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Newer Nickel Titanium Archwires in Orthodontic Treatment: An Overview

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I. Introduction

Nickel titanium alloy is useful in clinical orthodontics because of its exceptional springiness. The pioneer behind the development of these wires for orthodontics was Andreasen.

There are two major phases in the nickel titanium wires. The austenitic phase has the ordered body centered cubic structure that occurs at high temperatures and low stresses. The martensitic phase has a distorted monoclinic, triclinic or hexagonal structure that forms at low temperature a high stress. The shape memory characteristics of the nickel titanium alloys are associated with a reversible transformation between the austenitic and martensitic phases. The martensitic phase forms from the austenitic phase over a certain transformation temperature range or when the stress is increased above some appropriate levels. The difference in the temperature ranges for the forward transformation from the martensitic phase to the austenitic phase, and for the reverse transformation, is termed Hysteresis. For a nickel titanium archwire to possess shape memory, the transformation of the phases must be completed at the temperature of the oral environment[1].

Two new super-elastic nickel titanium wires were also introduced: Chinese NiTi and Japanese NiTi. Nickeltitaniumarchwires with Ionimplanted surfaces have been introduced to reduce the archwire bracket friction. As provided for orthodontic use, Nitinol is exceptionally springy and quite strong but have poor formability. The advantages of these wires can beenumerated as fewer archwires are required to achieve the desired changes, less chair side time, and less patient discomfort. Their poor formability makes them best suited for the pre-adjusted appliance. Placing bends in the wire adversely affects the spring back property of the wire. Clinical disadvantage of these alloys are that permanent bends cannot readily be placed in the wires and that the wires cannot be soldered[2].

Turbo Wire is a nine-strand rectangular braided Ni-Ti, with low stiffness and great flexibility. Turbo Wire is recommended as an initial wire to unravel and level while controlling torque and engaging brackets fully. It is also effective as a finishing wire, retaining torque but allowing vertical elastic use.Nitinol total control is an innovation among the NiTi wires. First, second and third order bends can be incorporated into this wire. Niti wires are used in the suresmile technology as well.

<u>Developments in Nickel Titanium Archwires.</u>

Copper- NiTi

It was Dr. Rohit Sachdeva who introduced a quartenary alloy of Nickel, Titanium and Copper & Chromium in 1994. This alloy had both superelastic and shape memory properties. Due to the incorporation of copper these wires have better defined thermal properties and showed better control over tooth movement. Wires are available in 3-transition temperatures 27, 35 & 40 degrees. The temperature range for the transition of martensitic to the austenitic phase forms the basis of the shape memory phenomenon. This was considered too low to be practical for orthodontic treatment earlier. The addition of copper to the alloy increases the transition temperature range approximately to the intraoral temperature. This helps the patient to activate and deactivate the arch-wire by rinsing with warm and cold beverages[3].

Chinese And Japanese NiTi

Miura has shown that the super elasticity of Japanese NiTi (marketed as sentalloy) allows it to deliver a relatively constant force for a long period. Such force application is considered physiologically desirable for tooth movement and for patient comfort.

Another super elastic wire Chinese NiTi, can be deflected 1.6 times as far as Nitinol while producing only 36% of the force as demonstrated by Burstone et al. The new super elastic NiTi wires (A-NiTi) are significantly different from earlier work-hardened NiTi (M-NiTi) wires and from Stainless Steel. Their super elasticity assures light, constant force at mouth temperature regardless of the amount of activation. Shape memory allows easy arch wire placement at lower temperatures, while the wires are in their martensitic phase. The combination of super elasticity and shape memory makes these wires quite comfortable for patients, even as rectangular initial arch wires. Non-linear unloading shows a rapid initial drop in the force applied to the teeth, implying that less force is delivered with a greater activation. Since stiffness increases and the wire become more efficient toward the end of movement, the clinician should not change the wire too often. A two-month appointment interval is usually sufficient, although treatment can be expedited if necessary by simply untying and retying the arch wires at monthly intervals, which will return them to their initial activation level. To take advantage of the temperature sensitivity of A-NiTI wires, orthodontists may want to advise their patients to alternate a cold drink with a hot meal once a day[4]. Theoretically, the cold drink will cause the wires to enter their plastic, martensitic phase and to momentarily self-adjust in the bracket slots as the teeth move between appointments. Chinese and Japanese NiTi has unique characteristics and offers significant potential in the design of orthodontic appliances. These possess excellent spring back, shape memory and super elasticity.

Aesthetic Wires.

The coated wires, which are currently available, either have an epoxy resin, polytetrafluoroethylene, or a low reflectivity rhodium coating[5] applied to the surface. Atomized Teflon particles are used to coat the wire using clean compressed air as a transport medium, which is then further heat treated in a chamber furnace. The rhodium coating is applied by using a plasma-immersion ion implantation technique[6].

The coated wires are found to be routinely damaged from mastication and activation of enzymes[3]. These wires have been shown to deliver lower forces in loading and unloading [5]. Poor colour stability has also been reported and up to 25 per cent of the coating lost after 33 days in vivo. The coating itself, the process of its application and the fact that the NiTi component of the wire may be smaller to accommodate the thickness of the coating [7], may account for these altered properties.

Recently, new esthetic nickel-titanium wires with toothcolor, Woowa (Dany Harvest, Seoul, South Korea) and BioForce High Aesthetic Archwire (Dentsply GAC, Islandia, NY), have been introduced in clinical orthodontics. Woowa has a double-layered coating structure (inner layer: silver and platinum coating; outer layer: special polymer coating). BioForce High Aesthetic Archwire has a proprietary, low-reflectivity rhodium coating that presents a white appearance.

Super cable arch wires

Super elastic nickel titanium coaxial wire known as ‘supercable’ introduced by Hansen in 1993 united the mechanical advantages of multi stranded cables and the properties of super elastic archwires. These comprises of seven individual strands that are woven together in a long gentle spiral to maximize flexibility and minimize force delivery4. Advantages included improved treatment efficiency, simplified mechanotherapy, elimination of archwire bending, flexibility, ease of engagement regardless of crowding, minimal anchor loss, a light continuous force eliminating any adverse response of the supporting periodontium, minimal patient discomfort after initial archwire placement and fewer patient visits due to longer archwire activation periods.

But they are not devoid of any disadvantages. The wire ends have a tendency to fray if not cut with sharp instruments. Other disadvantages includes tendency of wires to split and untangle in extraction spaces, inability to create bends, steps, or helices and tendency of wire ends to migrate distally leading to soft tissue irritation as the teeth begins to align[8].

Marsenol

This is a tooth colored Nickel Titanium wire coated with an elastomeric poly tetra fluroethyl emulsion exhibiting all the same working characteristics of an uncoated super elastic Nickel Titanium wire, manufactured by Glenroe technologies[9].

Memotain

Memotain is a CAD CAM fabricated lingual retainer, made of 0.014x0.014 in rectangular nickel titanium. The wire is highly flexible and custom cut to precisely adapt to the patient’s lingual tooth anatomy. It was invented in 2012 by an orthodontist Pascal Schumacher. The name memotain is a portmanteau from the combination of memory and retainer because of the uniqueness of using nickel titanium for the lingual wire[10].

Azurloy (preformed and straight)

Azurloy is a heat-treatable alloy with excellent formability in its non-treated form. Applications that take advantage of this formability, followed by heat-treating to increase the spring rate, might include:

- Multiple-loop systems
- Utility arches
- Overlay intrusion or Base Arches

Dual Flex Arch Wires

Dual flex arch has its anterior segment made up of 0.016” or .0016” x 0.022” titanol. It is a Nickel Titanium alloy manufactured by Lancer pacific, the posterior segment is made up of 0.016” or 0.018” Stainless Steel thus combining anterior and posterior segments of different stiffness[9]

Graded Thermodynamic/Tri Force Arch Wire

It has been preprogrammed to deliver the right amount of force for each area of the mouth. It is strongest to more deeply rooted molars, medium at the bicuspids and gentle at the anteriors. It is an Austenitic wire delivering force constantly. It prevents dumping of molars and unwanted rotation of premolar. Thermodynamic NiTi This is a feature where identical dimension arch wires are produced in heavy, medium, and light forms depending on percentage of austenite present at mouth temperature. The arch wire force/deflection characteristics vary at different temperatures leading to unwanted changes in loading and unloading forces for a given wire. The area of periodontium and variable transformation temperature was taken into consideration and graded force delivery within the same aligning arch wire, providing light forces for anteriors, medium forces for premolars, and heavy forces for molars with no discomfort. It gives three-dimensional control early in the treatment.

Bioforce Wire

It was introduced by GAC with the unique property of variable transition temperatures within the same archwire. They are high aesthetic archwires having a proprietary low-reflectivity rhodium coating giving a white appearance. These archwires allows graded force delivery by applying low gentle forces to the anteriors and increasingly stronger forces across the posteriors until plateauing at the molars. The level of force is thus graded throughout the arch length according to the tooth size. Beginning at around 100g and increasing to 300g, this wire provides the right force to each tooth, reducing the number of wire changes and provides greater patient comfort. They are the first biologically correct arch wires.

SureSmile technology

SureSmileArchwires, together with the SureSmile Advanced treatment planning system, combine advanced digital tools; with state-of-the-art robotically bent archwires to help in achieving clinically superior treatments in less time.The SS process digitally captures three-dimensional (3D) images of the teeth and brackets. Computer software develops a 3D therapeutic model of the patient’s dentition, and a virtual treatment plan (VTP) is formulated, which then guides a computer-aided robot to bend and reprogram the form of nickel-titanium (NiTi) archwires, to move the teeth into desired positions

The archwire geometry may also be viewed in isolation in three-dimensional space, and compound geometries such as curve of Spee, expansion, and asymmetric archforms can be designed into the archwire. After the geometry of the digital archwire has been finished, the orthodontist selects the appropriate cross-section, material, and force output from the computer menu[11].

II. Conclusion

Nickel-titanium alloys have shown a growing evolution, from the first samples with distinctive martensitic characteristics until the current ones, with thermoelastic and superelastic properties.

Recent advances in nickel titanium alloys have resulted in varied array of wire that exhibit a wide spectrum of properties. Presently the orthodontist may select, from all the available wire types, one that best meets the demands of a clinical situation. The selection of an appropriate wire size and alloy type in turn would provide the benefit of optimum and predictable treatment results. The clinician must therefore be conversant with the mechanical properties and the clinical application of these wires.

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