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Advances in Orthodontic Archwires: A Review

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ABSTRACT

The main tool for achieving desired tooth movement is an orthodontic archwire. Additionally, these wires are regarded as the foundation of orthodontic therapy. There are several materials available for orthodontic archwires. Both the mechanical qualities of the materials employed and the aesthetics of these wires have greatly improved over time, ultimately leading to patient happiness. The characteristics of orthodontic archwires and their drawbacks, which restrict their application in the modern period, are highlighted in this article. Choosing the best alloy for the patient's demands is the clinician's primary responsibility. Accurately examining each material's characteristics will enable this. This review also discusses the features of more recent materials, such as bactericide archwires and organic polymer wires, as well as the advent of robotic systems in bending archwires. Therefore, the current developments in orthodontic archwires and their characteristics for need-based selection are the main topics of this review paper.

Keywords:- Orthodontic forces, recent innovations, bactericidal archwires, robotic wire bending technology, and aesthetic wires.

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INTRODUCTION

Every other day, the field of orthodontics is changing. Advances have been made in diagnosis, treatment, and retention, among other areas. An essential component of an orthodontic device has always been orthodontic archwires. Archwires are a fixed appliance used to apply force to a tooth during orthodontic treatment. By exerting force and torque over the tooth surface, these wires unleash the energy they stored during insertion. According to some, applying less force yields better results than applying more force[1]. Smaller regions of hyalinization are also formed as a result of lighter orthodontic stresses. Early tooth movement results from the easy and quick resorption of these regions. Heavy power exertion causes a phenomena that slows down tooth movement for a predetermined amount of time by raising vascular blood pressure and decreasing periodontal cellular activity. For orthodontic treatment to be effective, a high-quality wire material that is better for teeth and other oral tissues is required. In the past, the first material utilized to create orthodontic archwires was gold. This material's sole disadvantage was its high cost, which prevented some patients from affording it. Subsequently, stainless steel gained popularity due to its superior mechanical qualities and affordability.[2] Its lack of aesthetic appeal was its sole drawback, which worries patients who are considering orthodontic treatment. Archwires were developed to improve patient satisfaction since metal braces have made older age groups more concerned with appearance. As a result, ceramic brackets and cables were introduced, improving their aesthetics[1]. Many clinicians continue to doubt these materials' qualities in comparison to stainless steel. In order to achieve the best treatment outcomes and patient compliance, this pushed for the introduction of innovative materials that mix mechanical and aesthetic qualities [2]. Therefore, it is imperative that physicians possess sufficient knowledge regarding the different material possibilities and the latest developments concerning these orthodontic wires[3].

PROPERTIES OF ARCHWIRES

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Strong formability, reduced stiffness, superior range, strong strength, weldability, solderability, and cost-effectiveness are all desirable qualities that archwires must possess in order to maximize their utility[1]. A single archwire material cannot meet all of these ideal characteristics; therefore, a variety of materials are available, along with some recent advancements, and the greatest results will be obtained from the specific wire for the intended use [2]. An essential component of orthodontic therapy has always been aesthetics. For instance, aesthetic archwires were required when aesthetic brackets were introduced. As new materials have become available, there has been a push to improve the appliances' clinical manipulation, building techniques, and design. Because of this, the clinician must always choose the wire carefully and manipulate it clinically. Optiflex (Ormco Corporation, Orange, California, United States), composite, and coated aesthetic archwires; Lee white wires (Lee Pharmaceuticals, Hyderabad/Secunderabad, Telangana, India); Marsenol (Glenroe Technologies, Tallevast, Florida, United States); organic polymer retainer wires; super engineering plastic (SEP) orthodontic wires; nanocoated archwires; orthodontic archwire bending robot system; Motoman UP6 (Yaskawa Motoman, Miamisburg, Ohio, United States); medical-grade titanium wires; SPEED finishing archwires (SPEED System Orthodontics, Cambridge, Ontario, Canada); and Henry Schein, Melville, New York, USA, nitanium tooth-toned archwires.New bactericide orthodontic archwires, TiMolium wires (TP Orthodontics, La Porte, Indiana, United States), Tri-Force wires (Young Specialties, Algonquin, Illinois, United States), Hills Dual-Geometry archwires (Strite Industries, Cambridge, Ontario, Canada), and BioForce wires (Orthomax Pty. Ltd, Burwood, Victoria, Australia). A brief discussion is given of the different characteristics of these advancements in archwires.

Aesthetic archwires

Nowadays, aesthetics plays a crucial role in dentistry. The goal of any orthodontic procedure is to produce the most aesthetically pleasing results possible. Additionally, the development of clear aligners and attractive brackets has led to an upgrade in archwire technology. These cables come in three varieties: coated, Optiflex, and composite[3].

ISSN: 0975-3583, 0976-2833 || VOL 15, ISSUE 11, 2024

Composite

Composites reinforced with fibers are the most often utilized. These offer a number of benefits, including increased yield strength, robustness, biocompatibility, reduced hypersensitivity, high modulus of elasticity, and simplicity of modification[4]. The archwire applies light continuous force and comes in a variety of diameters. Sharp bends are avoided to prevent fractures [5].

Optiflex

Talass first presented this in 1992 [6]. Clear optical fiber is used to make this wire. It is made up of three layers: a nylon coating, silicon resin cladding, and silicon dioxide core. Its broad range of action and ability to apply light forces are two of its advantages [6]. These wires are quite helpful for adult patients who are concerned about their appearance. Continuous light forces are applied. Additionally, these wires are quite effective in terms of flexibility and compatibility with orthodontic brackets. However, these cables are not cost-effective, which restricts their application.

Coated

It was created to lessen friction and improve aesthetics. Both traditional air-spray and electrostatic techniques are used. They can be tooth-toned archwires made of titanium, Teflon, or epoxy[6].

Masticatory forces and oral enzyme activity have an impact on these wires[7].

Lee white wires

Lee Pharmaceuticals was the manufacturer of these wires. These wires are constructed of nickel titanium (NiTi) and are resistant to stainless steel. Their epoxy finish is tooth-colored. In addition to being opaque, this has several other benefits, such as not peeling off or discoloring. Additionally, it is less effective at scratching[3]. This material has been shown to have outstanding color stability and wear resistance. In the end, this material provides better aesthetics and is very appropriate for ceramic and plastic mounts.

ISSN: 0975-3583, 0976-2833 || VOL 15, ISSUE 11, 2024

Marsenol

Glenroe Technologies designed this. Elastomeric polytetrafluoroethylene emulsion (ETE) wire is used to cover Marsenol. These NiTi wires are tooth-colored. Uncoated superelastic NiTi wires and Marsenol have comparable operating characteristics[8]. This material's primary benefits are its resistance to fracture and extended retention of its active properties. The wire's elasticity is another characteristic of this material. Because the material is tooth-colored, it is more aesthetically pleasing than traditional orthodontic wires.

Organic polymer retainer wire

This has a diameter of 1.6 mm and is made of round polyethylene terephthalate. An organic polymer retainer wire is bent using orthodontic pliers. The wire must be heated for a few seconds to reach a temperature of about 230 degrees. The wire will revert to its initial shape if this is not done[4]. Making maxillary retainers is the main use for this wire. This content is mostly intended for patients who are highly aesthetic-conscious and have had orthodontic treatment with ceramic and plastic brackets.

SEP orthodontic wires

Together with improved mechanical strength, these orthodontic wires also offer improved thermal and chemical stability[9]. Furthermore, because of their superior metallic qualities, they are the greatest substitute for metallic orthodontic wires. These cables come in a variety of forms, such as polyether ketone, polyether sulfone, and polyvinylidene difluoride, which are employed according to the clinician's convenience[10].

Nanocoated archwires

Nowadays, the most often utilized component in dry lubricant situations is nanoparticles. Without the use of liquid media, these dry lubricants reduce the friction between the two contacting surfaces.

In orthodontics, this idea is used to lessen the friction that exists between the wire and the tooth. When it comes to lowering the friction between two contacting surfaces, these

ISSN: 0975-3583, 0976-2833 || VOL 15, ISSUE 11, 2024

nanoparticles are thought of as dry lubricants[11]. Because of their natural tooth color, the nanocoated archwires enhance any ceramic bracket system and improve aesthetics. Additionally, this keeps archwires resilient, flexible, and friction-free.

Orthodontic archwire bending robot system

Using SOLIDWORKS software, this system is also known as the Cartesian-type archwire bending robot system (Dassault Systèmes SOLIDWORKS Corp., Waltham, Massachusetts, United States). The base, bending die, archwire bending system, and the wire's turning, feed, and supporting structure are the parts of this system[12]. To do the intricate wire bending, the robot's end needs to be flexible. Despite all of these benefits, this system has some drawbacks that restrict its application in orthodontics, such as the robots' accuracy and flexibility and the requirement for ongoing human supervision to enable precise operation in a complex cavity like the oral cavity [13].

Motoman UP6

It is a different kind of wire bending robot that is made up of a computer and an archwire bending actuator.

Robotics is a topic that is constantly evolving, with a greater emphasis on technologies related to human-computer interaction. This robot looks at a number of characteristics, including kinematics, archwire springback, and bending properties[14].

Medical-grade titanium wires

Numerous people have been shown to have allergies to nickel, copper, chromium, and other elements. Medical-grade titanium wires, which are constructed of pure titanium alloy and are thought to be the best option for the most sensitive patients, are therefore created to solve this issue. The two alloy kinds that are most frequently utilized in medicine are Ti6AL4V and Ti6AL4V extremely low interstitial (ELI). The wire is more reliable because of its exceptional fracture resistance. This wire has numerous applications outside of orthodontics,

ISSN: 0975-3583, 0976-2833 || VOL 15, ISSUE 11, 2024

including joint replacements, ligature clips, orthopedic cables, orthopedic pins and screws, and surgical staples[15].

SPEED finishing archwires

It is made up of interactions between wire slots, archwires, and superelastic spring clips. The deflection of the spring clip is caused by the bracket position's displacement from the archwire. With recuperation, this replenishes energy. Additionally, this energy is softly released by carefully aligning the teeth in three dimensions (3D)[16]. Its form is labiogingival and slopes. This facilitates the interaction between the spring clip and the wire slot. It is simple to use and recognize because the wire diameters vary according to the slot size. This is due to the fact that when the clip and wire are not aligned, the clip bends and accumulates energy that can only be released during 3D tooth implantation.

Nitanium tooth toned archwires

It is a kind of NiTi archwire as well. It has better plastic qualities and reduces friction. Additionally, the tooth-colored coatings on this blend in flawlessly with the real teeth. Additionally, it exhibits color coordination with composite, ceramic, and plastic orthodontic treatment brackets. This wire's primary drawback is that it is impacted by mouth cavity mastication and enzyme activity[17].

Hills Dual-Geometry archwire

The posterior portions are the main application for this wire. It is designed to be the best wire for sliding mechanisms.

The archwire's exceptionally high tensile strength and ideal stiffness are further benefits. For the 0.018 slot, the Hills wire measures 0.018 x 0.01 8 inches with a 0.018-inch round posterior, and for the 0.022 slot, it measures 0.021 x 0.021 inches with a 0.020-inch round posterior[17, 18]. Because they are composed of ultra-high-strength stainless steel, these wires have exceptional rigidity.

ISSN: 0975-3583, 0976-2833 || VOL 15, ISSUE 11, 2024

BioForce wires

One of the most recent innovations with the unique ability to change the transition temperature inside the same archwire is this one. This wire's exceptional aesthetic qualities come from its rhodium-plated white look. Applying less force to the anterior teeth and more force to the posterior teeth until the molar plateau is reached is the mechanism underlying how these archwires work. As a result, the force that should be used can be graded according to the size of the teeth. These BioForce wires are regarded as the first entirely organic wires[19,20.]

New bactericide orthodontic archwires

The inability to maintain oral hygiene is the biggest issue that individuals seeking orthodontic treatment face. This includes trash build-up and plaque growth around the brackets. This may result in gingivitis, which can develop into periodontitis if left untreated. In order to get around this, NiTi archwires are being improved to become bactericidal without changing their mechanical characteristics.

This demonstrates that the wire contains silver nanoparticles, which have been shown to cut the number of germs by over 90%. For patients who struggle to maintain good oral hygiene while receiving orthodontic treatment, this can therefore be regarded as a great substitute for traditional orthodontic archwires[21–23].

TiMolium wire

Alpha-beta titanium alloy is used to make it. This wire combines the qualities of titanium and stainless steel wires, namely titanium's flexibility, durability, and long-lasting strength with stainless steel's stiffness and ductility. It is made of a titanium, aluminum, and vanadium alloy. Vanadium and aluminum, respectively, stabilize titanium's alpha-beta phases at different temperatures.

Strength and surface smoothness are two qualities that this alloy excels at combining. TiMolium can be taken into consideration next because of its similar properties and the added benefits of its high strength and low modulus, even though stainless steel is most frequently used for orthodontic treatment because of its good qualities [17,24–26].

ISSN: 0975-3583, 0976-2833 || VOL 15, ISSUE 11, 2024

Tri-Force wires

These particular wire types are thought to apply a range of desired forces to a particular tooth location in the oral cavity, including firm pressure on the molars, moderate pressure on the premolars, and very light pressure on the incisors. Additional benefits of this kind of archwire include preventing the premolars from rotating and the molars from tilting unintentionally, as well as having a minimal effect on the anterior teeth that won't hurt patients. In addition, 3D control over these cables has been provided since the beginning of treatment[27–30].

Conclusions

Orthodontic archwires are widely used in orthodontic treatment because of their many advantages, which include superior mechanical and cosmetic qualities, strength, and longevity. Depending on the patient's needs and the clinician's preference, these various wires are used in different ways. Gold wires were employed in orthodontic therapy in the 1930s. Since then, as technology has advanced, a variety of materials with superior characteristics and biocompatibility have been introduced to make orthodontic treatment easier. All of these developments not only make it easier for clinicians and patients to relax and spend less time in their chairs, but they also improve aesthetic qualities, shorten treatment times, and increase treatment effectiveness. Since orthodontic wires make up a significant portion of orthodontic treatment, their characteristics have a significant impact on the outcome of the procedure. To achieve the best treatment results in terms of patient comfort and satisfaction, the orthodontist must possess a thorough understanding of biomaterials and orthodontic wires. In addition to ensuring that the patient is happy with the treatment, the orthodontist must ensure that the occlusion's functionality is preserved following the procedure. An essential component of all orthodontic treatments is occlusal harmony. Therefore, the clinician must be knowledgeable about all the materials and up to date on their latest developments, and these wires must be utilized sparingly.

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