Review article:

Newer orthodontic archwires – a review

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Abstract:

Orthodontic arch wires form an integral part of the fixed orthodontic appliance. These newer arch wires provide increased advantage in terms of efficiency, total treatment time and finishing. From moving teeth to shaping, expanding, and developing the dental arch, wires with their recognized properties, help the clinician reach his/her goals. The orthodontist must select wires based on the amount of force delivery that is desired, the elastic (working) range and spring-back, formability or ease of manipulation, cost, and the need for soldering or welding. This review article aims to put across various types of newer orthodontic arch wires available which has proven properties making the orthodontic treatment experience more pleasant and painless for the patient as well as provide satisfaction to the orthodontist to reach his/her treatment goals.

Keywords: Orthodontic archwires , orthodontic appliances

Introduction:

The optimum orthodontic force produces rapid tooth movement without causing cell damage and does not exceed vascular blood pressure. Low forces on a continuous frequency are always desired, which is predictable, effective, and optimum. Orthodontic wires today have properties which abide by and are used to apply force on teeth in order to move them to a targeted position. They release the energy stored upon its placement by applying forces and torque to the teeth through the appliances placed on them. There are numerous alloys used today in manufacturing arch wires. It started with the use of gold alloys in the 1930s to then moving to stainless steel and cobalt chromium in the 1950s and then adding Nickle Titanium and Beta Titanium in the 1970s. Today, with the need for more aesthetics, newer materials like composites, with ceramic fibres, epoxy's, etc have been used to produce arch wires to blend in with Ceramic brackets. Paradigm shifts in concepts of mechanics and budding bracket systems brought about the advent of newer variations in arch wires which in turn necessitated alterations in appliance design, construction, and clinical manipulation. Hence, the Orthodontist must make informed decisions on the choice of the arch wire material in each stage of the treatment, based on wire characteristics. The following are the newer arch wires.

Copper Ni-Ti:

Copper Ni-Ti was developed in 1994 by Rohit Sachdeva and Suchio Miyasaki, which contains 5-6% copper, and 0.5- 5% chromium in addition to composition of conventional Ni-Ti. One of the drawbacks of conventional Ni-Ti is energy loss during unloading, so copper was added to overcome this energy loss. Adding copper increase phase transformation temperature above that of oral cavity. So, chromium is added to change the phase transformation temperature closer to normal intra-oral temperature. The transition temperature range (TTR) for unloading from martensite to austenite for copper niti is nearly the same as its loading. In Cu-Ni-Ti wires, unloading force closely resembles the loading force due to reduced mechanical hysteresis compared to conventional Ni-Ti. Moreover Cu-Ni-Ti has 20% less loading force; this helps us to engage the wires without creating much trauma and discomfort to the patient.

There are 4 types of Copper Ni-Ti

Type I: (AF =15 °C) - It generates very high force and has few clinical indications.

Type 2: (AF= 27 °C) - It generates highest force among type 2, 3 and 4. It is best used in patients who have an average to higher pain threshold, patients with normal periodontal health and patients where rapid tooth movement is required and force system generated by the wire is constant.

Type 3: (AF=35 °C) -It generates force in mid-range, and best used in patients who have a low to normal pain threshold, periodontium normal to slightly compromised, and when low forces are desired.

Type 4 :(40°C) -It generates intermittent forces, indicated in patient who are sensitive to pain, compromised periodontium. It gets activated only after having hot food and beverages.

Smart Arch Multi-Force Super-elastic arch wires:

Smart Arch Arch wire programming was based on specific PDL compressive stress values derived from Viecilli and Burstone's finite element modelling of digital dental templates. SmartArch wires are manufactured by the method-known as multiple memory material technology-which precisely programs transition zones as narrow as .001" in a cross-section of shape-memory alloy wire.

Many separate super-elastic unloading zones can be programmed into a Copper Ni-Ti wire. Smart Arch wires deliver physiologically optimized forces over an extended period. With carefully applied orthodontic mechanics. Smart Arch wires can shorten the lag phase, reduces adjustment and reactivation requirements, and avoid indeterminate mechanics, thus increasing orthodontic efficiency.

An ideal treatment sequence begins with an .016" Smart Arch Copper Ni-Ti wire, moves into an .018" × .025" Smart Arch Copper Ni-Ti wire, and finishes with either TMA or stainless-steel arch wires.

Wire placement: Bend the arch wire to create stress-induced martensitic transformation. Any type of mild to moderate (1- 3mm) bend will suffice. Avoid sharp bends that cause permanent deformation and wire breakage.

Patience: Let the wire work. Allow time for the lag phase to finish and frontal absorption to take over. Any removal or adjustment of the wire causes a reversion to the lag phase. Resist the tendency to adjust too frequently.

Whole arch: Bond as many teeth as possible, including second molars and blocked-out teeth, right from the start. This allows the biology to work consistently across the entire arch. Orthodontists will need to shift their paradigm from an "adjust at every appointment" mentality to an attitude of observing the body's response to the mechanics and allowing the technology to work. Overactivation of Smart Arch wires reverts the patient into the lag phase, reducing efficiency and prolonging treatment

The conventional wire progression—stepping through multiple rounds of progressively greater size and force—results in forces that overpower some teeth and underpower others. The value of this new wire technology lies in

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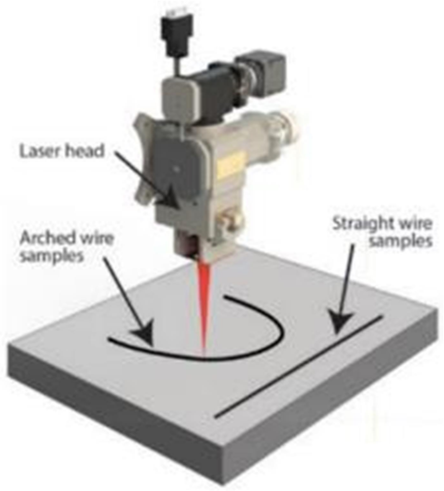
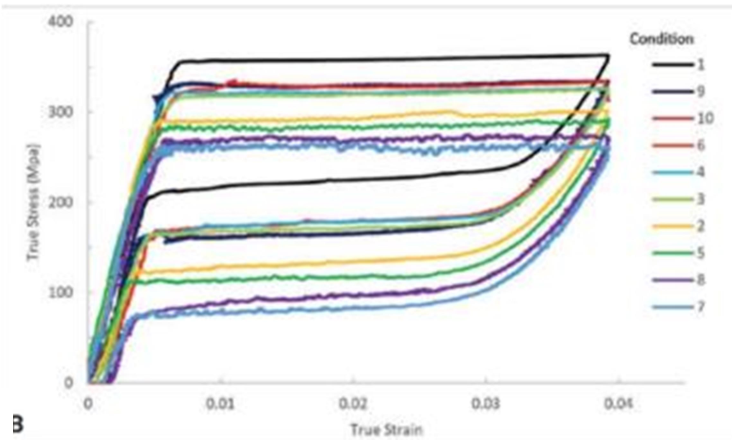
its capacity to apply physiologically appropriate forces to each individual tooth, thereby minimizing the formation of avascular necrotic tissue and shortening the lag phase. Smart Arch can be used with any bracket system, taking full advantage of the technology requires thoughtful treatment planning, accurate bracket placement, and careful observation before manipulating the bracket-wire system





Titanium Niobium:

A new 'finishing wire' made from a nickel-free titanium-niobium alloy (Ti-Nb) was introduced by Sybron Dental Specialities Inc., Orange, CA, USA. Ti-Nb is soft and easy to form, yet it has the same working range as stainless steel wires. Its stiffness is 20% lower than TMA and 70% lower than stainless steel wires. The high formidability and low spring back hence make it very useful as a finishing wire.

Timolium Arch Wires:

It contains titanium as the main metal and aluminium and vanadium which act as stabilising agents. It has both the alpha and beta stages of titanium, hence has its strength and smoothness.

Timolium possesses comparatively low stiffness, better strength and behaves as an intermediate between stainless steel and TMA and hence can be tried for almost all clinical situations. Low spring-back and high formability of titanium-niobium arch wire allows creation of finishing bends and thus it can be used as finishing arch wire. It is manufactured by TP orthodontics.

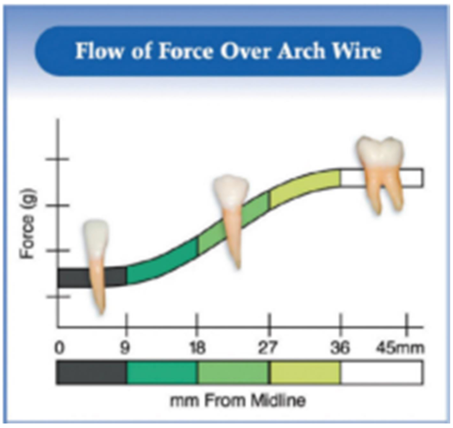
The manufacturer says "**TiMolium** wire combines the flexibility, continuous force and spring-back of nickel titanium with the high stiffness and bendability of stainless-steel wire. Consistently outperforms nickel titanium and beta titanium wire in breakage resistance, smoothness, polish, and flexibility."

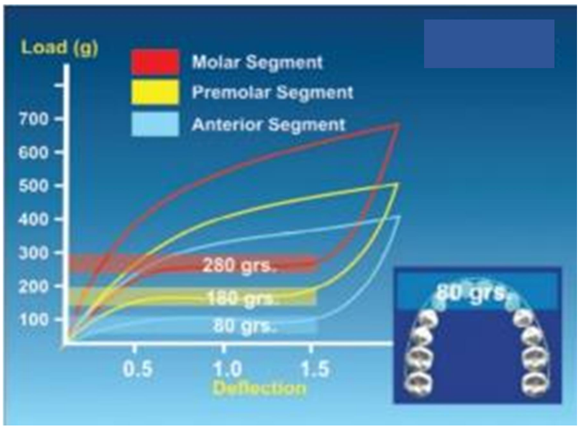
Bioforce Arch wires

Bioforce wire is a super-elastic shape memory Ni-Ti wire that provides gradually increasing forces from anterior to posterior segment, all within one arch wire. The concept was first described by Dr. Miura of Japan. His idea was that if one starts with a "cold alloy" and then heat treats it under controlled conditions, the stiffness of the resulting arch wire will be related to the length of its heat treatment. Bioforce wire can be deflected or activated in such a way that it will produce significantly lower forces when deflecting it in the area that engages relatively small anterior teeth, while it will gradually increase the force moving from the anterior to the posterior segment of the wire.

The major drawback of various type of Nickle Titanium wire is surface roughness. For BioForce this concern is addressed with an ionization implanting process utilized to alter the surface of the arch wire without negatively affecting the wire's unique super-elastic properties. During the ion beam implantation process, Nitrogen replaces Nickel on the top and changes the surface to Titanium Nitride.

The chief characteristics of these super-elastic wires is delivery of very light forces for a typical degree of wire deflection. One can easily conclude that it would be desirable to develop an arch wire that can produce low level of force for a given deflection or activation in its anterior segment, then progressively increase that level of delivered force toward its posterior end, the part that is usually inserted into the molar tubes. This is precisely why the BioForce arch wires were created. BioForce arch wires have the unique property of delivering remarkably accurate and biologically correct forces, to optimally move the teeth of different parts of the dental arch.





Combined wires:

The anterior portion of 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-1
2. Dual Flex-2
3. Dual Flex-3.

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. At the junction of the two segments, cast ball hooks are present mesial to the cuspids. The flexible front part easily aligns the anterior teeth and the rigid posterior part maintains the anchorage and molar control by means of the "V" bend, mesial to the molars. It is used at the beginning of treatment. They are very useful with the lingual appliance, where anterior inter bracket span is less.

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 rectangular anterior titanal segment when engaged in the bracket slots impedes movement of the anterior teeth, while closing the remaining extraction sites by mesial movement of the posterior teeth.

Dual Flex-3: This 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.

Triforce Wire:

Triforce is made by implantation of Nitriding in titanium which makes titanium more aesthetically, increases in hardness, reduces friction, reduces nickel ion release into mouth.

It is a pre-programmed wire and will deliver amount of force for a particular area of mouth. It delivers high forces to molars, medium force to premolars and light force to incisors. These wires are austenitic wires and delivers force constantly. It prevents intrusion of molars, unwanted rotations of premolars and gentle force to anterior causing no discomfort. It provides 3-dimensional controls from the beginning of the treatment.

Biotwist:

They are 0.021"x 0.025" pre-form rectangular made up of multiple stranded titanium super-elastic arch wires. They display low force and low stiffness along with excellent flexibility. Because of rectangular shape there is a good engagement in the slot. It is indicated for initial levelling and alignment since it is flexible and having advantage of torque control. They are also used at final treatment when the retention of torque is important.

Retranol:

Retranol is a bite opener reverse curve arch wires made up of work hardened Ni-Ti. This wire has working range greater than that of SS wires and affords ideal dimensional stability to prevent anterior tooth intrusion during retraction. It opens the bite by less than half the time that was needed with SS. Throughout treatment, retranol remains active without deforming.

Super Cable:

In 1993, Hanson combined the mechanical advantages of multistrand cables with the material properties of super-elastic Niwires to create a super-elastic nickel titanium coaxial wire, called the Supercable. It was found that both .016” and .018” Supercable wires exerted only 36-70% of the force of .014” regular nickel titanium wires and less than 100g of unloading force over a deflection range of 1-3mm. Supercable thus demonstrates optimum orthodontic forces for the periodontium. This wire, comprises seven individual strands that are woven together in a long, gentle spiral to maximize flexibility and minimize force delivery. The super-elastic properties of Supercable allow full bracket engagement with extremely low unloading force delivery. The ideal initial arch wire has superior strength and flexibility, resists permanent deformation, and maximizes both patient comfort and physiologic tooth movement.

Super Cable has the following disadvantages:

1) Tendency of wire end to fray if not cut with sharp instruments.
2) Difficulty of access for placement of Supercable stop distal to second molar tube
3) Inability to accommodate bends, step, or helices

Nanotechnology in orthodontic wires:

Nano is derived from the Greek word for ‘Dwarf’. A nanometre is 10^{-9} or one billionth of a meter. Nanotechnology is about manipulating matter, atom by atom. This technology has also been used in orthodontic wires, especially to reduce friction and plaque formation on brackets and arch wires. On minimising the friction between wires and brackets, treatment time can be reduced. Nanoparticles have been used as a component of dry

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lubricants in recent years. Dry lubricants are solid phase materials capable to reduce friction between two surfaces sliding against each other without the need for a liquid media. Inorganic fullerene-like nanoparticles of tungsten sulphide (IF-WS2), which are potent dry lubricants have been used as self-lubricating coatings for orthodontic stainless-steel wires. Redlich et al coated stainless-steel wire with nickel– phosphorous electroless film impregnated with inorganic fullerene-like nanoparticles of tungsten disulphide (IF-WS2) by inserting stainless steel (SS) wires into electroless solutions of nickel–phosphorus (Ni–P) and IF-WS2. The friction forces measured on the coated wire were reduced by up to 54%.

Anti-bacterial arch wires:

Ni-Ti and stainless-steel wires have anti-adherent and anti-bacterial properties with the coating of various proven materials such as silver for resistance against lactobacillus acidophilus, surface modification by photocatalytic titanium oxide which reduces dental plaque and subsequently dental caries due to orthodontic treatment.

Esthetic wires

Optiflex

Optiflex is the first non-metallic aesthetic orthodontic arch wires, developed by Dr. Talass. It is available in 2 sizes: 0.017 inches for 0.018’’ slot and 0.021 inches for 0.022’’ slot. Under applied stress, metal tends to go plastic deformation beyond its elastic limit and breaks after it reaches the UTS. But in glasses there is no plastic deformation and it behaves as elastic till reaching the breaking point.so the concept of Optiflex is that the glass is flexible till UTS.

It is highly aesthetic since it is made up of clear optic fibres comprised of three layers:

A. Silicon dioxide core: provides force for teeth movement

B. Silicon resin middle layer: provides moisture protection and gives strength

C. Outer nylon coating: provides stain resistant, prevents damage and increases the strength furthermore.

Fibre Reinforced Composites (FRCs) Arch wires:

Fibre reinforced composite arch wires are fabricated using a procedure called pultrusion. fibre bundles are pulled through an extruder, in which they are wetted with a monomer resin. Then the monomer is cured with heat and pressure resulting in polymerization. Circular or rectangular wires are formed during curing. This may be shaped into a different morphology by further curing, a process known as beta staging. For this, the monomer should initially only be partially cured. The composite archwires have higher coefficients of friction than stainless steel but lower coefficients than either Nickel-titanium or Beta-Titanium. At high forces and angulations abrasive wear of the composite surface at the arch wire-bracket interface is observed. Advantages of fibre reinforced composite wires include excellent combination of high elastic recovery, high tensile strength, low weight, excellent formability, excellent aesthetics because of their translucency, ability to form wires of different stiffness values for the same cross section which would facilitate the practice of constant cross-section orthodontics. Attachments can be directly bonded to these wires, which eliminate the need for soldering and welding. It is a safer choice for patients with nickel allergy. Burstone and Kuhlberg introduced a new fibre reinforced composite called "Splint-It" which has S2 glass fibres in a bisGMA (bisphenol-A glycidyl methacrylate) matrix. Various configurations such as rope, woven strip and unidirectional strip are available. These materials are only partly polymerized during manufacture, which makes them flexible, adaptable and easily contourable over the teeth. Later they are completely polymerized and can be bonded directly to teeth. It may be used for post treatment retention, as full arches or sectional arches, and to reinforce anchorage.the disadvantage is it can lead to release of glass fibres within the oral cavity, which is unacceptable

Polynorbogen arch wire

It is a newer plastic arch wire developed in Japan. Known for its elasticity and shape memory, its transition temperature is 35 degrees. Once the temperature exceeds the transition temperature; it began to display an elastic property and then returns to its original shape.At 50ºC, it can be stretched to 2 to 3 times its original length.

COATED ARCHWIRES

Teflon coated

Teflon is polytetrafluorethylene (PTFE). This is a polymer with repeating chains of –(CF2-CF2)- in it.. Teflon is an anti-adherent and aesthetic material; hence, it is coated on stainless steel wire by an atomic process that forms a layer of about 20-25ìm thickness on the wire that imparts to the wire a hue which is similar to that of natural teeth. Teflon-coated archwires results in lower friction than the corresponding uncoated archwires. Hence this coating has the potential to reduce resistance to sliding of orthodontic archwires.

Nitanium Tooth Tone Plastic Coated Arch wire:

These are stain and crack resistant. They are plastic and the friction reducing tooth coloured coating blend with natural dentition as well as ceramic, plastic, and composite brackets. These wires blend in with tooth anatomy and aesthetic brackets to further enhance the visual appeal of aesthetic bracket systems. And delivers 29 to 150 gm of force on teeth.

Marsenol:

Marsenol is a tooth-coloured elastomeric poly tetra fluoroethyl emulsion (ETE) coated nickel titanium wire. The working characteristics of these wire are like an uncoated super elastic Nickel titanium wire. The coating adheres to wire and remain flexible.

Lee White Wires:

It was manufactured by LEE pharmaceuticals. It is a resistant stainless steel or Nickel titanium arch wire bonded to a tooth-coloured epoxy coating. The epoxy coating which is completely opaque does not chip, peel, scratch or discolour. It has superior wear resistance and colour stability of 6-8 weeks.

Conclusion

With the availability of various archwires today, it is imperative for the orthodontist to be at pace with it, embrace newer technology and provide a more wholesome and efficient treatment. The choice remains with the orthodontist to choose the best of the wires according to type of malocclusion, required movement, anchorage and cost without compromising in the best treatment outcome[i]

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