of mechanical properties and surface characteristics of the intraorally used archwires is obvious.