European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 07, Issue 8, 2020

Orthodontic Arch Wires

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Abstract:
The materials used by orthodontists have changed rapidly in the last 8 decades and will continue to do so in the future. As esthetic wires are introduced, metallic wires will likely be replaced for most orthodontic applications. Wires are assessed by their properties like strength, stiffness, range, formability and weldability. As an ideal archwire has not yet been found, archwires should be selected within the context of their intended use during treatment. This article throws light on the different types of archwires available for orthodontic use.

INTRODUCTION:

The archwire has been an integral part of the orthodontic appliance, ever since Dr. Edward Angle placed the first appliance into the patient's mouth. Archwires are designed to move teeth with light continuous forces. These forces may reduce the potential for patient discomfort, tissue hyalinization and undermining resorption. Archwire should behave elastically when a force is applied. To achieve this various archwires are available.

Stainless Steel Wires:

Stainless steel was first introduced by Dr. F.Hauptmeyer during the First World War at Krupp's dental polyclinic in Germany for making the prosthesis. The refinement of the drawing process to form wires was invented in the late 1930s by ANGLE. Stainless steel is an alloy that approximately consists of 12 -30% chromium. When 10 to 13% chromium was present in the alloy, a coherent oxide layer was formed that passivated the surface, thereby rendering the alloy "STAINLESS". The stainless steel commonly used is 18-8 austenite steel. It contains chromium and nickel content of approximately 18% and 8%, respectively. The most important quality of 18-8 stainless steel is its high corrosion resistance. Stainless also has excellent corrosion resistant, work hardening capabilities and a frictional magnitude that was low. High modulus of elasticity makes wrought structure wires suitable for orthodontics.

At temperatures between 800 and 1200^{o}F (425-650^{o}C), the carbon in stainless steel reacts with chromium to form chromium carbide, which precipitates in the grain boundaries. The carbon inactivates the chromium at the grain boundaries increasing the susceptibility of the stainless to corrosion. As a result, stainless steel corrodes in the chromium depleted areas by a process called Sensitization. This can be prevented by a process called stabilization. It is a process by which carbon is made unavailable for the sensitizing reaction. This is done by keeping the carbon content exceptionally low. Or by adding other metals like titanium, columbium and molybdenum having greater affinity to carbon than chromium.

Australian Wires:

After many years of research and development in producing high tensile wire, Australian metallurgist Arthur J Wilcock finally produced a cold drawn heat-treated wire that combined the balance between hardness and resiliency with the unique property of zero stress relaxation that Dr.Begg was seeking. They were exclusively for Begg light archwire technique. Different grades of Australian wires are available: Regular, Regular plus, special, Special plus, premium, premium plus.

Cobalt – Chromium Wires:
Elgiloy a cobalt-chromium based alloy was originally developed by the Elgin Watch Company for making watch springs and was introduced into the orthodontics community in the mid-1950. Cobalt-chromium alloy was marketed as Elgiloy(tm) by Rocky Mountain Orthodontics. In addition to having stiffness as stainless steel, it also has its own strength and more importantly formability, which can be modified by heat treatment. They can be heat hardened at 482^{0} for 7 minutes after manipulation to increase the hardness. Non-heat treated wires have a smaller spring back as compared to stainless steel. High formability combined with increased elasticity and yield strength following heat treatment by 10% and 20- 30%, respectively, have made Blue Elgiloy, a cobalt-chromium wire type, popular in clinical practice.

Beta-Titanium And Alpha-Titanium Wires:
They were introduced in orthodontics around 1980 and have extraordinary resilience. Beta titanium wires are also known as a titanium-molybdenum alloy (TMA) (ORMCO, Orange, CA, USA) or Titanium-Niobium (ORMCO, Orange, CA, USA). Modulus of elasticity of these wires is lower than half of the stainless steel wires and almost twice that of Nitinol. Pure titanium has different crystallographic forms at high and low temperature. At temperatures below 885^{0}C, the stable form is α-titanium, which has the hexagonal closed pack crystal structure, whereas at higher temperatures the stable form is β-titanium which has the bcc structure. The elastic modulus and yield strength at room temperature for α-titanium are approximately 110 GPa and 40Mpa respectively.

Nickel-Titanium Wires:
It was introduced by Buehler in the late ’60s for the naval ordinance laboratory. The first nickel-titanium orthodontic alloy has 55% nickel and 45% titanium. It has high resiliency, limited formability, shape memory or thermal memory, pseudoelasticity or superelasticity. Two major phases and one intermediate phase can be found in Ni-Ti alloys at different temperatures. Major phases are austenitic at a higher temperature and the other one is the martensitic phase at a lower temperature, the intermediate phase, delays the transition from austenite to martensite upon cooling until lower temperatures are achieved. Phase transformation can be seen by decreasing the temperature from an elevated temperature and can also be induced by the application of stress and a volumetric change is associated during this transition. This transformation results in two unique features such as shape memory and pseudoelasticity or superelasticity.
Shape memory is achieved by first establishing a shape at temperatures near 482° C, the appliance wire is then cooled and formed into a second shape and heated through a lower transition temperature range (TTR), and the wire will return to its original shape. The cobalt content is used to control the transition temperature range, which can be near mouth temperature.
Superelasticity is the ability of the wire to sustain or deliver a near-constant force over a wide range of activation. Instead of temperature, stress is used to bring about changes in the crystalline structure, that is austenite to martensite and back to austenite.
The drawbacks of the wire are that it cannot be soldered or welded due to the passivating nature of titanium dioxide which is strongly adhered to the metal surface. The frictional forces are very high due to high titanium content, and therefore these wires are unsuitable for sliding tooth movements such as retraction on the wire.

Copper Niti Wires:
They were introduced by Rohit Sachdeva and suchio miuasaki in 1994. The alloy contains 5% - 6% of copper and 0.2% - 0.5% chromium in addition to nickel-titanium added to bring down the TTR to oral temperature. Copper is added to enhance the thermal properties of Nickel-Titanium alloy. There are four different types of copper NiTi archwires, with precise and constant transformation temperature enables the clinician to select archwire on a case/situation-specific basis.

Multistranded Wires:
Stainless steel wires with diameters as small as 0.178mm are twisted or braided to form large wires of round or rectangular cross-section. The wires can sustain large elastic deflections and have low load deflection rate compared to conventional round stainless steel. Strength, stiffness and spring back properties are good. It is noted that the stiffness of a triple-stranded 0.0175" wire was similar to that of single-stranded wire. Multistranded wire is 25% stronger than the 0.010" stainless steel wire.

Dual Flex Wires:
The anterior portion of the combined wire is made of titanal and posterior part is of stainless steel. Titanal is a nickel-titanium alloy manufactured by Lancer Pacific. It consists of 3 types. 1. Dual Flex-l, 2. Dual Flex-2, and 3.Dual Flex- 3.

The Dual Flex-1*:* It consists of an anterior section made of 0.016-inch round titanal and a posterior section made of 0.016-inch round steel.
The Dual Flex-2: It consists of a flexible front segment composed of a 0.016 x 0.022" rectangular titanal and a rigid posterior segment of round 0.018" steel.
The Dual Flex-3: It consists of a flexible anterior part of a 0.017 x 0.025-inch titanal rectangular wire and a posterior part of 0.018 square steel wire. The Dual Flex-2 and 3 wires provide anterior anchorage and control molar rotation during the closure of posterior spaces. They also initiate considerable anterior torque.

ESTHETIC ARCHWIRES:

Optiflex:
Optiflex is a non-metallic orthodontic archwire designed by Dr.M.F.Talass. It has got unique mechanical properties with a highly esthetic appearance made of clear optical fiber, completely stain resistant. It is effective in moving teeth using light continuous force, very flexible, it has an extremely wide range of actions. The fiber comprises of 3 layers, the inner core is silicon dioxide core, the middle layer is made with silicon resin and the outer layer is nylon layer. Core provides the force for moving tooth, middle layer protects the core from moisture and also provides strength and the outer layer prevents damage to the wire and also further increases the strength. Due to superior properties, Optiflex can be used with any bracket system.

Fiber-Reinforced Composite Archwires:
Fiber-reinforced polymer composites have been used as archwires for more than a decade. These materials have got many advantages over the conventional metallic alloys as they are highly esthetic, biocompatible. Other advantages include hydrolytic stability, less water sorption, stiffness is the same as metallic wires, post-processing formability and sliding mechanics are good. However, there is a chance of wearing in these archwires at the interface, chances of leaching of glass fibers within the oral cavity.

Teflon Coated Stainless Steel Wires:
Polytetrafluoroethylene is a synthetic fluoropolymer of tetrafluoroethylene and it has numerous applications. It is commonly called Teflon. Teflon coating imparts to the wire a hue which is similar to that of natural teeth. The coating is applied by an atomic process that forms a layer of about 20-25μm thickness on the wire. This layer then undergoes a heating process and acquires a surface with excellent sliding properties and substrate adhesion. It should also be noted that the Teflon coating protects the underlying wire from the corrosion process. However, since this coating is subject to flaws that may occur during clinical use, corrosion of the underlying wire is likely to take place after its prolonged use in the oral cavity.

Lee Wires:
Lee wires are resistant stainless steel or Nickel-titanium archwires which are bonded to a tooth-coloured epoxy coating. They are suitable for use with ceramic and plastic brackets. The epoxy coating is completely opaque does not chip, peel, scratch or discolour.

Bioforce Wires:
Bioforce wires are aesthetic and are superelastic. "Bioforce archwires' were introduced by GAC. The Ni-Ti Bioforce wires apply low, gentle forces to the anterior teeth and increasingly stronger forces across the posterior teeth until plateauing at the molars. The level of force applied is graded throughout the arch length according to the tooth size.

Marsenol Wires:
Marsenol is a tooth coloured elastomeric poly tetra fluroethyl emulsion (ETE) coated nickel-titanium wire. The working characteristics of these wires are similar to an uncoated superelastic Nickel-titanium wire.

CONCLUSION:
Recent advances in orthodontic wire alloys have resulted in a wide array of wires that exhibit an amazing spectrum of properties. Appropriate use of all the available wire types may enhance patient comfort and reduce chairside time as well as the duration of treatment. Though superior materials and techniques are now available and many replace conventional methods, one should keep in mind that no archwire is ideal or best for all stages of treatment. Since archwires are the main force system in orthodontics, the knowledge about newer archwires will help us to select the appropriate wire within the context of their intended use during treatment

Ethical clearance: Not needed as it a review article.
Source of funding: Self
Conflict of interest: Nil

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