

*Review Article***A New Frontier by Aesthetic Orthodontic Archwires- Coalesce of Aesthetics and Function**

Ashok P, Kumar VV, Sachan A, Panda S, Singh K, Agarwal N

Abstract: Orthodontics has now-a-days turned a pioneered branch of dentistry that offers and also demands the aesthetic factor in the treatment phase along with the treatment outcome. The path the branch has led was to fulfil the above criteria and the technological advancement in this field has given a new push towards achieving the same. The archwires are the predominant part during the treatment, so the demand for them to be aesthetic without compromising their characteristics is a prerequisite for the orthodontic treatment. Much advancement in the field of ion implantation, surface coating and fiber reinforced composite give a way for the required visual acceptance of the archwires along with their fulfilment in many of the physical and mechanical characteristics that the treatment deserves. The aesthetic Nickel Titanium & Stainless Steel archwires fulfilled in many parameters like colour stability, force deflection, biocompatibility and frictional resistance along with the fiber reinforced composites with their stiffness, force decay and resilience. The aesthetic archwires had revolutionized the Clear Labial Orthodontic treatment and paved a new way for coalesce aesthetics and function, making the treatment an efficient and visually perceptive one and this review efforts to give in more information of the same.

Keywords: Aesthetic Archwires; Aesthetic NiTi; fiber reinforced composite.

INTRODUCTION

In Orthodontics there is a startling increase in the desire for treatment which has low impact on the aesthetic appearance of the person, more and more adult patients want to procure comely smile, with Invisible appliance.¹ Numerous opportunities are available with modern advances in the field of Orthodontics to procure the above goal, with the avail of Clear Labial Orthodontics. Aesthetic Orthodontics Arch wires are a component of Clear Labial Orthodontics in collaboration with aesthetic brackets, but unlike the latter, they are not being plenteously studied in literature. Hence this review grants a viewpoint about the properties both physical and mechanical of aesthetic orthodontic archwires.



Figure 1: Ideal characteristics for an orthodontic archwire.

The most used materials for metallic archwires are Stainless Steel alloys, Cobalt

Chromium alloy, Nickel Titanium alloy and Beta Titanium alloy.² Each of these varies in their properties which makes them to be used in different stages of orthodontic treatment. Clear Labial Orthodontics is fancied by patient nowadays, and there is a good bargain between the efficiency and efficacy of the appliance, unlike Clear Aligners the clear Labial Orthodontics can remedy any kind of malocclusion. Since for Clear Labial Orthodontics, Ceramic Brackets come into play and there was also an obligation for aesthetic archwires to get a full aesthetic effect.

Manufacturing Process For Aesthetic Archwires

The aesthetic archwires should be optically imperceptible yet still they have to perform same like the metallic ones. So archwires should be coated to achieve the above criteria. Recently the mechanisms like Ion Implantation and Surface Coating are used to refine the aesthetic archwires.

Ion Implantation: It is predicated on the expedition of ions with the guidance of electric field, to implant them off the surface of solid so that there is a vicissitude in physical and chemical properties of the solid. The wires endured different processes of Ion Implantation for aesthetic purport are

Bioforce and the Sentalloy (GAC International) and the TMA (Ormco).³

Surface Coating: The surface was coated with a polymer to camouflage the underlying metallic archwire and forging it into aesthetic.⁴ Polymer coated metallic wires (Rocky Mountain Teflon coated) stainless steel wires are utilized back in 1970s, but the coating incline to chip off during treatment causing denudation of underlying metallic archwire. NiTi and SS are coated with Polytetraflouroethylene (PTFE), Epoxy Resin, Parylene Polymer or infrequently Palladium covering to procure kindred colour of enamel.⁵ They gave excellent aesthetic, along with resistance to flaring and maximum efficiency. Two commonly used coating for aesthetic archwires are PTFE and Epoxyresin.

Teflon PTFE: It's made by DuPont Co with a brand name Teflon is a synthetic polymer consisting exhaustively of carbon and fluorine. PTFE has the lowest coefficient of friction making it ideal for sliding mechanics utilization. The PTFE coating was applied utilizing thermal spraying, which is a process in which subtly heated material is sprayed in a molten condition onto a surface to compose a coating.

Epoxy Resin: Epoxy is a synthetic resin made by aggregating epoxide with another compound they are widely utilized in Orthodontic materials including composite resins, molds, polyurethane aligners. Epoxy resin coating is applied to an Orthodontic archwire by Electrostatic coating, which is a process where electrostatically charged particle coated onto a wire. The epoxy coat jack up a consequential thickness to archwire (0.002inch), so 0.018inch NiTi become 0.20inch diameter with epoxy coating.

Composite Archwires: An optimal and aesthetic archwire can be developed utilizing composite technology from perpetual fibers and polymer matrix to suit varying degree of stiffness required for each stage of orthodontic treatment. Many advancements are made to engender non-metallic archwires which resemble metallic properties.⁶ The two types of transparent polymeric composite

archwires that have recently been developed are Self-reinforced and Fiber-reinforced.

1. **Self-reinforced** composite archwires, based on a Polyphenylene polymer, are fiber free and exhibit high spring back, ductility, yield strength and modulus of elasticity.
2. **Fiber reinforced** composite wires for orthodontic purposes are fabricated utilizing a procedure called Pultrusion.⁷ Fiber bundles are pulled through an extruder, in which they are wetted with a monomer resin. Next, the monomer is remedied with heat and pressure, resulting in polymerization. During remedying, the wetted fiber is composed into a desired cross sectional morphology, which may be circular or rectangular. This wire may be further shaped into a different morphology by further remedying, a process kenneed as Beta staging.⁸ For this, the monomer should initially only be partially remedied.

Fiber-reinforcement of composites has been utilized in an array of dental applications, such as: provisional bridges, retainers, space maintainers, orthodontic wires, endodontic posts and cores, fine-tuned partial dentures, periodontal and orthodontic splints, as well as trauma stabilization Integrating glass fibers to reinforce a polymer leads to incremented vigor and rigidity.

Flexible non-metallic arches are typically made from glass spindles embedded in a polymeric matrix. The first consummately non-metallic archwires was introduced is "Totally Aesthetic Labial Archwires" with the commercial name of Optiflex (Ormco/Sybron).⁹ This wire has 3 layers, outer layer has nylon which gives vigor and stain resistant, the middle layer is moisture resistant silicone resin and silica core. Though aesthetically very delectating, but its force levels are too light for clinical use.

Aesthetic NiTi Wires: The aesthetic NiTi wires need to express a wide range of mechanical properties along with the aesthetic affect so, below there are the properties expressed by the aesthetic NiTi and the parameters for conducting the tests.



Figure 2: Aesthetic NiTi archwire in ceramic brackets.

Aesthetic Stainless Steel & TMA wires:

The stainless steel and TMA archwires undergo the same procedures like Ion

Implantation, Surface Coating with Teflon, PTFE or Epoxy resin to achieve the aesthetic properties. Epoxy coated wire with a property of maximum aesthetics and wear resistance was developed by (3M). A thin layered epoxy coated wire with a shade of B2 to simulate the tooth color was developed by (Class One). Archwires that are coated on the labial surface to avert the dispensable increase in diameter without compromising the aesthetic property were developed by (DBOrtho). Aesthetic TMA by a process of Ion Beam Implantation developed by (Ormco) which exhibited a property of low friction which was a prerequisite for sliding mechanics.

Table1: Depicting properties and characteristics expressed by aesthetic NiTi wires

PROPERTIES		PARAMETER	CHARACTERISTICS EXPRESSED
1	Biocompatibility ¹⁰ Relies on susceptibility to corrosion in the oral cavity because of the dynamism of oral environment.	Human gingival fibroblasts (HGF) The principle cells in the oral tissue along with epithelial keratinocytes.	Rhodium/ Teflon coated NiTi showed lower cytotoxic effects and DNA damage than other uncoated NiTiarchwires and resin coated NiTi wires.
2	Force deflection ¹¹ The loading and unloading force exerted on the archwire.	Three point bending test	Performance of archwire depends on wire material and its cross-sectional geometry. Force deflection depends on the inner core thickness. The coated wires showed a similar force deflection to noncoated wires.
3	Surface coating ¹²	Nano indentation ¹³	Bioaesthetic wires coated with gold and rhodium showed minimum roughness when compared to pryalene coated and other non-coated NiTiarchwires.
4	Color stability ¹⁴	CIE L*a*b* color ¹⁵ space using chromogenic agent.	Coated NiTi showed better color stability than fiber reinforced composite archwires.
5	Friction resistance ¹⁶	Abrasion testing jig	There is no significant difference in friction resistance between coated and non-coated NiTiarchwire.

Fiber Reinforced Composite Wires:

Table 2: Depicting the properties and characteristics expressed by fibre reinforced composite archwire.

PROPERTIES	CHARACTERISTICS
1 Biocompatibility	Nickel free (Allergic cases)
2 Torsion & flexure ¹⁷	Anisotropic when compared with metal alloys which are isotropic, thus altering the orientation and enabling to control the orthodontic force in all three dimensions.
3 Stiffness	The presence of glass fibers gives excellent stiffness with low weight.
4 Friction ^{18 19}	Composite archwires have high kinetic coefficient of friction than Stainless Steel but less coefficient of friction than either NiTi or BetaTi.
5 Resilience ⁹	Bis GMA and TEGDMA composite reinforced with S2 glass has only 1% loss of initial stress and retained sufficient resilience to function during initial and intermediate stages of orthodontic treatment.
6 Force deflection ²⁰	Composite archwires are able to deliver a consistent force till 30 days considering the deflection rate of 1mm.

Aesthetic Ligature Ties: Last but not the least ligating aesthetic archwire into the aesthetic bracket is a must for felicitous expression of the treatment mechanics, so the ligating materials should not compromise the aesthetics that are achieved by the archwire and brackets do the materials that can be used are: 1. Clear modules, 2. Aesthetic ligature wires. Aesthetic ligature ties are engendered utilizing Teflon surface coating and they are developed in sundry diameters like 0.10, 0.12 & 0.14 and lengths like short, long and pre-cut.

Limitations of Aesthetic Archwires

Albeit the above archwires have consummated the goal of aesthetics some constraints are ineluctably foreordained in the areas like force levels, color stability and surface scratch resistance. The force levels of fiber reinforced composite wires are reduced when the deflection was more than

2mm, the color stability of fiber reinforced composite is compromised after a few days in the oral environment due to chromogenic absorption of the glass fibers of composite. The scratch resistance of the coating is reduced and the surface coating may peel off after 30 days incrementing the surface roughness and reducing the aesthetics.¹⁶

CONCLUSION: The aesthetic archwires are a revolutionary innovation to meet the consummate aesthetic purport of Clear Labial Orthodontics, though there are a few inhibitions in the areas of force levels and dimensions, with the technology and perpetual innovations all the above constraints shall be overcome making the aesthetic archwires to reach a predominant area in the Orthodontic treatment.

Author affiliations: 1. Dr. Pothuri Ashok, PG student, 2. Dr. Verma Vinay Kumar, MDS, Professor and Head, 3. Dr. Avesh Sachan, MDS, Reader, 4. Dr. Sujit Panda, MDS, Professor, 5. Dr. Karuna Singh, MDS, Reader, Dr. Neha Agarwal, MDS, Reader, Department of Orthodontics and Dentofacial Orthopedics, Rama Dental College-Hospital and Research Centre, Kanpur, Uttar Pradesh, India.

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Corresponding Author:

Pothuri Ashok
Postgraduate student
Department of Orthodontics and Dentofacial
Orthopedics
Rama Dental College-Hospital and Research
Centre
Kanpur, Uttar Pradesh, India
PHONE NUMBER: +918960320769
E-mail- pothuriashok10@gmail.com

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