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Research Article

ORTHODONTIC ARCHWIRES: PAST, PRESENT AND FUTURE (REVIEW PART 2)

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A R T I C L E I N F O A B S T R A C T

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Aim- The aim of this review is to discuss about the orthodontic wires from its evolution to future.Also, to discuss in detail about their mechanical, physical properties and clinical applications.
Background- Orthodontic wires are components of fixed appliances used to carry out the necessary tooth movements as part of orthodontic treatment. A variety of materials like metals, alloys, polymers, and composites are used to produce orthodontic wires. Various laboratory tests are performed to evaluate the properties of the archwires. However, oral conditions may influence their behavior and it is important for the clinician to understand the properties of orthodontic wires as well as their clinical implications to achieve optimal results. This article reviews different materials used for manufacturing orthodontic wires and their properties along with clinical implications.

INTRODUCTION

The following article is the continuation of the previous article on Orthodontic Archwires: Past, Present and Future (Review Part 1). A wide range of archwires have been discussed in this article so that the clinician has a complete overview of the numerous archwires for different applications during orthodontic treatment at his dispense.

Super Cable[1]

1. In 1993**, Hanson** combined the mechanical advantages of multistranded cables with the material properties of superelastic wires to create a superelastic nickel titanium coaxial wire.
2. It comprises seven individual strands that are Woven together in a long, gentle spiral to maximize flexibility and minimize force delivery.

Properties

1. Improved treatment efficiency
2. Simplified mechanotherapy
3. Elimination of archwire bending.
4. Flexibility and ease of engagement regardless of crowding.

Clinical application

1. Supercablewires0.016" and 0.018" were the only ones that tested at less than 100 gm of unloading force over a deflection range of 1 to 3mm.
2. Supercablethus demonstrates optimum orthodontic forces for the periodontium, as described by Reitan andRygh.[1]
3. 0.018"supercable wire exerts less force than any of the solid 0.014" nickel titanium wires (80g vs. 115-200g), it offers the clinician the advantage of engaging a relatively large archwire at the start of the treatment.
4. Supercableis able to achieve a greater degree of uprighting, leveling, rotational correction than other initial archwires.
5. Supercable's unique construction and superelastic properties permit it to be gently engaged in even the most crowded cases without patient discomfort.

Placement technique recommended for optimal performance

1. Seat the supercable wire in the brackets, leaving 2mm protruding distally from each of the terminal brackets.
2. When cutting the supercable, always use a sharp distal end cutter. A dull cutter tends to tear the component wires and thus unravel the wire ends.
3. If a wire end snags on a buccal tube and slightly unravels, it can be rewound by twisting the frayed end between finger and thumb.
4. Resilience of supercable makes it impossible to place distal end bends. Flaming the wire ends only results in fraying. Therefore, a specially designed supercable distal end stops must be added to secure the distal end to the terminal brackets. (figure 1)
5. Speed supercable stop plier or a blunt distal end cutter can be used to simultaneously place and crimp the stop.

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6. Alternatively, light cured composite material can be placed over the protruding archwire ends, replacing the crimpable stops, or the composite can be cured over the stops to enhance the mechanical retention. (figure 2)

Figure 1 Supercable stop crimped and seated snugly against the mini-molar tube.1

Figure 2 Light cure composite applied to cover the distal end of supercable.1

Advantages:Supercable + SPEED system offer the following advantages

1. Avoidance of bite opening in the levelling phase, since the interaction between spring clip and archwire eliminates the undesirable reciprocal forces.
2. More effective and efficient control of rotation, tipping, and levelling mechanics with an 0.018" wire at the beginning of treatment.
3. Flexibility and ease of engagement regardless of crowding.
4. Spontaneous distal movement of cuspids during the initial levelling phase in severely crowded extraction cases.
5. Avoidance of incisal tipping or flaring due to the continuous action of the spring clip and distal movement of cuspids.
6. No evidence of anchorage loss.
7. A light, continuous level of force, preventing any adverse response of the supporting periodontium.
8. Minimal patient discomfort after initial archwire placement.
9. Fewer patient visits, due to longer archwire activation.

Disadvantages

1. Tendency of wire ends to fray if not cut with sharp instruments.
2. Tendency of archwires to break and unravel in extraction spaces
3. Inability to accommodate bends, steps, or helices.
4. Tendency of wire ends to migrate distally and occasionally irritate soft tissues as severely crowded or displaced teeth begin to align.

Combined Archwires[2]

1. 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.
2. The key to success in a multi attachment 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.

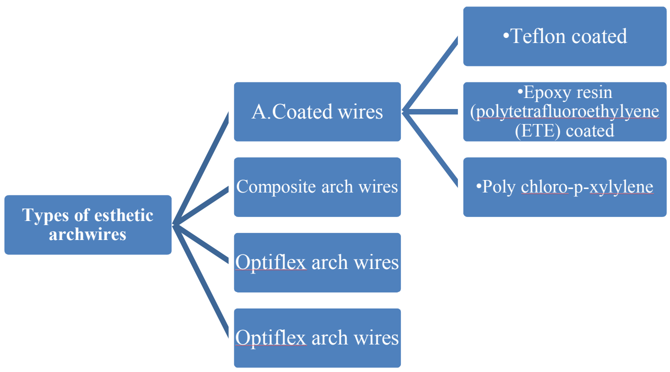
Three specific combined wires for the technique

a. Dual Flex-l
b. Dual Flex-2
c. Dual Flex-3

The Dual Flex-1: It consists of 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.

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 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.
The 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.

Esthetic Archwires:[3]



Ceramics and polycarbonates have been used to produce tooth colored brackets, and research is under way to produce a suitable archwire material, which will combine aesthetics with the required mechanical properties. Since orthodontic treatments extend over a number of months and more and more adult patients were undergoing orthodontic treatment, the aesthetic aspect of the appliance could not be ignored any more. The demand for aesthetics led several companies to begin production, in the late 1970's, of non-metallic brackets made from polycarbonate or ceramics Esthetic wires came into being in the mid-2000.

Coated Archwires[4]

Coating on archwire material have been introduced to enhance esthetics, decrease friction (a low friction coefficient) and can blend with the tooth color and also of ceramic brackets. Normally the coating is 0.002” thick. The coating frequently used is Teflon.

Epoxy coated wires[5]: Material used in coating are plastic resin materials such as synthetic fluorine-containing resin or epoxy resin composed mainly of polytetrafluoroethylyene to simulate tooth color. The epoxy coating is manufactured with a depository process that plates the base wire with an epoxy resin of approximately 0.002” thick. The process of applying this coating to the archwire includes some surface treatment on the wire and the use of clean compressed air as a transport medium for the atomized polytetrafluoroethylyene particles to coat the wire. The set is further heat treated in a chamber furnace.

Teflon coated stainless steel arch wires[3]: 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 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.
Teflon coating is applied in two coats by Conventional air spray or electrostatic techniques. Coating may not withstand the forces of mastication and enzyme activity of oral cavity, which results in increased in friction. Esthetic coated archwires did not show a uniform coating-thickness pattern. These wires had low esthetic value as they presented a nondurable coating after oral exposure. The remaining coating showed a severe deterioration and a greater surface roughness compared conventional SS and NiTi wires.

Available in Natural tooth shades Colored – Blue, Green, and Purple.

Lee White Wire: Manufactured by Lee pharmaceuticals. These are epoxy coated archwires with superior wear resistance and color stability of 6-8 weeks. They are available in preformed arches of Stainless steel and Nickel titanium. Lee wires are a resistant stainless steel or Nickel titanium archwires which are bonded to a tooth colored epoxy coating. They are suitable for use with ceramic and plastic brackets. The epoxy coating is completely opaque does not chip, peel, scratch or discolor.

Imagination wire: Introduced by GASTENKO in Sweden. It is a tooth colored epoxy coated archwire with a stainless steel or NiTi core. Offers superior esthetics, hypoallergic, reduces friction when used with Image brackets. Round, Rectangular and Square wires are available.

Orthocosmetic Elastinol: Manufactured by Masel Orthodontics.

Marsenol: Marsenol is a tooth colored nickel titanium wire. It is an elastomeric poly tetra fluroethyl emulsion (ETE) coated nickel titanium. It exhibits all the same working characteristics of an uncoated super elastic Nickel titanium wire. The coating adheres, to wire and remains flexible. Esthetic coating blends exceptionally well with ceramic or plastic brackets. Doesn’t stain or discolor and resists cracking or chipping.

Nitanium Tooth Toned Archwire[10,17]: Manufactured by Ortho Organizers

Superelastic Ni-Ti wire with special plastic and friction reducing tooth colored coatings. Blend with Natural dentition, Ceramic, Plastic and composite brackets. Maintains its original color and delivers gentle constant force. The wire delivers constant force on long periods of activation and is fracture resistant. Sizes: Round – 0.014”, 0.016”, 0.018” Rectangular – 0.016” x 0.022” 0.018” x 0.025”

1. Kusy[4] reported that a fluorocarbon-coated, white colored, tripe stranded stainless steel wire (Eastman Dental, NJ , USA) does not withstand the mechanical forces and enzyme activity in the oral environment.
2. Kusy[4] and his colleagues have developed an archwire containing S2 glass fibers (Owens Corning, Toledo O.H, USA) embedded in a polymeric matrix formed from Bis-GMA and TEGDMA, benzoin ethyl ether is present as a Photoinitiator.
3. Rectangular cross section and preformed archwires can be fabricated and the surface chemistry can be modified to provide enhanced biocompatibility and low coefficients of sliding friction. [4]
4. Poly (Chloro-PXylyene) coatings have been found to minimize glass fiber release during manipulation of the wires. This group has also developed a composite ligature wire consisting of ultra-high molecular weight polyethylene fibers in a poly n-butyl methacrylate matrix. [4]

Composite Wires[6]

One promising approach involves the use of composites which can be a mixture of ceramic fibers that are embedded in a linear or cross linked polymeric matrix .Such an archwire could be made with a tooth-colored appearance and with stiffness properties similar to metallic archwires. In Orthodontics, composite prototypes of archwires , ligatures and brackets have been made from S-2 glass fibers (a ceramic) and Acrylic Resins The volume percent of fiber in each composition may vary within a wide range, extending from as little as 5% to about 75-80%. With increasing amounts of fiber, there will be an increase in the stiffness as well as the yield strength of the material. Studies designed to examine the mechanical properties, viscoelastic losses, water sorption, hydrolytic stability, sliding mechanics and post processing formability of composite wires has shown strong support for their clinical viability.

Fabrication of Fiber Reinforced Composites (FRC)[3,6]

Two important processes associated with fabrication of FRCs

1. Pultrusion.
2. Beta staging

Pultrusion[7]

1. The process of manufacturing components of continuous lengths & a constant cross-sectional shape. E.g. Arch wires Bundles of continuous fibers are impregnated with a polymeric resin pulled through a sizing die.

2. Then passed through a curing die that imparts a precise shape (Electromagnetic radiation) 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 (fig 2 {1}). The wetted surfaces are then reconstituted into a profile of specific dimensions via a die from which they then exit into a curing chamber.
3. If further shaping of size of the profile of the wire the composite is only partially cured, and this is further processed using a second die and staged into the final form. (Fig 2 {2})
4. Composites with matrix solubility's above 10 wt % could be swaged after photopultrusion to change the cross section from circular to rectangular before thermal processing. (fig 2 {4})
5. Then relative proportions of the fibers and matrix materials are adjusted approximately and cured by electromagnetic radiation. (fig 2 {5})
6. As photons of light (ultraviolet) polymerize the structure quickly into a composite the morphological features of the vertical processes are revealed. If these are the final dimensions of the desired profile, the cure is completed, and the material is taken up on a large spool. (fig 2 {6})
7. In the photo pultrusion process these last 2 stages represent the difference between fabricating circular V/S rectangular profiles, respectively or straight V/S preformed profiles respectively. This system was used to form silicate glass fiber reinforced composites with varying degrees of conversion, by photo pultruding over a range of pulling speeds.
8. If further shaping of size of the profile of the wire the composite is only partially cured, and this is further processed using a second die and staged into the final form.
9. Composites with matrix solubility's above 10 wt % could be swaged after photopultrusion to change the cross section from circular to rectangular before thermal processing.
10. Then relative proportions of the fibers and matrix materials are adjusted approximately and cured by electromagnetic radiation.

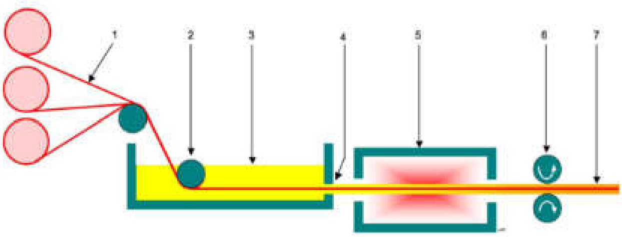


Figure 2 Pultrusion process

Beta Staging

- ✓ During pultrusion an intervening process in which partially cured resin and its bundles of continuous fibers are deformed into another form (e.g. preformed archwire) after which curing is completed.
- ✓ Preformed arch wires and rectangular cross section is possible by this process.

Customization of properties of composite: The properties of the composite wire can be customized through the use of various fabricating techniques, which include the orientation of the fibers within the composite material, percentage of fiber used, the reinforcing fibers may take the form of short fibers or continuous filaments, short fibers are generally 1/8 inch or less in length. Incorporation of short fibers results in a low stiffness wire having modulus of elasticity as low as 0.5 x 10^{6}. Preferably, a predominant number of the fibers are aligned along the longitudinal dimensions of the wire, where continuous fibers are employed; they are usually disposed in a parallel array relative to each other and aligned along the long axis of the wire. These wires can be formulated to exhibit a modulus in the range of 1.5-30 x 10^{-6} and greater.

Properties of composite wire:Can be round or rectangular.

1. Wide range of action
2. Light continuous force
3. Sharp bend must be avoided
4. Highly resilient - Effective in the alignment of crowded teeth.

***Ratio of Fiber to Polymer Matrix**:* When the fiber and resin contents are equal, spring back is greater than 95%, so that the energy applied at wire insertion may be retrieved months later without significant loss. At this same fiber-resin content the total water sorption is only 1.5% by weight, so that dimensional stability is good, and stains and odors are minimized. Stiffness ranging from that of nickel titanium to that of beta titanium. It was reported to be only 1/4th the weight of a stainless-steel wire of the same dimensions, and just as strong. Reformation of cross-sectional dimension from rectangular to round and from straight to preformed arches is possible as well

Advantages of Fiber Reinforced Composite

1. Low weight.
2. Excellent formability.
3. Excellent esthetics because of their translucency.
4. Ability to form wires of different stiffness values for the same cross-section.
5. Ability to directly bond attachments to these wires, eliminating the need for soldering and electrical resistance welding.
6. Incorporation of lubricant materials such as Teflon during manufacture, may also allow control over the frictional characteristics of the wire.
7. Allergic reactions to nickel, which are a concern for many metallic alloys, are averted with composite materials.

Disadvantages

1. Shape cannot be changed.
2. Use of topical fluoride agent with translucent composite wire could decreases the mechanical properties and might damage the surface of the wire.
3. Environmental conditions are more likely to affect fiber-reinforced composite archwires compared to alloy wires.
4. For fiber-reinforced composite, water may diffuse into the resin matrix and act as a plasticizer and make the movement of polymer chains easier under stress.

Splint-It

Burstone and Kuhlberg[8] have described the clinical application of a new fiber reinforced composite called "Splint-It" which incorporates S2 glass fibers in a bis GMA matrix. This is available in various configurations such as rope, woven strip and unidirectional strip. These materials are only partly polymerized during manufacture (pre-pregs), which makes them flexible, adaptable and easily contourable over the teeth. Later they are completely polymerized and can be bonded directly to teeth. Modulus of elasticity in flexure of splint-It is 70 percent greater than that of a highly filled dental composite. Yield strength is six times greater than that of a highly filled dental composite. It has 24 times greater resilience than that of a dental composite

Ceramic Wires

Optiflex Wires[9,10,11]

A composite ceramic fiber-plastic-nylon (ORMCO) designed by**M.F. Talass** in 1992.

Layers in optiflex wires (figure 3)

a. Silicon Dioxide Core: Provides force for moving teeth.
b. Silicon Resin Middle Layer: Protects core from moisture and adds strength.
c. Nylon Outer Layer: Stain resistant and prevents damage to wire and further increases strength.

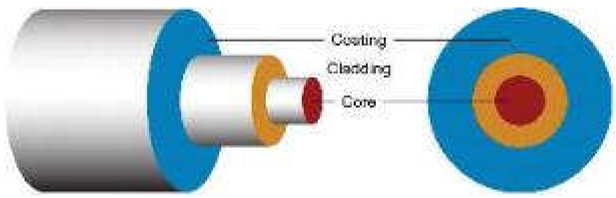


Figure 3 Layers of Optiflex wire10

Properties

1. The most esthetic orthodontic arch wire to date.
2. Ability to apply light continuous forces.
3. Very flexible.
4. Wide range of action.
5. Completely stain resistant.
6. Precautions to be taken with Optiflex.
7. Use elastomeric ligatures.
8. No Sharp bends.
9. Avoid using instruments with sharp edges, like the scalers etc., to force the wire into the bracket slot.
10. Use the mini distal end cutter.
11. No rough diet.
12. Do not "cinch Back - Optiflex should not be cinched back as a cinch back is actually not needed since friction between elastomeric ligature and the outer surface of the archwire will eliminate unwanted sliding of the archwire .Sharp bends must be avoided since they could fracture the core otherwise optiflex has practically no deformation.

Clinical applications

1. Adult patients.
2. Non extraction.
3. Can be used as initial archwire in cases with moderate amounts of crowding.
4. Optiflex can be used in presurgical stage in cases which require orthognathic intervention as a part of the treatment.

Availability: Optiflex is available in a pack of ten 6-inch straight length wires of 0.017" and 0.021" sizes.

Bioforce Wire[11]

1. Introduced by GAC. It was possible to produce variation in force delivery between archwires of identical dimension. This was possibleby specifying transition temperatures within given ranges.They were graded as arch wires.This property was further advanced to produce variable transition temperatures within the same archwire. This arch wire was called Bioforce archwire**.**
2. It is an aesthetic archwire. Is the first and only family of biologically correct archwires.
3. It applies low and gentle forces to anteriors. Increasingly stronger forces across the posteriors until plateauing at the molars.Beginning at approximately 100 grams, increasing to approximately 300 grams, it provides the right force to each tooth. The level of force applied is therefore graded throughout the arch length according to tooth size. (figure 4)
4. Bioforce(GAC) offers 80 gm of force for anteriors and up to 320 gm for molars.
5. Reducing the number of wire changes and providing greater patient comfort.

Figure 4 Bioforcearchwire

Clinical applications

During initial stages when anterior torque is needed, relatively large size (i.e. 0.018x0.025) can be given without the fear of significant root resorption.

During later stages of treatment i.e. if the posterior occlusion is not settled in or rotations have not been fully corrected or the bite opening is taking a long time because of the heavy musculature - these are good reasons to give a bioforcearchwire as the undesirable effects of the applied force-producing mechanisms will be minimized.

The application of a medium size BioForce, perhaps 0.018 X 0.018" or 0.016 X 0.022" at the very start of treatment of relatively mild cases, then leaving it in place for several months. In a few such cases, provided that the attachments were placed correctly, a complete resolution of the malocclusion, nearly to the point of not needing any additional arch wires or additional treatment was observed.

Silver plated wire[12]

Typical alloy plating that can provide aesthetic properties include silver alloy and gold. Rhodium, platinum, and palladium alloys can also be utilized. Out of these, silver alloys more closely match natural teeth color; this can be achieved by adjusting the alloy composition. Silver plated wire was created through an electroplating process. The film thickness was set to 0.5 mm and shared almost the same dimensions of non-coated stainless-steel wire.

In contrast, the dimensions of the underlying metal of Teflon-coated wire decrease as the resin coating thickness increases. Therefore, silver plated wire can be created based on a non-coated stainless-steel wire that retains its dimensions.

Properties of silver-plated wires:

Peel resistance:no significant peeling between the bracket slots of the silver-plated wire over 1 week. In silver plating treatment, the metal and the plating are chemically bonded together.

Discoloration: In general, chloridation by chlorine and sulfidation by sulphur result in silver discoloration, in particular silver is easily discolored when it comes into contact with a sulphur-containing gas. Discoloration observed is limited to the bracket slots. Since brushing does not reach into the bracket slots, plaque can persist. It is suggested that plaque remaining in bracket slots accelerate silver sulfidation over time. In the oral cavity, volatile sulphur compounds such as hydrogen sulphide, methyl mercaptan, and dimethyl sulphide can be present and can accelerate silver sulfidation. In the future, if an optimal plating technique is achieved, silver plating treatment can be applied to various dental treatment appliances.

Silver Rhodium Coated NiTi Round Archwires

Preformed Coated Orthodontic Wire Silver-Rhodium coating give the longest life and best performance in orthodontics.Ideal choice in combination with aesthetic ceramic brackets.This coating has a much longer life of 6 weeks therefore helps to increase time gap between patient recall. This coating also has less thickness as compared to teflon coated wire and has reduced friction.This coating is also more aesthetic.

Titanium Niobium wire[13,14,15]

A new 'finishing wire' made from a nickel-free titanium-niobium alloy (TiNb) was introduced by **Dr. Rohit Sachdeva** in1995 and manufactured by ORMCO[13] and Titanium Niobium/FA™, Sybron Dental Specialities Inc., Orange,CA, USA[14].

Properties

1. Ti-Nb is soft and easy to form, yet it has the same working range of stainless steel.
2. Its stiffness is 20% lower than TMA and 70% lower than stainless steel.
3. Ti-Nb wire have a larger plastic range, similar activation and deactivation curves and relatively low spring back.
4. Its bending stiffness corresponding to 48% lower than that of stainless steel and a spring back 14% lower than that of stainless steel.
5. We can easily make creative bends and avoid excessive force levels of a steel wire.
6. The stiffness of Ti-Nb in torsion is only 36% of steel, yet the spring back of Ti-Nb in torsional mode is Slightly higher than stainless steel
7. This property makes it possible to utilize the Ti-Nb wire for even the major third order corrections.

Clinical applications

1. The low spring back and high formability of the titanium niobium archwire allows creation of finishing bends.Hence, this wire can be used as a finishing archwire

Timolium archwire[15,16']

1. This is also called Alpha – beta titanium alloy, manufactured by TP Orthodonticsmanufactured by TP orthodontics. Timoliumarchwires combines the flexibility, continuous force, and spring back of nickel titanium with the high stiffness and bendability of stainless-steel wire.
2. Titanium is the major constituent of Timolium with aluminum and vanadium as stabilizing agents. The composition is titanium more than 85%, Aluminum 6.8% and Vanadium 4.2%. Aluminum stabilizes the alpha phase of titanium to room temperature, whereas vanadium stabilizes the beta phase.
3. This alloy contains both stabilizing elements and both alpha and beta phases of titanium alloy and thus display a rare combination of strength and surface smoothness.
4. Surface evaluation by scanning electron microscopy revealed a smooth surface with little surface irregularity for Timoliumarchwires considerably reducing the friction to a great extent. Though stainless steel with high values for strength, low friction, and smooth surface continues to be most commonly used archwire in orthodontic mechanotherapy, Timolium with its smooth surface, reduced friction, low modulus, and better strength could be also considered as a breakthrough in clinical orthodontic practice.

When compared to nickel titanium or beta titanium wire Timolium outperforms in the following

1. More resistant to breakage.
2. Smoother for reduced friction.
3. Brightly polished and aesthetically pleasing.
    - Nickel free for sensitive patients.
    - Easier to bend and shape.
    - Can be welded.
    - Loops and bends can be made without breakage.

Clinical application

1. Timolium wire is excellent for all phases of treatment.
2. During initial treatment: it is excellent for space closure, tooth alignment, levelling and bite opening.
3. During intermediate treatment: early torque control can beginbecause of the moderate forces that are delivered.
4. Final treatment phase: total control during detailing makes Timolium the wire of choice.

Multi Force Nitanium Archwires[17]

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.

SPEED tubular supercable[18]

SPEED Tubular Supercable is the next evolution of archwire design. Because SPEED Tubular Supercable is hollow! This breakthrough design permits Tubular Supercable to fold over on itself. It is a wire that is so flexible it can easily be engaged in the severest malalignment, while exerting just a fraction of the force levels of traditional initial archwires.(figure 5) SPEED Tubular Supercable is an ultra-light force wire delivering near optimal forces to the periodontium.(figure 6)

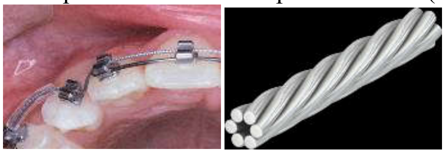


Figure 5 SPEED tubular wire

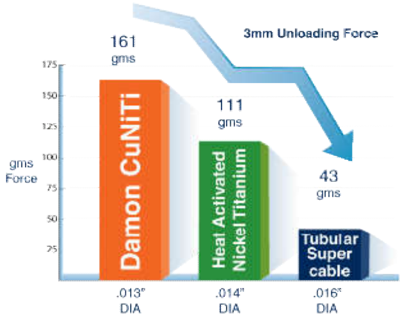


Figure 6 comparison of force levels

0.016" Tubular Supercable exerts on average

1. approximately 1/4 the force of .013 Damon Optimal Force CuNiTi
2. approximately 1/3 the force of .014 Heat Activated Nickel Titanium

HILLS Dual-Geometry arch wire[18]

The HILLS Dual-Geometry arch wire is the optimal wire for "Sliding mechanics" and "anterior retraction" while maintaining nearly perfect torque control.(figure 7)

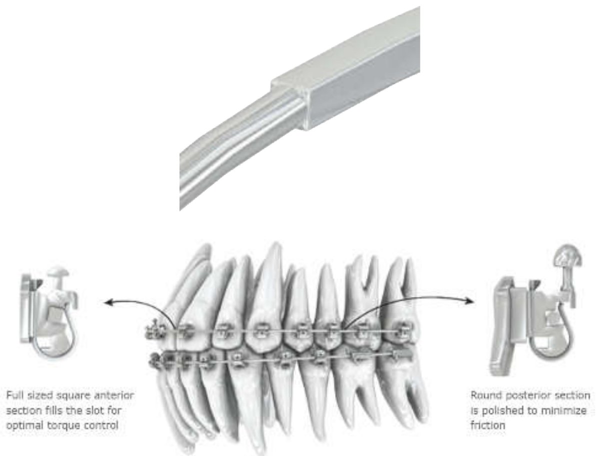


Figure 7 HILLS Dual-Geometry arch wire

Hills Dual-Geometry Wire for Posterior Translation

Intended specifically for posterior translation, this design features a slightly larger round posterior diameter. The larger posterior cross-section enhances rotational control and facilitates precise alignment of the roots during tooth translation.

Slot Size	Hills Posterior Translation - Dimensions	Arch	Arch Size
.022	.021 x .021 x .020 x 38mmAnterior Length	Upper	Large Medium Small
	.021 x .021 x .020 x 34mmAnterior Length		
	.021 x .021 x .020 x 28mmAnterior Length	Lower	
	.021 x .021 x .020 x 26mmAnterior Length		
.018	.018 x .018 x .018 x 38mmAnterior Length	Upper	Large Medium Small
	.018 x .018 x .018 x 34mmAnterior Length		
	.018 x .018 x .018 x 28mmAnterior Length	Lower	
	.018 x .018 x .018 x 26mmAnterior Length		

Hills Dual-Geometry Wire for Anterior Retraction

Intended specifically for anterior retraction, this design features a slightly undersized round posterior diameter. The reduced posterior cross section minimizes contact between the SPEED Spring Clip and the archwire, reducing friction, and ensuring optimal efficiency of tooth movement during space closure and retraction.

Slot Size	Hills Anterior Retraction- Dimensions	Arch	Arch Size
.022	.021 x .021 x .018 x 38 mm Anterior Length	Upper	Large Medium Small
	.021 x .021 x .018 x 34 mm Anterior Length		
	.021 x .021 x .018 x 28 mm Anterior Length	Lower	
	.021 x .021 x .018 x 26 mm Anterior Length		
.018	.018 x .018 x .017 x 38 mm Anterior Length	Upper	Large Medium Small
	.018 x .018 x .017 x 34 mm Anterior Length		
	.018 x .018 x .017 x 28 mm Anterior Length	Lower	
	.018 x .018 x .017 x 26 mm Anterior Length		

SPEED D-Wire[18]

A unique half-round, half-square wire is ideally suited for control while sliding. The unique D-Wire™ profile ideally cooperates with the SPEED Spring Clip to ensure a high degree of precision and control during sliding mechanics even when the wire is used as a sectional. (figure 8)

Figure 8 SPEED D-Wire

Dimension	Arch	Arch Size	Material
.018 x .018	Upper or Lower	Large Medium Small	Stainless Steel or Nickel Titanium
.021 x .021			

SPEED Wire[18]

It is uniquely shaped to enhance cooperation between bracket and archwire. It is ideally suited for full 3-Dimensional control while finishing. The arch form reflects the "In-Out" offsets of the SPEED appliance. (figure 9,10)

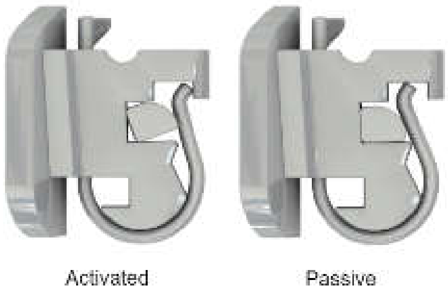


Figure 10 Any rotation of the bracket relative to the wire, away from the relationship shown on the left, results in labial deflection of the Spring Clip and thereby storage of appropriate energy for recovery. This relentless homing action enables precise tooth positioning in all planes of space.

Features and Benefits

1. Facilitates wire insertion and Spring Clip closure.
2. Saves time - almost no primary bending required.
3. Arch form reflects in-out offsets of the SPEED Appliance.
4. Eacharchwire has a midline mark.
5. Rounded edge is always directed toward the labial - gingival in either arch.

Dimension	Arch	Arch Size	Material
.017 x .022	Upper	Large	Stainless Steel
	or	Medium	or
.020 x .025	Lower	Small	Nickel Titanium

Turbo Wire[11,19]

Turbo wireis a nine-strand rectangular braided NiTi, with low stiffness and great flexibility. The braiding process actually increases the super elastic properties of NiTi. This combination yields an efficient means to achieve torque control, with an initial wire, in even the most severe malocclusion. 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[20]

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.

24 Karat Gold Plated Archwire[17]

The perfect archwire to compliment your patient’s 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 Stainless-Steel and nitanium pro-form archwire with midline marked black for upper and red for lowers.

Retranol[17,20]

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. Opening the bite now requires less than half the time that was needed with stainless-steel. 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 SpeeNiTi Archwire[17]

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[17]

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[17]

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.[21] 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[17]

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

Nitrogen Coated Archwires[17]

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

***Gold NiTi Wires*[17]**

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

***Drift Free Archwire*[17]**

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. Many times the mark or the spot to demarcate the midline wears off.

***Medical Grade Titanium*[17]**

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

***Triangular Wires*[17]**

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*[17]**

It has been introduced by **Binder and Scott**. In a nonextraction 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 stainless-steel ligature wire.

***Organic polymer wire (QCM)*[17]**

Organic polymer retainer wire made from 1.6 mm diameter round polyethylene terephthalate.[11] 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*[22]**

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 stainless-steel ligature, and stress-relaxation decay significantly greater than SS ligature.

***Esthetic Retainer Quick Change Method (QCM)*[17]**

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.[11] Plastic portion comes in three intercanine widths, with or without activating omega loops in the posterior arms.

***Azurloy (preformed and straight)*[19]**

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:

1. Multiple-loop systems
2. Utility arches
3. Overlay intrusion or Base Arches

***The dynforce archwire*[23]**

The dynforce archwire has a full-size anterior segment (e.g. .021x.025) and undersized posterior segments with rectangular cross-section (e.g. .018x.025 or .018x.022). It aims at minimizing binding in fixed orthodontic appliances.Posterior segments of the Dynforce are undersized, hence with lower coefficient of binding.Hooks 6,5 mm long work like power arms: the pointof application of the retracting force is close to thecenter of resistance of the dental arch, hence theangulation of the wire relative to the brackets andthe deflection of the wire are minimized during the retraction phase.Efficient sliding mechanics was performed thanks tolow wire-bracket binding and proper point of application. Particularly, theuse of low force nickel-titanium archwires (size .010 or.012) during the alignment phase, and the use of thedynforce archwire during the phase of closure ofspaces are advocatedof the retracting force.

***Hybrid orthodontic archwire*[24]**

This orthodontic archwires have an improved cross-sectional configuration. The archwires include four flat sides as well as four curved surfaces that interconnect the four flat sides. The curved surfaces facilitate insertion of the archwire in self-ligating brackets with clips as well as insertion in buccal tube appliances and brackets that are not self-ligating thus facilitating alignment, and easy insertion and removal of the archwires. In addition, the distance between two of the four flat sides is increased in comparison to conventional archwiresthat provide equivalent torque control in order to maintain good torque control over the associated appliance and the adjacent tooth. The hybrid orthodontic archwires of the present invention provide the advantages of both rectangular and roundarchwires, i.e. archwires having rectangular cross-sectional configurations and archwires having round cross sectional configurations. In particular, the orthodontic archwires provide less resistance to movement of the appliances along the archwires during treatment. This tends to reduce the overall treatment time needed to move the teeth to desired positions, resulting insaving of time and money.

***SmartArch Multi-Force SuperelasticArchwires*[25]**

Smart Archarchwires deliver physiologically optimizedized forces over an extended period. Withcarefully applied orthodontic mechanics, Smart Archwires can shorten the lag phase, reduce adjustmentand 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 steelarchwires.

Basic considerations

1. ***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.
2. ***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.
3. ***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.
4. 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 SmartArch wires reverts the patient into the lag phase, reducing efficiency and prolonging treatment.

Future of Orthodontic Archwires[26]

In recent years, nanoparticles have been used as a component of dry lubricants. Dry lubricants are solid-phase materials that are able to reduce friction between two surfaces sliding against each other without the need for a liquid media. Biocompatible nanoparticles have been coated on orthodontic Stainless-steel wires to reduce friction. Inorganic fullerene-like nanoparticles of tungsten disulfide (IF-WS2), which are potent dry lubricants, have been evaluated as self-lubricating coatings for orthodontic SS wires.

In a recent study, orthodontic Stainless-steel wire was coated with a nickel-phosphorous (Ni-P) film impregnated with IF-WS2. Coating was done by inserting Stainless-steel wires into solutions of Ni-P and IF-WS2. The coated wires were then analyzed by SEM (scanning electron microscope) and energy-dispersive X-ray spectrometer as well as by tribological tests using a ball-on-flat device. Friction tests simulating archwire functioning of coated and uncoated wires were carried out by an Instron machine. The adhesion properties of the coated wires after friction were analyzed using a Raman microscope. The frictional forces when measured on the coated wire were reduced by up to 54% when compared to uncoated stainless-steel wire. The friction coefficient was also significantly reduced from 0.25 to 0.08. These studies concluded that Stainless-steel wires coated with these nanoparticles might offer a novel opportunity to substantially reduce friction during orthodontic tooth movement. It has been reported in animal studies that these nanoparticles are biocompatible.

A tungsten disulfide nanocoating has also been evaluated for friction reduction of Ni-Ti substrates. Ni-Ti substrates were coated with cobalt and an IF-WS2 nanoparticle film by electrode position procedure and the friction test results showed an up to 66% reduction of the friction coefficient on the coated substrates when compared to uncoated substrates.

The results of such studies may have potential applications in reducing the friction when using orthodontic Ni-Ti wires.

One drawback to the incorporation of Ni in these types of coatings is the potential for allergic reactions in patients with nickel sensitivity. Therefore, the effect of such Ni-P coatings on stainless-steel and Ni-Ti wires should be evaluated for biocompatibility in animal models and further human trials.

CONCLUSION

The field of dental biomaterials is constantly evolving. Recent advances in orthodontic wire alloy 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 particular 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.

In conclusion, the future in orthodontic treatment will rely mainly on nanotechnology should all the current attempts succeed in its clinical application at a reasonable cost to the orthodontist and patients.Because much of this knowledge is still a distant reality on the technologic horizon, innovative materials will dominate orthodontic therapy for some years to come.

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