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International Journal of Esthetics and Restorative Dentistry

Original Research

Evaluation of Flexural Strength of Esthetic Archwire Versus Conventional NITI Wire - An In Vitro Study

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How to cite: Ashna Y, N Kumar, Jayalakshmi S, BalajiGanesh S. Evaluation of flexural strength of esthetic archwire versus conventional Niti wire – An in vitro study. Int J Esth Res Dent. Volume 2023, Article ID 23221608, 7 pages.
DOI: https://doi.org/10.56501/intjesthresdent.2023.800

Received: 03-01-2023 *Accepted: 19-01-2023* *Published: 24-01-2023*

Abstract

Aim: This in vitro study aims to determine the flexural strength of esthetic archwire vs conventional NiTi wire.

Materials and methods: Conventional NiTi wire and esthetic archwire were both tested on Instron E3000 universal testing machine for their flexural strength at 4 mm displacement and unloaded at 3mm, 2mm and 1mm respectively. The force was noted and graphs were plotted.

Result: The conventional NiTi wire showed more flexural strength of 0.82N at 4 mm displacement. The esthetic archwire showed lesser strength of 0.45N at 4 mm displacement.

Conclusion: From our study, we can conclude that the conventional NiTi wire has more flexural strength compared to the esthetic archwire.

Keywords: *Flexural strength; Eesthetic archwire; Conventional NiTi wire; Orthodontics; Innovative technology.*

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INTRODUCTION

Orthodontics is concerned with the prevention and correction of malocclusions in the teeth and the proper placement of the jaws in the face. The key reasons for seeking orthodontic care are aesthetics and function. Metal appliances have been used to move teeth in orthodontic care since the turn of the twentieth century [1]. Wires were inserted into a specific slot in the brackets, and attachments were bonded to the tooth. Fixed orthodontic appliances are another name for this clinical setup [2]. Before the emergence of etching-bonding methods for tooth enamel, metal bands were affixed to the teeth with cement [3]. The orthodontist will use this setup to monitor tooth movement during treatment. In the early 1900s, orthodontists used materials like gold, platinum, silver, steel, gum rubber, vulcanite, and occasionally zinc, copper, and brass. In the 1950s, stainless steel (SS) was used for the first time in orthodontics, and it quickly took over as the most popular material for brackets and archwires [4,5].

Nickel–titanium (Ni–Ti) archwire, derived from Buehler's Ni–Ti alloys produced at the Naval Ordnance Laboratory, was first used in orthodontics in the early 1970s. Orthodontists currently use SS brackets and archwires made of SS and Ni-Ti metal alloys in a range of shapes and sizes (round and rectangular) [6]. Nickel-titanium (Ni-Ti) wires greatly advanced orthodontics by transmitting light, continuous forces over a wider range of displacements [7]. Conventional (non superelastic), superelastic, and thermal Ni-Ti wires are the three types. Rectangular wires have the most versatility in the thickness plane and bending theory allows for separation of their faciolingual and occlusal apical orientation responses. The first orthodontic device to permit complete three-axis tooth movement regulation was the ribbon arch appliance [8-10]. Since the development of nickel-titanium and beta-titanium (TMA) alloys, which take advantage of titanium's superior biocompatibility, corrosion resistance, and low stiffness, these have gained popularity [11,12].

Since Dr. Edward Angle placed the first orthodontic appliance in the patient's mouth, the archwire has become an important part of the orthodontic appliance. Gold and other precious metals were the preferred materials for producing these wires back then [13]. The high aesthetic demand of patients, combined with the advent of composite and ceramic brackets, sparked research into aesthetic archwires [14]. One promising strategy for creating an aesthetic archwire with excellent overall properties is to use composites, which can be made of ceramic fibres embedded in a linear or cross-linked polymeric matrix [15,16]. The strength and spring back are equivalent to that of nickel titanium alloy. Furthermore, when the wire eventually fails, it loses its stiffness but stays intact. Orthodontic treatment is thought to be based on biomechanics [15,17]. Effective bonding, caries prevention, root resorption (tooth lengthening), patient compliance, and retention techniques are additional guidelines that will guarantee effective orthodontic therapy [18]. This study aims to determine the efficacy of esthetic arch wire and the conventional NiTi wire on the property of flexural strength.

MATERIALS AND METHODS

Two specimens of tooth-colored aesthetic archwire and a conventional NiTi wire were examined. Each specimen had a length of 25 mm and was taken from the nearly straight posterior section of a typical lower arch form. A universal testing machine, “Instron E3000” was used to conduct three point bending testing (Figure 1,2). At the midpoint, the wire specimens were supported and displaced. With loads applied to the rectangular wire thickness, the wires were positioned faciolingually for measurement.

Each specimen was deflected to a displacement of 4 mm before being unloaded to the initial displacement of 0 mm. During both loading and unloading, force and displacement data were obtained (Instron Bluehill software). Force values were measured during wire deactivation at 3mm, 2mm, and 1mm deflections. For the same, a graph was developed.

Figure 1: The above picture shows the esthetic arch wire specimen being tested on the Instron E3000 universal testing machine before application of force.

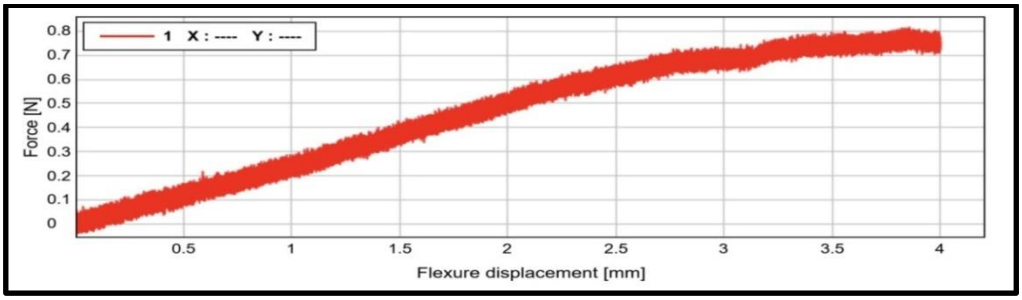
Figure 2: The above picture shows the esthetic arch wire specimen being tested on the Instron E3000 universal testing machine on application of force.

RESULTS

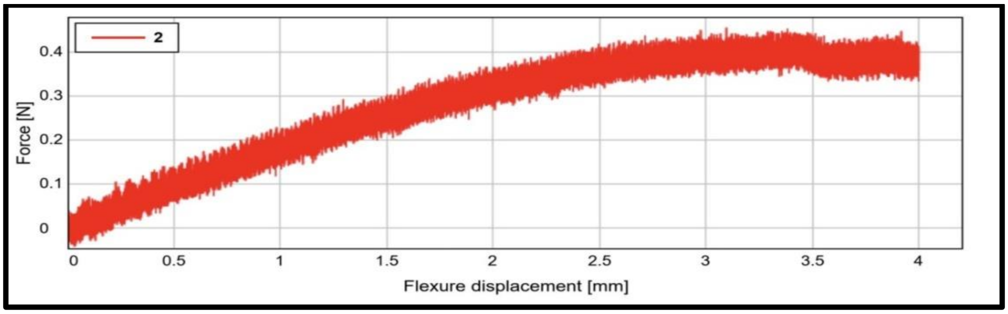
The conventional NiTi wire showed more flexural strength of 0.82N at 4 mm displacement. The esthetic archwire showed lesser strength of 0.45N at 4 mm displacement. At 1mm displacement, the NiTi wire showed a flexural strength value of 0.27 N, at 2 mm it was noted to be 0.45 N, at 3 mm it was 0.59 N and finally at 4 mm displacement it was recorded to be 0.82 N. Similarly, the same test was done for esthetic archwire and the values were obtained. At 1 mm displacement, it showed a flexural strength value of 0.17 N, at 2 mm it was 0.22 N, at 3 mm it was noted to be 0.25 N and at 4 mm displacement it was found to be 0.45 N (Table 1). The displacement graphs were plotted for the above values with the force applied and the flexural displacement. Both conventional niti wire and esthetic archwire showed a gradual increase in the flexural strength with the increase in the displacement from 1mm to 4 mm. On comparison of the values obtained, the conventional NiTi wire was reported to have greater flexural strength value (Graph 1 and 2).

Table 1: Table represents the tabulation of the results showing the displacement and the force noted for esthetic archwire and conventional NiTi wire respectively.

Displacement (in mm)	Esthetic archwire (in n)	Conventional Niti wire (in n)
1	0.17	0.27
2	0.22	0.45
3	0.25	0.59
4	0.45	0.82



Graph 1: The graph represents the flexural displacement of the conventional NiTi wire. X axis denotes the flexural displacement and Y axis represents the force. The flexural strength of the conventional NiTi wire was found to be 0.82 N.



Graph 2: The graph represents the flexural displacement of the esthetic archwire. X axis denotes the flexural displacement and Y axis represents the force. The flexural strength of the esthetic archwire was found to be 0.45 N.

DISCUSSION

During orthodontic care, the use of aesthetic appliances has increased. As a result, the action of these materials during orthodontic mechanics is a major concern. From our study we can observe that the conventional NiTi wire has shown greater flexural displacement than the esthetic archwire. The force gradually decreased with the decrease in displacement from 4mm to 3mm, 2mm and 1mm respectively. Several other studies have also been conducted on various types of arch wires. Compared to stainless steel or beta-titanium wires, Ni-Ti wires have a higher springback and recoverable energy when subjected to the same amount of bending or torque [19,20].

In clinical practice, the thermal Ni-Ti is distinguished by shape memory rather than superelasticity [21]. A reversible phase transition between the austenitic shape and the martensitic structure happens in Ni-Ti wires when they are subjected to stress or temperature changes, producing distinct superelastic properties in bending [22,23]. Theoretically, larger cross sections produce higher unloading values than smaller cross sections and this has been corroborated by several experimental findings [24,25].

In general, the lightest, most dependable force that results in the desired tooth movement is the most effective one. Since some aesthetic wires are rougher than others and have different flexural strengths, it is critical to choose materials with less change in surface morphology after deflection. Esthetic wires can be used in the clinic, but the cases to be handled with them must be carefully chosen to ensure that their evolution and aesthetics are not affected [26].

The preferred wire for aesthetic orthodontic treatment must be less rough to allow for sliding between the wire and bracket and to reduce friction. The lower load-deflection is pivotal at the alignment and levelling point [23,27]. Light and continuous forces are released during the deactivation of wires with wide degrees of deflection, mitigating permanent tissue damage during tooth movement [28,29]. In contrast to non-coated archwires, aesthetic coated archwires had lower flexural strength. Some aesthetic orthodontic wires may become rougher as a result of the deflection. The study's limitations state that different mechanical stimulations may affect each wire's performance differently; however, this does not imply that the wires will perform differently in actual clinical settings. Instead of testing the orthodontic wires directly, more research should be done by placing them on a model. To identify additional factors that contribute to the aesthetic coating's loss during use, more investigation is necessary.

CONCLUSION

From this in vitro study, we can conclude that the conventional NiTi wire has more flexural strength compared to the esthetic archwire.

Conflict of Interests: Nil

Source of funding: Nil

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