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Review Article

Orthodontic wires: Recent advances

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ABSTRACT

Arch wires are the backbone of orthodontic treatment. They generate required forces and bring about tooth movement through the medium of brackets and molar tubes. There are a variety of archwires that come in various cross sections. Recently many advances have been made and newer orthodontic wires have been introduced. In this article we will discuss the recent advances in orthodontic wires.

1. Introduction

During orthodontic treatment, forces are applied to the teeth through the interaction of orthodontic wires with brackets and molar tubes. The criteria that determine the properties of an ideal archwire are (1) high formability, (2) low stiffness, (3) high range and (4) high strength. Weldability and solderability are also required properties. In addition to these the material should be cost effective. All these requirements are not achieved by any one orthodontic archwire material. Using specific archwires for specific purposes gives best results.[1]

2. History of Orthodontic Wires

Back in 1887, Edward Angle used orthodontic accessories made of nickel silver alloy. 14-18 carat gold was routinely used in those days.

Noris Taylor and George Paffenbarger introduced steel as a substitute for gold in 1931. In 1993, Archie Brusse, founder of Rocky Mountain Orthodontics suggested for the first time the clinical application of stainless steel in orthodontics.

In 1940, cobalt chromium alloy was developed by the Elgin Watch Company. Cobalt Chromium alloys found their way into orthodontics practice as Elgiloy in 1960 by Rocky Mountain Orthodontics. Elgiloy Corporation in 1950 introduced Cobalt Chromium Nickel orthodontic wire alloy.

The newest alloy to be introduced in orthodontics is Beta Titanium. 1980s marked the first clinical application of Beta Titanium after which it gained a wide clinical acceptance and popularity.

NiTi alloy was produced by Unitek Corporation in 1972 for clinical use under the trade name Nitinol. A new superelastic nickel-titanium alloy was reported to be used clinically and in laboratories in 1985 and it was known as “Chinese NiTi”. “Japanese NiTi” was introduced in 1986.[2] Orthodontic archwires can be classiffied on the basis of the material they are made up of and their crosssection.

3. 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

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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

4. Newer Advances in Orthodontic Archwires

The field of orthodontics is evolving day by day. Many newer technological advances have been seen in all areas including diagnosis, treatment, retention. Orthodontics archwires have also evolved. We will discuss some newer orthodontic archwire materials.

4.1. Esthetic arch wires

Esthetic orthodontics has gained popularity in recent years. There has been a growing demand that paved way for esthetically acceptable orthodontic appliances such as clear aligners and esthetic brackets. There is a huge rise of esthetic archwires and brackets in the market as compared to mid-1990s.[3] Esthetic archwires are of two types: they can be either coated or composite.

4.2. Coated archwire

NiTi or Stainless Steel wires are coated with Teflon/5META/Tooth colored epoxy resins.[4]Coating materials are synthetic resin or plastic resins such as epoxy resins.[3] Coating improves esthetics and reduces friction but there are a few disadvantages too. Coated wires are damaged from masticatory forces and enzyme activities in the oral cavity according to a study.[5]Another study states that the underlying metal of the esthetic archwire gets exposed due to splitting of the coating during usage.[6]

4.3. Composite archwires

Composite archwire also known as optiflex are made of clear optical fibre. It has three layers:

1. Outer layer of strain-resistant nylon that increases strength and prevents damage to the archwire.
2. A middle layer of silicon resin that adds strength, and protects the core from moisture
3. Core made of silicon dioxide that provides the force for moving teeth.

The wire is available in various sizes and cross sections. Moreover it has a wide range, high resilience and applies light continuous forces. In order to avoid fracture of the core, sharp bends should be avoided.[4]

4.4. Marsenol

It was manufactured by Glenroe technologies. It is E.T.E (Elastomeric poly tetra flor ethylene emulsion) coated tooth colored nickel titanium wire. Marsenol shows similar working characteristics to an uncoated super elastic nickel titanium wire.

4.5. Lee white wire

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.[3]

4.6. Organic polymer retainer wire

It is made of round polytheline terephthalate with a diameter of 1.6 mm. This wire can be bent with a plier. It needs to be heat treated at a temperature less than 230 degrees for a few seconds. Otherwise, it returns to its original shape.[4]

4.7. Super engineering plastic (sep) orthodontic wires

Super engineering plastics are plastic materials with improved thermal and chemical stability and high mechanical strength.[7,8] 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:[9]

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

4.8. 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.[10]

Redlich et al[11] conducted friction tests on stainless steel wire coated with inorganic fullerene like nanoparticles. These nanoparticles are impregnated in a electroless nickel-phosphorous film. The tests showed reduction in friction by up to 54%.

4.9. 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.[12,13]

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.[14]

4.10. 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.[15] Some robotic systems popular in orthodontics are described below:

4.11. Insignia

Insignia framework provides clinicians with a software that plans the final occlusion. Along with patient specific brackets and indirect transfer jigs, it offers custom archwires. The archwire is customised by a printing robot that has a very small error margin. The robot accurately uses the system to trace and bend the wire accordingly. (Figures 1 and 2)

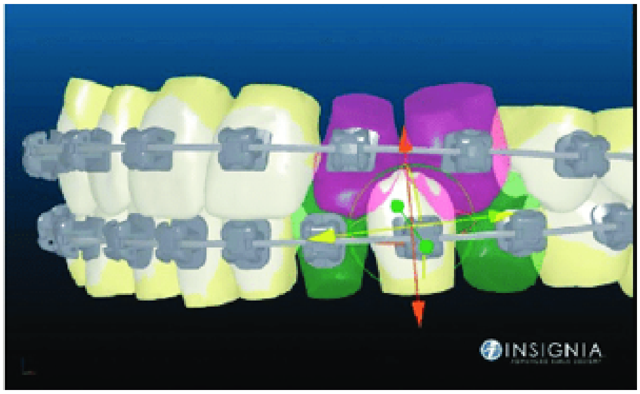

Fig. 1: Insignia system software

The treatment outcomes of insignia have been seen to be close to those characterised by ABO criteria. Furthermore, the treatment time was shorter in cases treated by insignia.[15]

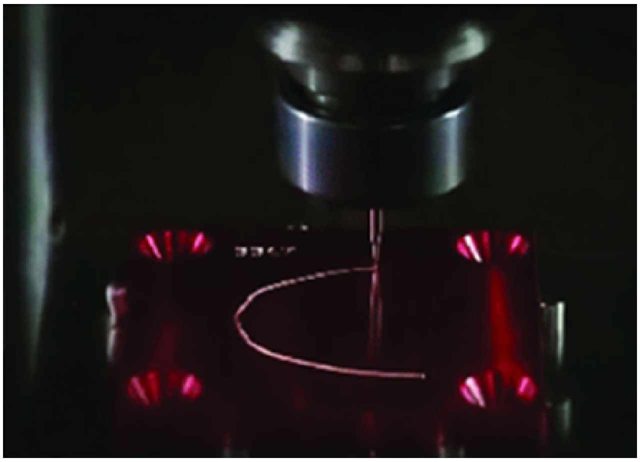

Fig. 2: Wire fabrication robot

4.12. Suresmile

In this system, intraoral digital images are recorded using a white light scanner or by cone beam computed tomography (CBCT). The teeth are adjusted into correct positions digitally. The 3D image information is further refined after it is sent to a computer. The dentist registers the final position of teeth and the amount of tension required for the wire and bracket into the computer. The data is then sent by internet to the SureSmile office. The robots come in at this stage. The orthodontic archwire is grasped by two automated pliers that warms and twists the archwire into the desired pattern.[16] (Figure 3)

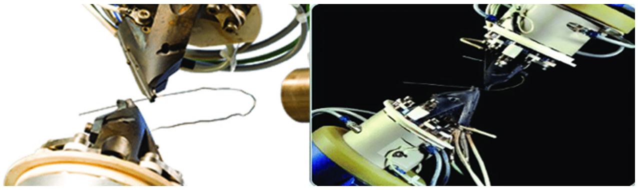

Fig. 3: Suresmile wire bending robot

4.13. Lambda system

LAMBDA stands for “Lingual archwire manufacturing and design aid” is a system for precise and fast bending of orthodontic archwires. This system understands movement only in X-Y plane, so a closed loop cannot be bent with the help of this system (Figure 4)

4.14. Cartesian type archwire bending robot

In this system, solid-works software is utilized to design the structure of orthodontic archwire bending robot and to examine the procedure of orthodontic archwire bending. The robot component comprises of base, the turning, feed, and supporting structure of the wire, bending die and

Fig. 6: Archwire bending robot based on Motoman UP6

Fig. 4: LAMDA system

archwire bending system.[15]

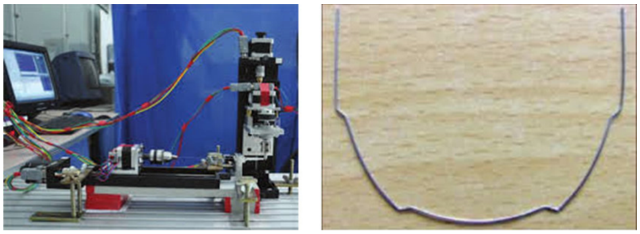

Fig. 5: Cartesian type archwire bending robot

4.15. Motoman UP6

MOTOMOL UP6 is another type of archwire bending robot made of archwire bending actuator and computer. The MOTOMAN robot end associated with it is utilized to bend the archwires. The different items examined by this robot are bending properties, the kinematics, point of enhancement of the curve wire, incorporate bending position.[17] (Figure 6)

Advancements in the field of robotics are growing day by day. The research in the future will focus on bending algorithm and archwire springback and human computer interaction technology.[15]

5. Conclusion

Recent advances in orthodontic archwires have led to the development of varied array of wires that exhibit a wide spectrum of properties. Presently an orthodontist can choose a wire that best meets the demand of a clinical situation among the wide range of wires available. Newer and newer archwires that have been introduced from time to time have revolutionised the field of orthodontics.

6. Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

7. Source of Funding

None.

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