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REVIEW ARTICLE

Esthetic arch wires – A Review

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Abstract

Archwires are the active components of orthodontics appliances and demand for aesthetics led several companies to begin production of esthetic archwires. So the purpose of this article is to review properties availability and manufacturing of various available esthetic archwires.

INTRODUCTION

Orthodontic mechanics is based on the principle of elastic energy storage and its conversion into mechanical work through tooth movement. 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.[1]

Ideal features of esthetic wire[1]

- Mechanical properties
- Correct dimensions
- Biocompatible
- Pleasantly aesthetic
- Consistent with the translucency of aesthetic brackets and different hues of the teeth

Types of esthetic archwires

A. Coated wires

Teflon coated

Epoxy resin (polytetrafluoroethylyene (ETE) coated

Poly chloropxylylene

B. Composite arch wires

C. Optiflex arch wires

D. BioForce archwires

COATED ARCHWIRES [2]

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 [3]

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[4]

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.

Manufactures

Lee White Wire:

Manufacturers – Lee pharmaceuticals.
Epoxy Coated Archwire
Superior wear resistance and color stability of 6-8 weeks.
Preformed arches
Stainless steel & 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

Manufacturer – 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:

Manufacturer: 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"

Future of orthodontic wires[2]

Kusy 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. Kusy 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

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. Poly (Chloro-P-Xylyene) 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 poly ethylene fibers in a poly n-butyl methacrylate matrix

COMPOSITE WIRES[5]

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. There are numerous processes for the fabrication of continuous fiber-reinforced composite parts.

Fabrication of Fiber Reinforced Composites (FRC) [5, 6]

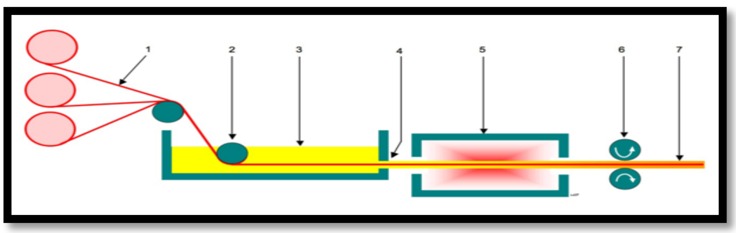
Two important processes associated with fabrication of FRCs:

- **Pultrusion.**
- **Beta staging**

PULTRUSION[6]

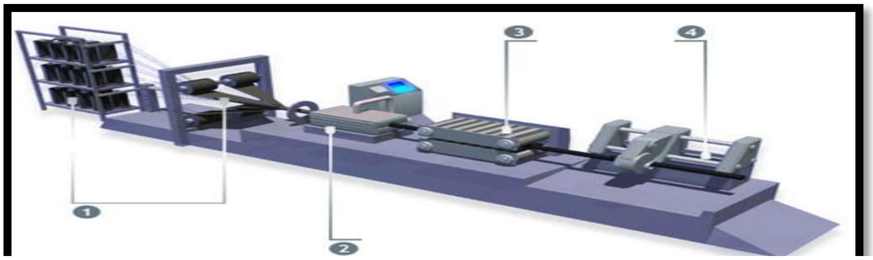
The process of manufacturing components of continuous lengths & a constant cross sectional shape. E.g. Arch wires

Bundles of continuous fibers are impregnated with a polymeric resin pulled through a sizing die. 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 A {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



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 A {2})

- 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 A {4})
- Then relative proportions of the fibers and matrix materials are adjusted approximately and cured by electromagnetic radiation. (fig A {5})
- As photons of light (ultra violet) 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 A {6})
- 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.



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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.

Properties of composite[5]

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 106. 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.

Ratio of Fiber to Polymer Matrix

- When the fiber and resin contents are equal, springback 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[5]

- Low weight.

- Excellent formability.

- Excellent esthetics because of their translucency.

- Ability to form wires of different stiffness values for the same cross-section.
- Ability to directly bond attachments to these wires, eliminating the need for soldering and electrical resistance welding.
- Incorporation of lubricant materials such as Teflon during manufacture, may also allow control over the frictional characteristics of the wire.
- Allergic reactions to nickel, which are a concern for many metallic alloys, are averted with composite materials

DISADVANTAGES[5]

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

COMPOSITE WIRES

The wire can be ROUND or RECTANGULAR

Properties of composite wire

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

An investigation of the frictional properties of composite wires against several orthodontic brackets showed that reinforcement fibers were abrasively worn from the wire surfaces when tests were conducted at normal forces or angulations. The potential release of glass fibers within the oral cavity was considered unacceptable, and a polymeric surface coating was suggested as a potential remedy.

Splint-It

- Burstone and Kuhlberg[7] 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[8]

A composite ceramic fiber-plastic-nylon (ORMCO) Dr. TALASS 1992

Layers in optiflex wires

A) Silicon Dioxide Core:

Provides force for moving teeth.

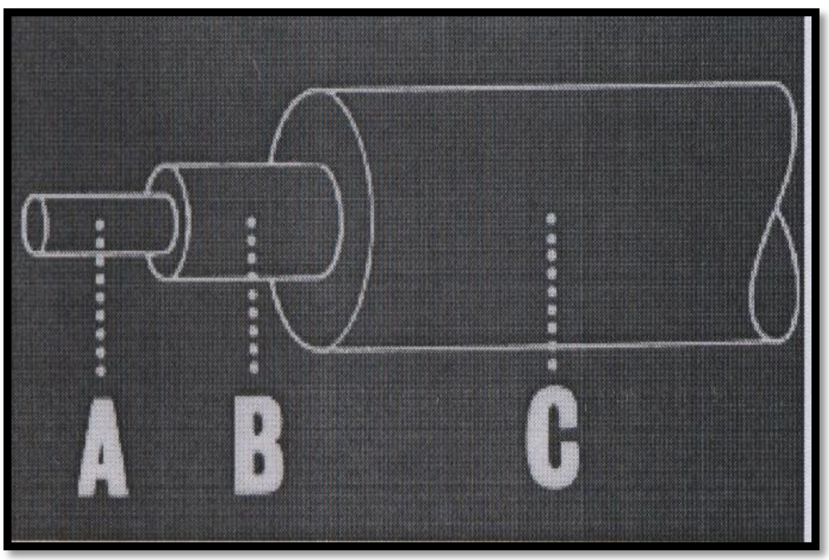
B) Silicon Resin Middle Layer:

Protects core from moisture and adds strength.

C) Nylon Outer Layer :

· Stain resistant

· Prevents damage to wire and further increases strength.



Properties:

- The most esthetic orthodontic arch wire to date.
- Ability to apply light continuous forces
- Very flexible
- Wide range of action
- Completely stain resistant

Precautions to be taken with Optiflex

- Use elastomeric ligatures.
- No Sharp bends
- Avoid using instruments with sharp edges, like the scalers etc., to force the wire into the bracket slot.
- Use the (no .501) mini distal end cutter
- No rough diet

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

Optiflex- 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 High Aesthetic Archwire (Dentsply GAC, Islandia, NY)

BioForce archwires' are one arch wires introduced by GAC. It is possible to produce variation in arch wire force delivery between archwires of identical dimension by specifying transition temperatures within given ranges. These are graded thermodynamic arch wires. BioForce is aesthetic and is part of the first and only family of biologically correct archwires. The NiTi BioForce wires apply low, gentle forces to the anteriors and increasingly stronger forces across the posteriors until plateauing at the molars. It is possible to produce variation in arch wire force delivery between archwires of identical dimension by specifying transition temperatures within given ranges. The manufacturers have taken this process are step further, by introducing variable transition temperatures within the same archwire. Force in BioForce archwires increases from approximately 100 grams and to approximately 300 grams. The level of force applied is therefore graded throughout the arch length according to tooth size. BioForce High Esthetic archwires are available in .018 x .018 and .020 x .020 in medium.

BioForce provides the right force to each tooth, reducing the number of wire changes and providing greater patient comfort.

Summary

At present, an area of potential interest is the use of true shape memory polymers for orthodontic wires. Fiber reinforced composites are regarded as the last great frontier of orthodontic materials. Due to their excellent esthetics and strength, as well as the ability to customize their properties to the needs of the orthodontist, they are expected to replace metals in orthodontics, just as composites have replaced aluminum in the aircraft industry. In current day practice, patients opt for esthetics. From the view point of esthetics, practitioners assert that esthetics is desirable but that function is paramount.

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