ORIGINAL RESEARCH

A Review of Orthodontic Archwires

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ABSTRACT

Today more than hundred years have passed since Dr Edward angle placed his first archwire into a patient's mouth and orthodontics began. It was during that period many innovations did occur that have been explained in terms of art. As time passed scientifically based orthodontics evolved and we see from that time much new innovation in material science have sum uped with new treatment approach and modalities. However, when we turn around and see the developments and innovations in the material science, we stand with pride: but the urge to make treatment still more comfortable and less time consuming, have led us to the introduction of a plethora of new orthodontic materials and products that represent significant improvement over their predecessors. This article compiles all archwire from angle era till recent available newer archwire.

Keywords: Esthetic archwires, Newer archwires, Teflon coated archwires, Variety of archwires.

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INTRODUCTION

Orthodontics has achieved the status of a recognized specialty of dentistry because of a long period of craftsmanship and professional expertise. The evaluation of wire manufacturing technology and the development of new orthodontic techniques have led to the search for better quality alloys, more biologically effective for the teeth and supporting tissues. Esthetics has become today an important and integral part of the orthodontic treatment. With the invention of revolutionary esthetic brackets, the need for esthetic wires became very strong.[1]

With the development of new alloys it becomes necessary to understand how the available energy of tooth movement varies with wire composition for wires of equal diameter. Since, there is now a variety of orthodontic wire alloy from which choose the clinician is now faced with more decision in regard to wire selection.[2]

The purpose of this article is to review the available literature pertaining to these wide ranges of available archwires and compile the knowledge as to facilitate choice of wire at particular treatment stage during orthodontic treatment. Future of the orthodontics lies in the effective and esthetic treatment.

MATERIALS

Variety of archwire German silver wire, stainless steel (SS), multistranded, cobalt chromium, nickel-titanium (NiTi), beta titanium, alpha titanium.

Newer archwires are supercable, copper NiTi, bioforce, turbowire, biotwist wire, multiforce NiTi wire, nitanium tooth toned plastic coated wire, 24 karat gold wire, retenol, reverse curve, L-shaped, gold NiTi, triforce wire, menzansium wire, nitrogen coated wire, timolium wire, titanium niobium wire, drift free archwire, triangular wire, medical grade alloy, dead soft security archwire.

Esthetic wire is optiflex, polynorbogen, combined wire, composite wire, teflon coated wire, esthetic polymer wire (quick change method), stress relaxing composite ligature wire, and esthetic retainer (QCM).

Types teflon coated wire epoxy wire, leeway wire, marsenol, filaflex, orthocosmetic elastinol, titanium tooth toned archwire, imagination wire, polyphenylene polymers esthetic orthodontic archwires, teflon coated SS wire.

DISCUSSION

The Early Archwires (German Silver and Piano Wires)

Before Angle began his search for new materials, orthodontist made attachment from noble metals and their alloys gold (at least 75%, to avoid discoloration), platinium, iridium, and silver alloys were esthetically pleasing and corrosion resistant, but they lacked flexibility and tensile strength. These alloys also were inappropriate for complex machining and joining when used in the traction bars of the time. In 1887, Angle tried replacing noble metals with German silver, a brass. An accomplished metallurgist, Angle knew that he had to prepare the German silver 'according to the use for which

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it was intended 'To obtain the desired properties, Angle acted, as stated in 1888, 'by varying the proportion of Cu, Ni and Zn' around the average composition of the Neusilber brass (German silver, 65% Cu, 14% Ni, 21% Zn), as well as by applying cold working operations at various degree of plastic deformation.[3] As a result, angle made German silver rigid enough for jack and traction screws, elastic enough for expansion arches, or malleable enough for bands.

Gold Wires

They come under precious metal alloys. Before 1950, precious metal alloys were used routinely for orthodontic purpose primarily because nothing else would tolerate intraoral conditions. Gold in its pure state is very soft, malleable and ductile.[4] Modulus of elasticity—96,500 to 1,17,200 MPa which is slightly higher than that for gold casting. It increases approximately 5% after hardening heat treatment. Nowaday's use of Gold is greatly reduced because it is too soft to use as an ortho appliance high cost and also because of recent advances in wire materials and mechanical properties of the same.

Stainless Steel Archwires

Stainless steel entered dentistry in 1919, being introduced at Krupp's Dental Polyclinic in Germany by the company's dentist Dr F Hauptmeyer. By the 1960s, gold was universally abandoned in favor of SS. This is how SS was marketed in lieu of gold: (1) the force per unit activation of SS was greater than that of gold (i.e. high stiffness was an advantage they claimed); and (2) by being smaller in size, SS appliances were regarded as being more esthetic than gold appliances. Stainless steel also had excellent corrosion resistance, work-hardening capabilities, and a frictional magnitude that was so low that it became the standard of the profession. High modulus of elasticity that makes wrought structure wires suitable for orthodontics.[4]

Australian Archwires

After many years of research and development in producing high tensile wires, Mr Wilcock finally produced a Cold drawn heat treated wire that combined the balance between hardness and resiliency with unique property of Zero stress relaxation that Dr Begg was seeking.[5] Different grades of Australian wires formerly available were: regular, regular plus, special, special plus.

Multistranded Stainless Steel Wires

Multistranded wires are made of SS and composed of specified numbers of thin wire sections coiled around each other to provide a round or rectangular cross-section. Strength, stiffness, and springback properties of multistranded wire in a bending mode of stress. It is noted that the stiffness of a triple-stranded 0.0175" (3 × 0.008") SS archwire was similar to that of 0.010" single-stranded SS wire. The multistranded wire was also 25% stronger than the 0.010" SS wire.[4]

Cobalt Chromium Alloys

Cobalt chromium alloys are available commercially as Elgiloy. Soft (blue), ductile (yellow), semi resilient (green), and resilient (red) in increasing order of resilience. Elgiloy, was patented by the Elgin National Company (lincoln, Neb) as the main spring of their analog watches with 'the heart that never breaks'. That particular alloy contained eight elements, the most important of which were Co (40%), Cr (20%), Ni (15%), and Fe (16%). At some point scientists at Rocky Mountain Orthodontics perceived that the use of elgiloy for springs, drive bands, torsional bars, ball bearings, and cables could be valuable to orthodontic practitioner, since archwires were routinely used in some of these modalities during patient treatment. In addition to having similar stiffness characteristics as SS, the alloy was capable of having its strength, and more importantly its formability, modified by heat treatment.[4]

Nickel Titanium

The engineering of nickel-titanium alloys has made remarkable progress since the original work of Buehler for the Naval Ordinance Laboratory in the early 1960s. Buehler's preliminary results led to development of the first NiTi orthodontic alloy 55% nickel and 45% titanium. This alloy possesses low elastic modulus and high range.[4] Nitinol wires behave 'normally', their properties are not affected by temperature within the range likely to occur in the oral cavity or by stress and it is said to possess a stabilized martensitic structure because its ability to behave in a superelastic manner is suppressed by the amount of cold working which has occurred during manufacture.

Beta and Alpha Titanium Wires

These wires were developed by AJ Wilcock Jr in 1988 and claimed to have extraordinary resilience whilst maintaining formability.[4] Like the SS and NiTi orthodontic wires pure titanium has different crystallographic forms at high and low temperatures. At temperatures below 885ºC, 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 is approximately 110 GPa and

40 MPa respectively. Beta could be bent 105% further or twice the distance of SS before reaching its yield point. Beta titanium cannot be soldered, but it can be welded to itself with minimal strength change.[6]

Newer Archwires

Super-cable

In 1993, Hanson combined the mechanical[5] advantages of multistranded cables with the material properties of superelastic wires to create a superelastic NiTi coaxial wire. This wire, called supercable, comprises seven individual strands that are woven together in a long, gentle spiral to maximize flexibility and minimize force delivery. Supercable wires 0.016" and 0.018" were the only ones that tested at less than 100 gm of unloading force over a deflection range of 1 to 3 mm. Supercable thus demonstrates optimum orthodontic forces for the periodontium, as described by Reitan and Rygh.[5]

Copper-NiTi

Copper NiTi is the most recent introduction to the family of NiTi alloy wires and the credit goes to Rohit Sachdeva and Suichi Miyazaki (1994).[5] Copper NiTi is a quaternary alloy, which has distinct advantages over the formerly available NiTi alloys. For very small activations, it will generate a near constant force. It is more resistant to permanent deformation and exhibits excellent spring back characteristics. It exhibits a small drop in unloading force than is true with other NiTi alloys. Addition of Copper combined with more sophisticated manufacturing and consistent transformation temperatures, i.e. 15, 27, 25 and 40ºC. The last property of the alloy brought to orthodontics very useful phenomenon-variable transformation temperature orthodontics.

Bioforce Wire

Bioforce Sentalloy that is able to deliver selective forces according to the needs of the individual dental arch segments.[5] Evans and Durning classified wires like bioforce as phase V or graded thermodynamic NiTi. Bioforce (GAC) offers 80 gm of force for anteriors and up to 320 gm for molars. Anteriors receive three times force needed optimal, biological tooth movement is achieved efficiently without the excess force. And with an application of Ortho Ice, BioForce becomes incredibly malleable and easy to tie into the most malposed teeth.

Turbo Wire

Turbo wire[5] is a nine strand rectangular braided NiTi, with low stiffness and great flexibility. Turbo wire is recommended as an unravel and level while controlling torque and engaging bracket full. It is also effective as a finishing wire, retaining torque but allowing vertical elastic use.

Bio Twist NiTi

The bio twist is a 0.021 × 0.025 pre-form rectangular arch wire formed with multiple strands of titanium super elastic wire. This multistrand structure gives the wire low force and low stiffness with excellent flexibility, and the rectangular shape allows significant engagement of the slot. Bio twist wire is great for use at the beginning of treatment during the unraveling stage because it will facilitate leveling and aligning while also controlling torque. This wire can also be used at the end of treatment when the retention of torque is important but it will allow movement from forces, such as vertical elastics.[7]

Multi Force Nitanium Archwires

These archwires offer increased forces throughout the three regions. The anterior region consists of light super elastic forces; the bicuspid region is engineered to produce a graduating amount of super elastic force as it travels toward the posterior region; the posterior region exhibits the highest force and is designed to bend and then return to original.

Nitanium Tooth Tone Plastic Coated Archwire

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

24 Karat Gold Plated Archwire

The perfect archwire to compliment your patients golden brackets. These wires are coated with a super hard finish that will not come off during treatment. The super smooth finish enhances sliding mechanics. Available in both SS and nitanium pro-form archwire with midline marked black for upper and red for lowers.

Retranol

Retranol 'The Bite Opener' reverse curve archwires, are produced from work hardened NiTi. This wire provides a greater working range than SS wires and affords ideal dimensional stability to avoid dumping the anterior during retraction.[7] Opening the bite now requires less than half the time that was needed with SS. Retranol also needs fewer archwire changes and adjustments. Throughout treatment, retranol remains active without deforming. Available in round and rectangular, upper and lower arch forms.

Reverse Curve of Spee NiTi Archwire

Ultimate offers five reverse curve of spee (RCS) archwire shapes to meet your correction of curve of spee needs. All are carefully finished to ensure that the wire slides easily through the bracket slot and applies continuous force for ideal movement. Reverse curve of spee can be used for bite correction or, with springs and elastomerics, for retraction. Available in two form superelastic 2 and heat-activated Ultra Therm® forces.

L Shaped NiTi Wires

It has deeper curve of spee thus makes easier to open the bite, prevent molar dumping and retracting flared incisor in the mixed dentition.

Triforce Wire

Implantation – Nitriding. Advantage it makes titanium more esthetically, increases in hardness (1111 HV at 16 hours on 1000deg temp), reduces friction (0.22–0.25), reduces nickel release into mouth.[8]

It is a preprogrammed wire to deliver the right amount of force for each area of mouth. It delivers high forces to molars, medium force to bicuspids and light force to incisors. These wires are austenitic wires and delivers force constantly. It prevents dumping of molars, unwanted rotations of premolars and gentle force to anterior causing no discomfort. It provides three dimensional controls from the beginning of the treatment.

Menzamium Wire

The stainless steel is fabricated in patented high pressure melting process where manganese and nitrogen replace allergic component of Ni8. It is ideal for nickel sensitive patient. It is also corrosion resistant and durable.

Nitrogen Coated Archwires

Appearance of titanium alloy is not esthetic, several methods of surface hardening as well as several coating has been developed Implanting nitrogen surface of NiTi alloys by Ion.

Gold NiTi Wires

A NiTi wire coated with super hard gold 24 carat. Allows silky smooth sliding mechanics and gives a fabulous rich look.

Timolium

Timolium (titanium vanadium) is an advanced technology titanium wire with a smooth surface that greatly reduces friction. The surface of Timolium is much smoother than traditional TMA (beta titanium) wire. Higher resistance to breakage with its smooth surface, Timolium wire has fewer surface defects to act as crack propagators. Its high yield strength withstands bending without breaking. Intricate loops and bends can be made easily to accommodate a variety of treatment options. Orthodontists using Timolium agree that it is ideal for torquing and tipping ceramic brackets, with higher yield and compressive strength than TMA.[6]

Titanium-Niobium Archwire

Recently a new 'finishing wire' made from a nickel free titanium-niobium alloy was introduced. According to manufacturers, sproduct information TiNb is soft and easy to form, same working range as SS, and stiffness is 20% lower than TMA and 70% lower than SS. The mechanical properties of these newly introduced titanium-niobium finishing wires were investigated[5] both in bending and torsional loading mode, the stiffness, yield point, post-yield behavior, and spring back of titanium-niobium wires were experimentally determined and compared to those of equally sized SS wires.

Drift Free Archwire

A built 1 mm midline stop prevents lateral archwire shift. The shifting of archwire might injure the buccal mucosa on one side and the wire is out of the buccal tube on the other side. Permanent stop also acts as a midline reference point. Measurements can be taken easily.

Medical Grade Titanium

Metal allergies are common in dentistry, sometimes patient gets inflamed gingival, puffy face and breathing problem. Pure titanium are as sturdy as SS but contain no copper, nickel, molybdenum/chromium to eliminate all allergies. Ideal for sensitive patient.

Triangular Wires

Broussard and Graham in 2001 introduced SS triangular wire for orthodontic use. The triangular wires are equilateral triangle in cross-section of 0.030" to a side with rounded edges special wires are required for its bending. These wires can be used for making retainer, removal appliance and bonded lingual retainer.

Dead Soft Security Archwire

It has been introduced by binder and scott. In a non-extraction case, an archwire is usually placed to initiate tooth movement immediately after bonding. However, in an extraction case a proper archwire might create undesired tooth movement before extraction are performed. This problem can be avoided by placing sectional arches made of dead soft brass wire or twisted double strand of 0.008" or 0.010" dead soft SS ligature wire.

Esthetic Wires

Optiflex

Optiflex is a nonmetallic orthodontic archwire designed by Dr Talass.[5] 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. Due to superior properties optiflex can be used with any bracket system

Polynorbogen

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

Combined Wires

The key to success in a multiattachment straight wire system is to have the ability to use light tipping movements in combination with rigid translation and to be able to vary the location of either, at any time the need arises during treatment. They used three specific combined wires for the technique; Dual Flex-l, Dual Flex-2, and Dual Flex-3 (Lancer orthodontics). The Dual Flex-1 consists of a front section made of 0.016" round Titanal and a posterior section made of 0.016" round steel. The Dual Flex-2 consists of a flexible front segment composed of an 0.016 × 0.022" rectangular titanal and a rigid posterior segment of round 0.018" steel. The Dual Flex-3, however, consists of a flexible front part of a 0.017 × 0.025" Titanal rectangular wire and a posterior part of 0.018 square steel wire.[5]

Composite Wires

Manufacturing the composite wire in the photo pultrusion process, fibers are drawn into a chamber where they are uniformly spread, tensioned and coated with the monomer.[5] Comparison of composite wire in bending mechanical tests show that wires are elastic until failure occurs. Moreover, when failure finally does occur, the wire loses its stiffness, but it remains intact.

Teflon Coated Wires

- *Epoxy coated archwire*: It is tooth colored archwire. It has a superior wear resistance and color stability of 4 to 8 weeks.
- *Lee white wire*: It is a resilient SS or NiTi archwire bonded to a colored coating, suitable for use with ceramic and plastic brackets. The epoxy is completely opaque and does not chip, peel, stain or discolor.
- *Marsenol*: Marsenol is a tooth colored NiTi wire. It is an elastomeric polytetra fluroethyl emulsion (ETE) coated NiTi. It exhibits all the same working characteristics of an uncoated super elastic NiTi wire.
- *Filaflex:* High tensile SS core
- *Orthocosmetic elastinol*: It is esthetically coated high performance NiTi super elastic archwire. The esthetic coating blends exceptionally well with ceramic or plastic brackets. It does not stain/discolor and resist cracking or chipping.
- *Titanium tooth toned archwire*: It is a super elastic NiTi wire with special plastic and friction reducing tooth colored coating. It blends well with natural dentition, ceramic, plastic and composite brackets.
- *Imagination wire*: This wire was introduced by Gastenco in Sweden. It offers superior esthetics, hypoallergic, reduces friction when used with image brackets. The wires are available as round, rectangular and square.
- *Polyphenylene polymers esthetic orthodontic archwires*: Polyphenylene (Primospire, Solvay Advanced Polymers, and Alpharetta, Ga) polymer was extruded into wires with clinically relevant round and rectangular cross-sections.[5] Tensile, flexure, spring-back, stress-relaxation, and formability characteristics were assessed.
- *Teflon coated stainless steel archwires*: 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 to 25 µm thickness on the wire.[5] Teflon coating protects the underlying wire from the corrosion process.

ORGANIC POLYMER WIRE (QCM)

Organic polymer retainer wire made from 1.6 mm diameter round polyethylene terephthalate.[5] This material can be bent with a plier, but will return to its original shape if it is not heat–treated for a few seconds at temperature less than 230°C (melting point). Patients who have worn esthetic ceramic or plastic brackets during orthodontic treatment are likely to want esthetic retainers after treatment, so these wires are used for esthetic maxillary retainers.

Stress-relaxing Composite Ligature Wires

A stress-relaxing composite ligature was developed that has both mechanical and esthetic characteristics that make it attractive for use in orthodontics. The neutrally-colored polymer-polymer composite was created by encasing ultra-high molecular weight poly (ethylene) fibers in a poly (n-butyl methacrylate) polymer, which was formulated from a polysol and an optimal benzoin ethyl-ether concentration. The resulting composite ligature exhibited a tensile strength more than twice that of dead-soft SS ligature, and stress-relaxation decay significantly greater than SS ligature.[5]

Esthetic Retainer Quick Change Method (QCM)

The new esthetics organic polymer is easy to fabricate and fit to the dental arch.

It consists of anterior plastic part and a flat organic polymer wire with 10° labial torque is attached to 0.032" SS posterior arms, each 11 cm long.[5] Plastic portion comes in three intercanine widths, with or without activating omega loops in the posterior arms.

CONCLUSION

Today more than hundred years have passed since Dr Edward angle placed his first archwire into a patient's mouth and orthodontics began. It was during that period many innovations did occur that have been explained in terms of art. As time passed scientifically based orthodontics evolved and we see from that time much new innovation in material science have supped-up with new treatment approach and modalities. However, when we turn around and see the developments and innovations in the material science, we stand with pride: but 'the urge to make treatment still more comfortable and less time consuming, have led us to the introduction of a plethora of new orthodontic materials and products that represent significant improvement over their predecessors. Technology development will continue at a pace equal to or greater than in past years. Metallurgy will surely 1 day provide us with a programmed arch-wire that will adapt itself at different stages of treatment and surely take orthodontics to new horizon.

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