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Newer orthodontic archwires- a review

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Abstract
Archwires are a very important and integral part of treatment with fixed orthodontic appliances. With the development in the field of orthodontics, many newer arch wires have come up that provides a clinician variety of options to choose from. These newer wires provides a lot of advantages over conventional wires in terms of efficiency, total treatment time, and finishing. Moreover, the demand for esthetic treatment options in orthodontics led to the development of esthetic archwires. These new archwires try to combine both esthetics as well as good clinic performance. The knowledge of these archwires is absolutely imperative to keep up with the newer trends.

Keywords: newer archwires, esthetic orthodontic wires, smart archwire, bactericide niti wire, polyphenylene wire

Introduction
Archwires are an essential part of orthodontic treatment to move the teeth to a targeted position by the application of forces to them. The current demand for an optimum, predictable and effective force system, lead to development of many newer orthodontic archwires. The various newer archwires includes supercable, copper NiTi, timolium, titanium-niobium, bioforce wires, wires specifically designed for speed self ligating brackets, smart arch wire, bactericide niti wire coated with silver nano particles etc. Moreover, the demand for esthetic treatment options in orthodontics led to the development of esthetic archwires. These new archwires try to combine both esthetics as well as good clinic performance. Currently available esthetic arch wires are of two categories- coated and uncoated wires. Coated wires include Teflon coated, epoxy coated and nitanium tooth toned arch wire. Uncoated archwires include optiflex, polynorborgen, fiber reinforced composites and polyphenylenes. This article reviews the existing literature on the topic of newer archwires.

Copper NITI Wires
One of the newer wires introduced by Rohit Sachdeva, which contains 5-6% copper, and 0.5-5% chromium in addition to nickel and titanium. Copper is added to decrease energy loss during unloading, but has side effect that it increases phase transformation temperature above that of the oral cavity. So, to compensate, chromium is added to return phase transformation temperature to 27 ℃.
In copper NiTi, unloading force more closely resembles the loading force, due to reduced mechanical hysteresis[1]. This makes it easier to insert large sized rectangular wires without creating undue patient discomfort. There are 4types of Copper NiTi-
Type I: (AF =15 ℃)
It generates very high force and has few clinical indications.
Type 2: (AF= 27 ℃)
It generates highest force among all the types. It is best used in patients who have an average or 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 ℃)
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 : (AF=40 ℃)
These wires generate forces when mouth temperature exceeds 40 ℃.
It is best used in patients who are sensitive to pain, with compromised periodontal condition and poor patient co-operation.

Titanium Niobium Wires
This arch wire is designed for precision tooth to tooth finishing. The stiffness of the wires is 80% of TMA wires. These wires are soft and pliable yet possess a resiliency after bending which becomes equivalent to stainless steel wires. Important features of this wire are-
Used as finishing wire, soft and pliable, stiffness in bending is half of stainless steel, spring back in bending is 14% lower than stainless steel, good weld ability [1, 2].

Timolium Wires
It is an alpha beta alloy with titanium, aluminium, and vanadium as its components. This alloy has smooth surface texture, less friction, better strength than existing titanium based alloys, high yield strength and fewer surface defects. Timolium wires are excellent for all phases of treatment including alignment and bite opening, space closure as well as for torque control. Available in two arch form- standard and straight arch form.

Bioforce Wires
These are graded thermally active NiTi wires according to Evans and Durning classification. Method of force delivery is by variation in arch wire material composition or structure. Introduction of variable transition temperature within the same archwire leads to a form of graded force delivery within the same aligning archwire providing light force (80gms) in the anterior region and a heavier force of 300gms in the posterior region. The known manufacturer (GAC) has developed such greaded thermally activated nickel titanium wires as 'Bioforce' arch wire [3].

Dual Flex Arch Wires
These are two types:
Type-1: The wire is consisting of an anterior segment made up of 0.016" nickel-titanium wire and posterior segments of different stiffness. Cast ball hooks are provided at the junction of two segments just mesial to the canine. Flexibility of anterior segment allows bracket engagement of wire in the crowded anteriors whereas rigid posterior segment controls rotation movements: prevent tipping from elastic traction and permit bite opening. This type of arch wire is ideal for alignment in lingual orthodontics when ìnterbracket width is less.
Type-2: The wire is consisting of an anterior segment made up of 0.016"x 0.022"nickel-titanium wire and posterior segment made up of 0.018"stainless steel wire. It is useful for retraction of anteriors to upright position. Engagement of rectangular nickel-titanium wire restricts movement of the anterior teeth while closing remaining extraction space by mesial movement of the posteriors [3].

Tri-Force Wires
It is preprogrammed wire to deliver the right amount of force for each area of the mouth. It delivers high force to molars, medium force to bicuspid and light force to the incisors. These wires are austenitics wires and deliver force constantly. It prevents dumping of molars, unwanted rotation of premolars and gentle force to anteriors causing no discomfort. It provides three-dimensional control from the beginning of treatment.

Drift Free Arch Wires
These are arch wires with midline stop to prevent lateral arch wire shift. Because shifting of the arch wire might cause injury to the buccal mucosa. The permanent midline stop also act as a reference point.

Triangular Wires
Broussard and Graham in 2001 introduced stainless steel triangular wires for orthodontic use. These triangular wires are equilateral triangle in crossection of 0.030" to a side with rounded edges. Special pliers are required for its bending. These wires can be used for making retainers, remover appliances and bonded lingual retainers. Round wires create occlusal interference, so to eliminate the problem triangular wires can be used which adapts better interproximally than round wires. A flat surface of the triangular wire reduces jiggling and thus reduces tooth abrasion as compared to the round wires in the Hawley labial wire. Clasps with triangular wire promote patient comfort, periodontal health and appliance stability.

Medical Grade Titanium Alloy Wires
As nickel, copper, molybdenum and chromium are allergen so medical grade titanium alloy is a pure titanium alloy, which is ideal for most sensitive patients.

Reverse Curve Niti Wires
It is used for bite opening and simultaneously correction of rotation, intrusion and to control anterior tooth flare and upright the molars.

L-Shaped Niti Wires
It is deeper curve of spee thus makes easier to open the bite, prevent molar dumping and retracting flared incisors in mixed dentition.

Gold NITI Wires
NiTi wires coated with super hard gold (24 Karat). It allows silky smooth sliding mechanism and gives a fabulous rich look.

CV NITI Wires
Like copper NiTi, CV NiTi has highly predictable force level it. It overcomes the problems of copper NiTi i.e., copper allergy, colour change of wire and chemical taste. In CV NiTi, transition temperature range has been set at specific temperature, through pressure variation and heat treatment. But in copper NiTi, nickel has been partially replaced by copper to produce ternary alloy[3]. There are three types of CV NiTi:

Type-1: Maximum Force Activation (27 °C)
- Wire works immediate upon insertion in the mouth.
- Since activated immediately, it is suggested that the wire be first cooled down for easier bends and engagements.
- Ideal for positioning an impacted tooth into alignment faster and effectively.

Type-2: Moderate Force Activation (35 °C)
- Recharges with any warm liquids.
- Perfect for leveling, alignment or rotating teeth.

- Also popular as settling wire.

Type-3: Minimum Force Activation (40 °C)

- Best for Initial arch wire as it produces light force and eliminate patient discomfort.

Speed Super Cable

In 1993, Hanson combined the mechanical advantages of multistrand cables with the material properties of superelastic wires to create a superelastic 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 superelastic properties of Supercable allow full bracket engagement with extremely low unloading force delivery. The ideal initial archwire has superior strength and flexibility, resists permanent deformation, and maximizes both patient comfort and physiologic tooth movement [4].

Hills Dual Geometry Archwire

It has been engineered to be an optimal wire for sliding mechanics in the posterior segments via a polished round posterior segment while ensuring maximum anterior incisor crown torque control with a square anterior segment. The archwire is constructed with an ultra high tensile strength stainless steel with optimum stiffness. The Hills archwire is available in 2 sizes: 0.018x0.018 inch anterior with 0.018 inch round posterior for the 0.018 slot and 0.021 x 0.021 inch anterior with 0.020 inch round posterior for the 0.022 slot [4].

Speed Finishing Archwires

The beveled labial-gingival shape of "SPEED" finishing archwires encourages full expression of the interaction between the superelastic spring clip, the archwire, and the archwire slot. Any deviation of the bracket position relative to the wire results in deflection of the spring clip, which stores appropriate energy for recovery This energy is released gently through precise 3 dimensional tooth positioning. In addition, this quarter round archwire shape facilitates wire insertion and spring clip closure. The rounded edge of the archwire is always directed occlusally in the labial-gingival in either arch. The wires are available in either 0.017x0.022 inch for the 0.018 slot or 0.020x 0.025 inch for the 0.022 slot [4].

Smart Arch Multi-Force Superelastic Archwires

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. For example, 10 separate superelastic unloading zones can be programmed into a Copper NiTi wire.

Smart Arch archwire programming was based on specific PDL compressive stress values derived from Viecilli and Burstone's finite element modeling of digital dental templates. The result is an archwire with seven specific zones preprogrammed to apply appropriate forces to each individual tooth, both maxillary and mandibular [5].

Smart Arch archwires deliver physiologically optimized forces over an extended period. With carefully applied orthodontic mechanics, Smart Arch wires can shorten the lag phase, reduce adjustment and reactivation requirements, and avoid indeterminate mechanics, thus increasing orthodontic efficiency. An ideal treatment sequence begins with an .016" Smart Arch Copper NiTi wire, moves into an .018" × .025" Smart Arch Copper NiTi wire, and finishes with either TMA or stainless steel archwires. Basic considerations involved in Smart Arch diagnosis, treatment planning, and biomechanics include the following.

Wire placement: Bend the archwire 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 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" (tinkering) 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.

New Bactericide Orthodonthic Archwire: Niti with Silver Nanoparticles

The arch wires exert the forces to the teeth when placed into the slot of the brackets, that are bonded to the labial or lingual surface of the teeth. Oral hygiene, then, is more complicated for patients. The normal development of dental biofilm is favored due to the adhesion of dental plaque around the brackets. Then, the chances for developing an enamel decay or a gingivitis and further development of periodontal disease is a real situation. So this new bactericide orthodontic NiTi arch wire was developed by means of electrodeposition of silver nanoparticles, without any further loss of mechanical properties, that can help to control the dental plaque in patients bearing brackets. Bacteria culture results showed that the reduction of the bacteria due to the presence to the nanoparticles of silver is higher than 90%. Consequently, the new treatment with nanoparticles of silver could be a good candidate as bactericidic orthodontic archwire [6].

Esthetic Archwires

Fiber Reinforced Composites as Archwire

FRC's are made from S-2 glass fibers (a ceramic) and Acrylic Resins (Polymer). Fiber reinforced composites (FRC) makes use of 'pre-preg' or partially polymerized fiber matrix complex that fully polymerizes in the clinical setting. Its greatest application- as djuncts for active tooth movement. They have good bonding characteristics to the tooth and also to the appliance itself. An FRC can be bonded to another and attachments added directly [7]

Structure: Three configurations of FRC are available- Round rope type, 2 mm wide strips and woven type

Uses- Can be wrapped around corners of an arch and thus is useful in cuspid-to-cuspid retainers. Unidirectional parallel configurations have best mechanical properties for bending

FRC can be bonded by direct and indirect technique with good bond strength, as polymeric matrix is the same as the bonding adhesive. The advantage of indirect technique being shorter curing time needed intra-orally. If attachments such as brackets tubes or hooks, they can be directly bonded on the FRC [7, 8]

Advantages: Esthetic as the connecting bar is clear or translucent. It is biocompatible, has high modulus of elasticity in flexure. Attachments can be added for inter-maxillary tooth movement without bands or brackets, making it simple to position hooks with ideal direction and point of force application. Vertical elastics can be applied directly to FRC bars, either on full arches or on segments for closure of an open-bite.

Limitations: FRC bars are strong and rigid in tension but less in bending mode and are weakest in shear and torsion. Unlike metals, they are not homogenous materials so shear loads need to be minimized. Sound bonding technique is required.

Optiflex Archwire
It was designed by M.F. Talass in 1992. It combines unique mechanical properties with a highly esthetic appearance.

Structure: Made of clear optical fiber comprises of three layers: i. Silicon Dioxide Core: Provides the force for moving teeth, ii. Silicon Resin Cladding: Protects core from moisture and adds strength and iii. Nylon Coating: It is stain resistant and prevents damage to the wire and further increases strength.

Properties: Wide range of action, ability to apply light continuous forces, sharp bends must be avoided since they could fracture the core otherwise optiflex has practically no deformation [8, 9]

Availability: Optiflex (Ormco Corporation) in sizes 0.017" and 0.021".

Polynorborgen: It is a shape memory plastic developed in Japan. The glass transition temperature is 35 ℃. Once the temperature exceeds the transition temperature, it begins to display an elastic property and then returns to its original shape [5]. At 50 ℃, it can be stretched to 2-3 times its original length.

Polyphenylene Polymers
These wires have flexible segments into an otherwise rigid all-phenylene backbone can produce a high strength, yet processable, polymer. The pendant R groups and the nonrigid segments [-A-]m (both representing a wide range of possible organic groups) disrupt the excessive alignment and rigidity of the covalently linked phenylene groups, leading to a high-strength, yet processable, polymer. Generically, these polymers are called polyphenylenes. Because the blocks of phenylene groups in the backbone chain are rigid, these polymers are also called self-reinforced polymers (SRP).

Properties- Modulus of elasticity is 5.5GPa and Strength 152-207MPa. It has well defined cross sectional shapes with no distortion. Surfaces are smooth with no visible defects almost no permanent deformation on being deflected upto 15 degrees. This wire is highly ductile and exhibist high sprinback in both round and rectangular cross sections. Shows good formability into desired shapes when heated until soft with a stream of warm air. Stiffness is 78% of a 0.016 beta titanium wire [10]. This force level places SRP's in the category of an alignment and levelling wire. Also, Polyphenylenes exhibit time dependant stress relaxtion and creep. So the forces lower over time even at a constant deflection. This is the biggest disadvantage of SRP's.

Coated Archwires
Teflon Coated
• **Structure:** Coating on archwire material has been introduced to enhance esthetics and decrease friction. These wires are designed to be esthetically more acceptable by the patient. They are given a plastic tooth colored coating so that it can blend with the tooth color and also of ceramic brackets. Normally the coating is 0.002" thick. The coating frequently used is TEFLON. Teflon coating is applied in two coats by conventional airspray or electrostatic techniques [8, 11]

Epoxy Coated: Epoxy coated archwire is tooth colored and has superior wear resistance and color stability of 6-8 weeks. Epoxy coated archwires are available under the trade name of Filaflex (American Orthodontics), have high tensile stainless steel core and durable tooth coloured plastic coating. This is available in preformed round 0.018" arches. They are available under another brand name of Orthocosmetic Elastinol (Masel Orthodontics) which is esthetically coated high performance NiTi superelastic archwires and blends exceptionally well with ceramic or plastic brackets and doesn't stain or discolor plus they resist cracking or chipping [12, 13]

Nitanium Tooth Toned Archwire:
It is a superelastic Ni-Ti wire with special plastic and friction reducing tooth colored coatings which blends with natural dentition, ceramic, plastic and composite brackets

Disadvantages: However, the coated white colored wires have routinely succumbed to forces of mastication and enzyme activity of oral cavity [14, 15].

Conclusion
Recent advances in orthodontic wire alloys have resulted in a wide array of wires that exhibit an amazing spectrum of properties. Until the 1930s, the only orthodontic wires available were made of gold. Since then several other materials with desirable properties have been adopted in orthodontics. Appropriate use of all the available wire types may enhance patient Comfort, reduce chairside time, duration of treatment, as well as satisfy the esthetic needs of the patient.

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