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Comparative analysis of the mechanical properties of fiber and stainless steel multistranded wires used for lingual fixed retention

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ABSTRACT

Objective. To evaluate the effect of different resins used for the co-polymerization of EverStick fiber-reinforced fixed orthodontic retainer on its mechanical properties and to compare the mechanical properties of these configurations to commonly used multistrand wires.

Materials and methods. Ten 0.0175-in. WildCat (WC175), ten 0.0215-in. WildCat (WC215) three-strand twisted wires and thirty EverStick fibers were tested in this study. The EverStcik fibers were equally shared in three groups (n = 10). The samples of first group (ESRE) were polymerized employing Stickresin (Light cure enamel adhesives), the second one (ESFT) employing Flow Tain (Light cured composite), whilst the specimens for the third group (ES) were not combined with resin. All samples were loaded in tensile up to fracture in a universal tensile testing machine and the modulus of elasticity, tensile strength and strain after fracture were recorded. The same groups were also tested employing Instrumented Indentation Testing (IIT) and Martens Hardness (HM), Indentation Modulus (E_{IT}) and elastic index (η_{IT}) were determined. The results of tensile testing and IIT were statistically analyzed employing one way Anova and the Student Newman Keuls test (SNK) at a = 0.05 level of significance.

Results. WC175 and WC215 showed higher modulus of elasticity and tensile strength but lower strain after fracture compared to Everstic groups. IIT illustrated significantly higher values for HM, E_{IT}, and η_{IT} for WC groups compared to ESRE, ESFT and ES. ESFT showed higher HM and elastic index compared to ESRE and ES, a finding which is attributed to the fact the FlowTain is a filler-reinforce composite with higher hardness compared to unfilled resins.

Significance. Multistrand wires demonstrated higher values in mechanical properties compared to EverStick ones. The co-polymerization with difference resins does not affect the tensile properties of Everstic, however the use of a light cured composite has a beneficial effect on hardness.

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1. Introduction

Permanent or long term fixed retention is currently an essential component of treatment, as it has been demonstrated to maintain stability of the orthodontic result. Bonded retainers on the lingual surface of the mandibular and often the maxillary anterior teeth, are routinely used in the orthodontic practice as an integral part of therapeutic protocols [1].

There are two main categories of mandibular fixed wire retainers: (a) round, rigid stainless steel wires (0.030–0.032-in.) bonded only on the canines and referred to as canine-and-canine retainers; and (b) canine-to-canine retainers, which consist of smaller cross section multistranded round wires, or small cross-section rectangular wires bonded to all anterior teeth [1,2]. In addition to the traditional wire retainers, fiber reinforced materials and also alumina ceramic retainers have been alternatively introduced [3–9]. Fiber reinforced retainers have superior aesthetics as the blend with the natural tooth shade, they eliminate the need for working plaster models and they offer a good alternative to wire retainers for patients with Nickel allergy. However due to their increased stiffness they seem to act as a rigid splint that is not compatible with physiologic tooth movement, thus increasing their failure rate [7–9]. Some clinicians also find that the placement of fiber reinforced retainers is often a relatively complex and technique sensitive procedure [8].

Ideally a fixed retainer should be easy to place, passive when bonded, stiff enough to promote stability and at the same time somewhat flexible in order to allow for biological tooth movement. The latter is very important because it helps maintain the periodontal health and at the same time it reduces the stress concentration within the composite [10]. By definition, a stiff, solid wire will prevent tooth mobility for physiological tooth movement relative a multistranded wire. However, even a relatively small diameter multistranded wire bonded individually to the six anterior teeth will impede tooth mobility significantly. Factors affecting the stiffness of the construction, namely the teeth and bonded wires, include the shape and size of proximal contacts, the width and shape of the teeth and the position and size and stiffness of the bonding material [11].

The wires used for the construction of fixed retainers can be adapted to the lingual surface of the anterior teeth by manual bending prior to bonding, thereby providing a passive fit. The passivity of the retainer is essential since residual stress in the wire may be expressed on the teeth resulting in alignment irregularities. However an absolutely passive situation can hardly be achieved with the multistranded wires since their flexibility makes them prone to distortion during their exposure to masticatory loads [12].

Pullout force tests have shown that the surface characteristics of the wire might affect the wire-composite interfacial characteristics and eventually the integrity of the retainers as a whole [13]. A larger diameter wire with a greater surface area embedded in the adhesive will require a greater force to detach it from the enamel surface. Stranded wires offer the advantage of increased surface roughness and contact area with the adhesive and for this reason they offer a favorable profile for bonding. Fiberglass strips on the other hand, are actually soaked in composite and therefore present the largest contact area. In the case of the fiber-reinforced retainers, failures do not arise from composite-fiber interfacial breakdown rather they are attributed to the rigidity of the construction, which results in a stiff body response. Therefore, in essence, glass-fibers retainers act like stiff units, which resist physiological tooth movement causing eventually fracture of the retainer [14]. However, for both fiber-reinforced retainers and multistranded wire retainers, the size and periodontal status of teeth of the teeth, the physical and mechanical properties of the wire and the adhesive and the intraoral aging, modulate the biomechanical performance of the retainer in the dynamic oral environment [13–16].

The aim of the study was to compare the mechanical properties between fiberglass-reinforced retainers and 3- stranded orthodontic wire retainers. The null hypothesis is that there are not significant differences in mechanical properties among multistranded wires and fiber reinforced composites tested.

2. Materials and methods

2.1. Tensile testing

Thirty EverStick fibers (G.C Europe, Leuven, Belgium), ten 0.0175' WildCat (DENTSPLY Int York, PA USA) and ten 0.0215' WildCat 3-strand twisted wire were tested in tensile testing.

The 30 EverStick fibers were equally divided in three groups of 10 specimens each. The samples of first group (ESRE) were polymerized employing Stickresin (Light cure enamel adhesives) (G.C Europe), the second one (ESFT) employing Flow Tain (Light cured composite, Reliance Orthodontics Products, Itasca, IL), while the specimens for the third group (ES), were polymerized without any resin addition. All samples were polymerized for 40 sec with about 50% overlapping irradiations with a curing unit (Radii plus SDI, Victoria, Australia) emitting at 440–480 nm with 1500 mW/cm^2 intensity. A short description of groups tested is presented in Table 1.

The diameter of EverStick samples were measured in three different points with a digital micrometer and the mean value was used for tensile properties calculations. However the calculation of tensile properties of multistranded wires requires the estimation of additional geometrical features of wires

Table 1 – Short description of different groups included in this study.

Group	Short description
WC175	3-Stranded wires with 0.0175' nominal cross section
WC215	3-Stranded wires with 0.0215' nominal cross section
ESRE	EverStick co-polymerized using the StickResin provided by the manufacturer
ESFT	EverStick co-polymerized using the FlowTain light cure composite
ES	EverStick irradiated without any additional resin