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Review Article

Orthodontic wires: Recent advances

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ABSTRACT:
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-** In order to provide the required tooth movements as part of orthodontic therapy, orthodontic wires are parts of fixed appliances. Orthodontic wires are made from a range of materials, including metals, alloys, polymers, and composites. A number of laboratory experiments are conducted to assess the archwires' characteristics. To get the best outcomes, the doctor must understand the characteristics of orthodontic wires and their clinical consequences, as oral diseases may affect their behaviour. This article examines the various materials used to make orthodontic wires, their characteristics, and any potential clinical ramifications.

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INTRODUCTION

The interaction of orthodontic wires with brackets and molar tubes applies forces to the teeth during orthodontic therapy.A key component of the profession is the use of orthodontic wires, which produce the biomechanical forces that move teeth through brackets. The orthodontist should take into account a number of aspects when choosing wires for a given treatment, such as the desired force delivery, formability, elastic range or springback, and if soldering and welding are required to create the appliance. Nowadays, orthodontists mostly use wires made of four main base metal alloy types: nickel-titanium, cobalt-chromium-nickel, β-titanium and stainless steel. Because of the requirement to keep a sizable inventory, orthodontists also have to worry about the cost of wires, which can differ significantly between wire alloys and the companies that distribute them.[1]

HISTORY OF ORTHODONTIC ARCHWIRE

Edward Angle began using nickel-silver alloy orthodontic equipment in 1887. In those days, 14–18 carat gold was frequently utilised.

In 1931, George Paffenbarger and Noris Taylor proposed steel as an alternative to gold. The initial suggestion for the practical use of stainless steel in orthodontics was made in 1993 by Archie Brusse, the founder of Rocky Mountain Orthodontics.

The Elgin Watch Company created a cobalt-chromium alloy in 1940. Elgiloy, a cobalt-chromium alloy, was introduced into orthodontics treatment in 1960 by Orthodontics Rocky Mountain. The Cobalt Chromium Nickel orthodontic wire alloy was firstintroduced by Elgiloy Corporation in 1950.

Beta titanium is the most recent alloy to be used in orthodontics. Beta titanium saw its first therapeutic use in the 1980s, and it subsequently became widely accepted and well-liked.

In 1972, Unitek Corporation created the NiTi alloy for therapeutic usage under the brand name Nitinol. In 1985, it was claimed that a novel superelastic nickel-titanium alloy called "Chinese NiTi" was being utilised in labs and clinical settings. In 1986, "Japanese NiTi" was first used.[2]

CLASSIFICATION OF ARCHWIRES[2]

According to the Materials used arch wires can be classified as

1. Precious metal alloy
2. Stainless steel
3. Australian

4. Cobalt-Chromium alloys
5. Nickel Titanium alloy
6. Beta Titanium alloy
7. Composite
8. Esthetic

According to Cross- section:

1. Round
2. Rectangular
3. Square
4. Braided
5. Multi stranded
6. Co axial

NEWER ADVANCES IN ORTHODONTIC ARCHWIRES

SUPER CABLE[3]

1. The material qualities of superelastic wires and the mechanical benefits of multistranded cables were combined by Hanson in 1993 to create a superelastic coaxial wire made of nickel and titanium. (Fig1)
2. In order to minimise force delivery and maximise flexibility, it is made up of seven separate strands that are woven together in a long, gentle spiral.

Fig1

Properties

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

They are composed of seven distinct strands that are woven into a long, delicate spiral to increase flexibility and lessen power transfer. The benefits of archwires include enhanced reduction of anchor loss, simplified mechanotherapy, limited archwire flexing, flexibility, and ease of usage even in congested areas, as well as no damage to the supporting periodontal tissue. These include decreased patient numbers, less discomfort for patients following initial archwire implantation, and light continuous force to eliminate response. Because the arch takes longer to activate, there are fewer visits.[4]

It does, however, have certain disadvantages. The wire's propensity to break or collapse in the extraction space, as well as its incapacity to bend, step, or spiral, are further disadvantages.

TiMOLIUM WIRE

Alpha Beta Titanium Alloy is another name for this product, which is manufactured by TP Orthodontics. These archwires combine the flexibility, long-lasting strength, and durability of NiTi with the high stiffness and ductility of stainless steel wire.[5]

Titanium is the main component of titanium, whereas aluminium and vanadium act as stabilisers. 4.2% is vanadium, 6.8% is aluminium, and more than 85% is titanium. At room temperature, aluminium and vanadium stabilise the alpha and beta phases of titanium, respectively. This alloy exhibits a special blend of strength and surface smoothness because of the stabilising elements and titanium alloy alpha and beta phases it contains.[6]

COMBINED ARCHWIRES[4]

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[7]

Tooth-colored brackets have been made from ceramics and polycarbonates, and research is being done to create an archwire material that combines thenecessary mechanical qualities with aesthetics. The aesthetics of the appliance could no longer be disregarded because orthodontic treatments take several months to complete and more and more adult patients were receiving orthodontic treatment. Due to the desire for aesthetics, a number of businesses started producing non-metallic brackets from ceramics or polycarbonate in the late 1970s. In the middle of the 2000s, aesthetic wires were invented.

COATED ARCHWIRE[8]

Archwire coatings have been developed to improve aesthetics, reduce friction (a low coefficient of friction), and mix well with ceramic brackets and tooth colour. The coating is typically 0.002" thick. Teflon is the most commonly used coating.

EPOXY COATED WIRES[9]

Plastic resin materials, such as epoxy resin made primarily ofpolytetrafluoroethylyene to mimic tooth colour or synthetic fluorine-containing resin, are employed in coating. The basic wire is coated with an epoxy resin that is roughly 0.002" thick using a conventional technique to create the epoxy coating. In order to apply this coating to the archwire, the wire must first undergo some surface preparation. Next, the atomised polytetrafluoroethylyene particles are transported to the wire using clean compressed air. A chamber furnace is used to further heat treat the set.

TEFLON COATED STAINLESS STEEL ARCH WIRES[7]

Teflon coating gives the wire a colour that resembles that of real teeth. An atomic procedure applies the coating, creating a layer on the wire that is between 20 and 25 μm thick. After that, this layer is heated to create a surface with superior substrate adhesion and sliding qualities. It should be mentioned that the Teflon covering prevents corrosion on the wire underneath. However, with extended usage in the oral cavity, corrosion of the underlying wire is likely to occur since this coating is susceptible to defects that may arise during clinical use.

OPTIFLEX ARCHWIRE

Dr. Talass created the esthetic non-metallic orthodontic labial arch wire known as Optiflex (Fig. 13) in 1992, and Ormco produced it, made of transparent optical fiber, that is stain- and fade-resistant and has great mechanical qualities. It has three levels. (a) A core made of silicon dioxide provides the force needed to move the teeth. (b) An intermediary layer made of silicon resin shields the core from moisture and boosts strength. (c) A nylon outer layer that is resistant to strain, shields the wire from deterioration and increases strength. The effective tooth movement with less sustained effort and greater flexibility of Optiflex archwires make them advantageous for orthodontic treatment. It can thus be applied generally to various bracketing systems. However, avoid sharply bending the wire. Avoid using metal ligatures since they could shatter the glass core. Use the Mini Distal End Cutter, which can cut all three layers of his Optiflex, to cut the wire’s distal end. Adult patients who are concerned about their appearance utilize it. The initial alignment can be done using Optiflex wire. Compared to coaxial wires, less force is produced for the same amount of deflection. The costly Optiflex archwires must be changed every 4–6 weeks.

LEE WHITE WIRE[10]

Lee white wires manufactured by LEE pharmaceuticals are resistant stainless steel or Nickel titanium archwires with a tooth colored epoxy coating. The epoxy coating is opaque, does not show any discoloration and 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.

ORGANIC POLYMER RETAINER WIRE[11]

It is composed of 1.6 mm-diameter spherical polytheline terephthalate. A pair of pliers can be used to bend this wire. For a few seconds, it must be heated to a temperature lower than 230 degrees. If not, it reverts to its initial form.

Super engineering plastics are plastics that have exceptional mechanical strength and enhanced chemical and thermal stability.[12]

SEPs can be applied as alternatives to metallic orthodontic wires due to superior mechanical properties. Toxicity is also expected to be low due to superior thermal and chemical stability. SEPs can be of various types but the ones that have the feasibility to be used as orthodontic wires are:[13]

1. Polyether ether ketone (PEEK)
2. Polyether sulfone (PES)
3. Polyvinylidene difluoride (PVDF)

MARSENOL

A tooth-colored nickel titanium wire is called Marsenol. It is nickel titanium coated with elastomeric poly tetra fluroethyl emulsion (ETE). It functions in exactly the same way as an uncoated, extremely elastic nickel titanium wire. The coating stays flexible and sticks to the wire. Ceramic or plastic brackets look great with aesthetic coating. resists chipping and cracking and doesn't discolour or stain.

BIOFORCE WIRES

This is a new invention brought about by GAC and has the unusual ability to vary the transition temperature inside the same archwire. The low reflectance rhodium-plated white appearance provides high esthetics to the archwire.[14]These archwires allow a gradual transfer of force by applying a weaker force to the front teeth and a progressively stronger force to the back teeth until the molar plateau is reached. Force levels are therefore graded according to tooth size across the arc length. This wire, which goes from about 100–300 gm, applies the ideal amount of force to each tooth, lowering the number of wire changes and enhancing patient comfort. They are the first wires that are properly organic.

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.

ORTHODONTIC WIRES WITH DIAMOND-LIKE CARBON (DLC) COATING

DLC coatings have become popular in biomedical applications. The most noted property of DLC coatings is hardness. DLC coating done by Plasma based ion implantation and deposition (PBIID) gives hardness values of 6-20 GPa. [15]

The surfaces of stainless-steel and nickel-titanium orthodontic wires are coated by a DLC layer by PBIID method. The DLC coating decreases the frictional force and increases the hardness value. DLC coated wires that have lower modulus of elasticity might show higher flexibility. [16]

NANOCOATED ARCHWIRES

We can reduce the treatment time and increase the desired tooth movement by minimizing the friction between the orthodontic wire and brackets. In recent years, nanoparticles have been used as a component of dry lubricants. Dry lubricants are defined as solid phase substances that decrease the friction between two sliding surfaces against each other without the requirement for a liquid media. For orthodontic stainless steel wires inorganic fullerene-like nanoparticles of tungsten sulfide (IF-WS2) have been used as a dry lubricant coating. [17]

TRIANGULAR WIRES

In 2001, Broussard and Graham released triangular stainless-steel wires for orthodontic use (Fig. 2). These triangular wires have rounded edges and 0.030-inch cross-sections on one side, making them equilateral triangles. For bending, specialized pliers are needed. These wires can be utilized to create integrated lingual retainers, removal tools, and retainers. Round wires cause occlusal interference, so using a triangular wire that fits more easily between teeth than a round wire can solve the problem. The flat surface of the triangular wire reduces wobble and tooth wear compared to the round wire of the Hawley Labial Wire.[18]

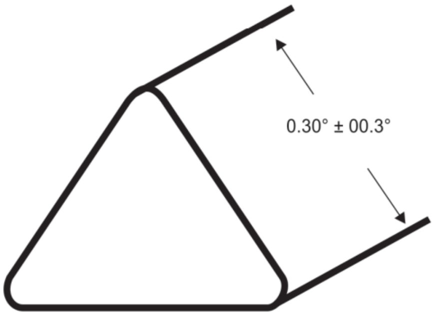

Fig 2

SPEED FINISHING ARCHWIRES [19]

The final archwire for “SPEED” has a sloping labial-gingival shape that makes it easy to depict how the superelastic spring clip interacts with the archwire and archwire slot. If the clip is misaligned with the wire, the spring clip will bend and store enough energy to recover. Precise 3D tooth implantation softly releases this energy. Additionally, the arched design of this quadrant makes it easier to enter wire and close spring clips. Wires are available in either 0.017 × 0.022" for 0.018 slots or 0.020 × 0.025" for 0.022 slots.

RETRANOL

The Retranol Bite Opener's reverse curved archwire is composed of NiTi that has been work-hardened. Compared to stainless steel wire, this wire has a greater operating range and gives the best form stability to keep the anterior teeth from tipping during retractions. There are less archwire modifications and adjustments needed for this wire. Retranol does not deform during the course of treatment. It comes in arc, round, and rectangular shapes.

DEAD-SOFT SECURITY ARCHWIRE

By Binder and Scott, the dead-soft archwire was first presented. After bonding, an archwire is typically put into start tooth movement for nonextractedteeth.[4]Using the proper archwire, however, may cause a tooth to shift before extraction when a tooth is being extracted.2 Use two twisted strands of dead soft 0.008" or 0.010" dead-soft SS ligature wire or a half archwire made of dead soft brass wire to get around this issue.

ORTHODONTIC ARCHWIRE BENDING ROBOT SYSTEM

A robot is a computer programmed machine that can automatically carry out complex actions. Robots either have an internal control system embedded in them or an external control. They are used for a wide range of roles in the medical environment for example some invasive surgeries. Similarly, robots are becoming popular in dentistry especially for archwire bending in orthodontics.[20]

CONCLUSION

Dental biomaterials is a field that is always changing. Recent developments in orthodontic wire alloy have produced a diverse range of wires with a broad range of characteristics.Currently, the orthodontist can choose the wire type that best suits a certain clinical scenario out of all those that are accessible. In turn, choosing the right wire size and alloy type would offer the advantage of optimal and consistent treatment outcomes. As a result, the clinician needs to understand these wires' mechanical characteristics and therapeutic uses.

In conclusion, if all of the present efforts to apply nanotechnology in clinical settings at a cost that is affordable for patients and orthodontists are successful, then the future of orthodontic treatment will mostly depend on this technology.

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