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FROM TRADITIONAL TO TRANFORMATIVE ORTHODONTIC ARCHWIRES - THE EVOLUTION

Orthodontics

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ABSTRACT

Orthodontic wires are essential elements in the field of orthodontics, facilitating the controlled movement of teeth to achieve optimal alignment and bite. Recent advancements in archwire technology have markedly improved treatment outcomes, patient comfort, and efficiency. This paper reviews the evolution of orthodontic wires, highlighting significant innovations such as heat-activated nickel-titanium (NiTi) wires, advanced copper NiTi alloys, and hybrid archwires combining multiple materials to leverage their respective strengths

KEYWORDS

orthodontic Arch wires, SS wires, Esthetic archwire, NiTi archwire

INTRODUCTION

In the 21st century, contrary to earlier times, there is now a noticeable increase in the number of adult patients seeking orthodontic care. Higher-quality alloys that are more physiologically effective for teeth and supporting tissues are required by the evaluation of wire manufacturing processes and the development of novel orthodontic treatments. Dentists must make important choice regarding wire selection due to the large range of orthodontic wire alloys available. This article's goal is to review the literature that is currently available on these popular arch wires in order to gain information that will help with wire selection at particular treatment stages. The future of orthodontics depends on effective and esthetic treatments.

The criteria that determine the properties of an ideal arch wire are

A. High Formability
B. Low Stiffness
C. High Range
D. High Strength.

Weldability and solderability are also required properties. In addition to these the material should be cost effective. With the development of new alloy 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.

History

By the 1960s, gold as an arch wire had largely been replaced. It gave way to thinner, more resilient stainless steel wires such as Wilcox's Australian wire. However, in 1974, Unitek patented its nitinol (Nickel Titanium Naval Ordnance Laboratory) wire having the lowest modulus of elasticity and most extensive deactivation range of any equivalent cross sectional wire of the time. This allowed the application of light forces over a protracted range. By 1986, “superelastic” alloy wires that undergo stress induced change in their crystal form had been developed. These offered significant advantages over nitinol. The range of wires available to orthodontist has been futher extended by the addition of various other elements including cobalt-chromimum. Beta titanium and, in 1994 copper. Copper NiTi changes its crystal form at a specific temperature. Most recently, a nickel free wire, titanium-niobium has been introduced. With these new wires, especially the super elastic wires, it is no longer necessary to incorporate multiple loops, significantly enhancing aesthetics as well as comfort.

A number of manufacturers now offer NiTi and stainless steel arch wires coated with tooth colored material to enhance their aesthetics, especially when combined with ceramic brackets. Unfortunately, these coatings tend to wear away with time; however, further research should see this resolved. The search for improved aesthetics is leading us down the road of fiber reinforced composites. These materials are not yet clinically useful as arch wires; however, they have been incorporated into bis-GMA ribbons and bonded, as strips, to multiple teeth, to provide retention and also anchorage, reducing the number of conventional brackets required.

Types Of Orthodontic Archwires

Stainless Steel

Was introduced by Wilkinson in 1929. Stainless steel arch wire exhibit adequate strength, high resilience, formability, high stiffness, biocompatibility and economic feasibility. The drawback of these arch wires includes high modulus of elasticity; more frequent activations are required to maintain the same force level.

Nickel-titanium Alloys

This alloy was developed in 1971, and marketed as 'Nitinol'. The name nitinol is an acronym derived from the elements which comprises the alloy (Nickel, tititanium, nol-naval ordinance laboratory). It had excellent spring back properties. The drawback of these archwires is that they cannot be neither welded nor soldered, and cannot receive bends or loops or helices.

Basically of 2 types :

A. Thermal NITI
B. Elastic NITI.

Beta-titanium or TMA or CAN Wire

Goldberg and CJ Burrstone invented beta-titanium and it is also known by TMA or CAN wire. The main advantage of these arch wires include high range of action, high spring back, receive bends, loops and helices, and they can be welded or soldered. Also, the absence of nickel makes these wires useful in patients allergic to nickel. Ideal for situations where forces less than stainless steel and more than Ni-Ti alloy are required.

Cobalt-chrome-nickel Alloy

Cobalt- chrome-nickel alloy is also known as elgiloy. These wires exhibit excellent formability, joinability, spring back and biocompatibility. These wires have properties similar to those of stainless steel but can be supplied in the softer and more formable state and then could be hardened by heat treatment. This process increases the strength of the wire significantly. This alloy is manufactured in four

tempers, depending on the amounts of cold work: Blue-soft and easy to bend , Yellow-ductile Green-semi-resilient, Red-resilient.

Australian Stainless Steel Wire
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. Different grades of Australian wires formerly available were: regular, regular plus, special, special plus.

Multi Stranded Archwires
Dentaflex is available as triple strand, coaxial six strand and braided eight strand. D-Rect is an 8 stranded interwoven braided rectangular arch wire with 3dimensional control and slot filling capabilities.

Optiflex Archwires
Optiflex is a modification of the optical fiber and is developed by Taalas1 in 1992 and produced by Ormco cooperation. This is the first nonmetallic arch wire ever used in orthodontics. These wires have three layers which consists of silicon dioxide core which provides force for the movement of teeth. Silicon resin middle layer protects the core from moisture and adds strength and stain resistant nylon outer layer. When compared with other aesthetic coated wire where the coating gets scrapped of after few days and tends to discolour due to contamination in the oral cavity, the optiflex will be stable with no discoloration for several week.

BioForce Wires (Fig 1)
A BioForce wire is a superelastic shape memory nickel–titanium wire that provides gradually increasing forces from anterior to posterior segment, all within one archwire. The method of force delivery is by variation in archwire material composition or structure. Introducing variable transition temperature within the same archwire leads to the form of graded force delivery within the same aligning archwire producing light force (80 g) anteriorly and a heavier force of 300 g posteriorly (depending on the periodontal surface of the teeth).

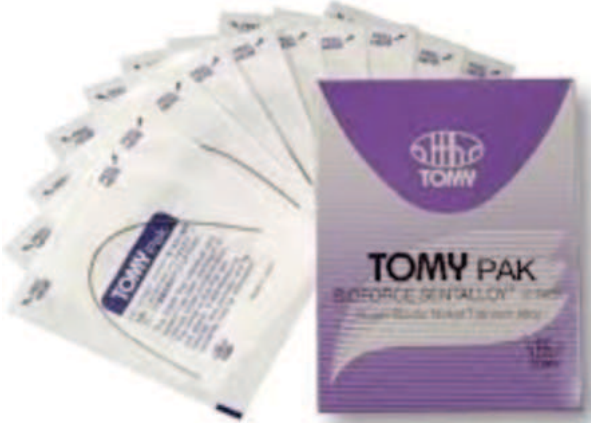

Figure 1 - Bioforce Wires

Recent Advances In Orthodontic Archwires .
Lee White Wires
These wires were made by Lee Pharmaceuticals. They have tooth-colored epoxy coating which is very well suitable for ceramic and plastic brackets which ultimately serves superior aesthetics. This is opaque and serves various other advantages, for example, it does not show discoloration and does not peel off. Moreover, it does not scratch as well .It shows excellent wear resistance, and the color stability of this material is proved to be excellent.

Marsenol
Basically a form of Nickel Titanium Archwire.Super elastic alloy that uses shape memory effect to produce the ideal orthodontic wire. First brought in by Glenroe technology. Marsenol has a coating of elastomeric polytetrafluoroethylene emulsion (ETE) wire which material is tooth-colored, hence providing superior aesthetics than conventional orthodontic wires. The working properties of Marsenol are similar to that of uncoated superelastic NiTi wires . The major advantages of this material are that it is fracture resistant and it remains active for a longer duration of time. Another property of this material is the flexibility of the wire.

Nanocoated Archwire
One of the most important benefits of coating the arch wires with nanoparticles would be the significant reduction in the frictional resistance at the bracket wire interface. Such a reduction in friction can help shorten overall treatment time, especially in patients undergoing extractions where tooth translation is achieved by sliding mechanics. The nanocoated arch wires are supplement to any ceramic bracket system which facilitates aesthetics due to its natural tooth color. This also maintains the friction, flexibility, and resiliency of arch wires.

SEP Orthodontic Wires
They serve as the best alternative to metallic orthodontic wires due to their excellent metallic properties. These wires are available in various types which are used as per the convenience of the clinician including polyether ether ketone, polyether sulfone, and polyvinylidene difluoride. These orthodontic wires provide a better quality of thermal and chemical stability as well as better mechanical strength.

Organic Polymer Retainer Wire (Fig 2)
Typically, these intraoral substitutions like ceramic brackets,coated wires and similar materials are used in patients who present with certain metal allergies .Because there are still limits to the effectiveness of such precautionary measures use of totally non-metallic appliance made of organic polymer were introduced . This is fabricated from round polyethylene terephthalate and has a diameter of 1.6mm. The wire has to be heated for few seconds to a temperature of 230 degrees approximately. If this is not done, the wire will return to its original shape.

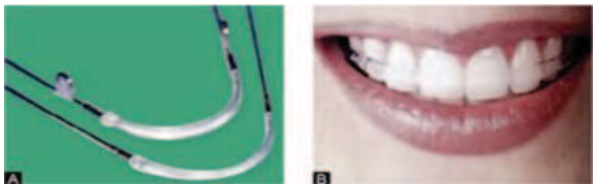

Figure 2 -organic Polymer Retainer Wire

Medical-grade Titanium Wires
Medical-grade titanium wires are made which are pure titanium alloy and are also considered to be ideal for most sensitive patients. It has two types of alloys, Ti6AL4V and Ti6AL4V which possesses excellent fracture resistance property which enhances its reliability.

Timolium Archwires
Titanium–vanadium alloy has a smooth surface com pared to TMA wires that greatly reduces friction with the bracket. The yield strength is higher than that of TMA wires, and it withstands bending without break ing and the wire has good formability. The stiffness of timolium is greater than that of TMA but lesser than that of stainless steel. The alloy is nickel-free and hence ideal for patients with nickel hypersensitivity.

SPEED Finishing Archwires
SPEED finishing archwires are a type of orthodontic wire that are designed to enhance bracket and archwire cooperation: The archwire's shape is designed to work with the bracket to provide 3D control during finishing. Allow for precise bends.The SPEED Beta Titanium Wire can hold precise bends for final detailing.

Smart Wires (Fig 3)
Smart wires can incorporate tiny sensors that monitor various parameters, such as the amount of force applied to teeth or the wire's position. This data can be transmitted to orthodontists in real-time, allowing for more precise adjustments and better tracking of treatment progress. By providing real-time data on tooth movement and wire performance, smart wires enable orthodontists to make informed decisions about adjustments. This can lead to more efficient treatment plans and potentially reduce the number of office visits needed.

Figure 3 - Smart Wires

3D Printed Titanium Archwires

These archwires are crafted using advanced 3D printing technology and titanium alloy materials. 3D printing allows for highly customized archwires tailored precisely to the individual patient's dental anatomy and treatment needs. This level of customization can improve fit and effectiveness. The titanium alloy used in these arch wires provides a combination of strength, flexibility, and durability. This material helps in applying optimal force for effective tooth movement and can reduce the need for frequent adjustments.

Hybrid Arch Wires

Hybrid archwires are an innovative development in orthodontics designed to combine the beneficial properties of different materials to optimize performance in various aspects of orthodontic treatment. Hybrid archwires typically combine different types of metals or alloys, such as nickel-titanium (NiTi), stainless steel, and titanium. For example, a hybrid wire might incorporate NiTi for its flexibility and shape memory with stainless steel for its strength. The goal is to harness the advantages of each material—flexibility, strength, durability, and controlled force delivery—to improve the overall performance of the wire.

CONCLUSION

Orthodontic arch wires are pivotal components in modern orthodontic treatment, serving as the primary medium through which tooth movement is achieved. Over the years, advancements in arch wire technology have significantly enhanced the efficiency, comfort, and outcomes of orthodontic care. From the development of heat-activated NiTi wires and copper-infused alloys to the innovation of 3D printed custom archwires and hybrid materials, each advancement represents a step forward in refining the orthodontic process.Recent innovations, such as smart wires with embedded sensors and the introduction of hybrid archwires combining the strengths of multiple materials, underscore the ongoing commitment to improving patient experiences and treatment results. These advancements not only provide orthodontists with more precise tools for controlling tooth movement but also contribute to more efficient treatment plans and enhanced patient comfort

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