

Contemporary orthodontic archwires: A literature review

Reyam M. Noori¹^{*}, Yassir A. Yassir^{2,3}^{id}, Grant T. McIntyre⁴^{id}

¹Postgraduate Student, Department of Orthodontics, College of Dentistry, University of Baghdad, 8988+3CW, Baghdad, Iraq.

²Assistant Professor of Orthodontics, Department of Orthodontics, College of Dentistry, University of Baghdad, 8988+3CW, Baghdad, Iraq.

³School of Dentistry, University of Dundee, Dundee DD1 4HN, UK.

⁴Honorary professor of Orthodontics, School of Dentistry, University of Dundee, Dundee DD1 4HN, UK.

*Corresponding Author: Reyam M. Noori

DOI: <https://doi.org/10.55145/ajbms.2024.03.01.002>

Received June 2023; Accepted August 2023; Available online September 2023

ABSTRACT: Archwires are the principal force generators used in orthodontic treatment. They are one of the fixed appliances' active components. They produce various tooth movements by interaction with brackets and buccal tubes. Recent advancements in orthodontics have resulted in a wide variety of archwire alloys with a broad spectrum of characteristics. The proper application of these wires can shorten treatment duration, improve patient comfort, and reduce chairside time. Furthermore, the need for esthetic orthodontic treatment alternatives resulted in the introduction of esthetic archwires. These innovative archwires attempt to combine both the esthetics and good clinical performance. Understanding recent archwires will aid in selecting the most appropriate wire for their intended usage throughout treatment.

Keywords: Newer archwires, esthetic archwires, orthodontics



1. INTRODUCTION

Precious metal alloys were commonly employed for orthodontic purposes before 1950 because nothing else would be able to withstand the intraoral environment. However, they were no longer used later for orthodontic appliances due to its softness and high cost. In 1887, Angle attempted to replace noble metals with German silver (brass). Gold was totally abandoned by the 1960s and replaced by stainless steel which could provide a smaller cross-sectional area [1, 2]. Then after years of research, Mr. Wilcock introduced Australian wires, a cold-drawn heat-treated archwire that combined resilience and hardness and it was available in different grades: regular, regular plus, special, and special plus [3].

Elgiloy, a cobalt-chromium alloy, was introduced into orthodontic practice in the 1960s, four tempers were available: soft, ductile, semi-resilient, and resilient. It can undergo welding and soldering as stainless steel orthodontic wires [4]. A more important feature is that its formability can be modified by heat treatment [1]. In the early 1970s, Dr. George Andreasen was the first who introduced nickel titanium (NiTi) wires in orthodontics, and in 1972, Unitek Corporation produced Nitinol, the trade name for NiTi alloy [4].

The primary goal of modern orthodontic treatment is to reduce treatment time by maximizing biological response [5]. The introduction of materials with acceptable esthetics for patients and good clinical performance for orthodontists has become necessary [6]. Recent advancements in orthodontics have resulted in a wide variety of archwire alloys with a broad spectrum of characteristics. The proper application of these wires can shorten treatment duration, improve patient comfort, and reduce chairside time. Despite this evolution in orthodontic materials and techniques, it is important to remember that no archwire is optimal or suitable for all stages of treatment [7], and since the archwire is the primary force system in orthodontics, understanding recent archwires will aid in selecting the most appropriate wire for their intended usage throughout treatment [8].

Some of the newer archwires that have been introduced in orthodontics include:

1) Copper-NiTi archwires

Copper NiTi is a quaternary alloy with 5-6% copper, 0.5-5% chromium, nickel and titanium. This newer wire has been introduced by Rohit Sachdeva [2, 7, 9, 10]. The addition of copper reduces energy loss that occurs during unloading and also controls the Austenite Finish (AF) temperature more accurately so that the wire can exhibit true shape memory [11]. The addition of copper also allows these wires to generate a more homogeneous force from one side of the wire to another, allowing for faster and more efficient tooth movement [12, 13, 14].

Copper NiTi offers several advantages over the previously available NiTi alloys which include: the generation of an almost constant force for a very small activation, more resistance to permanent deformation, excellent springback characteristics [2], and a reduced mechanical hysteresis with an unloading force more similar to the loading force and this makes the insertion of large sized rectangular archwires easier without unnecessary patient discomfort [10].

There are four types of Copper NiTi [10]:

- **Type 1:** (AF=15 °C) It has few clinical applications as it generates very high force.
- **Type 2:** (AF=27 °C) It gives high force, and is best fitted for patients with an average or high threshold of pain, patients having healthy periodontium, and those who require rapid tooth movement. The wire provides a constant force system.
- **Type 3:** (AF=35 °C) It gives a mid-range force, and is best fitted for patients with a low or normal threshold of pain, patients having normal or slightly compromised periodontium, and when mild forces are needed.
- **Type 4:** (AF=40 °C) These wires give forces when the temperature of the mouth rises above 40 °C, and are best fitted for pain-sensitive patients, patients with compromised periodontium, and poor patient compliance.

2) Supercable archwires

Superelastic coaxial NiTi wire was introduced by Hanson in 1993 by merging the mechanical benefits of multistranding with the material properties of superelastic archwires. This wire was called supercable, it is composed of seven separate strands that are braided to form a gentle long spiral with greater flexibility and less force delivery [2, 7, 9, 10, 15, 16, 17]. It is available in three different sizes: 0.016", 0.018", and 0.020" [18].

It was found that both 0.016" and 0.018" sizes of supercable wires give only 36% to 70% of the force of size 0.014" regular NiTi wires with an unloading force of less than 100 g over a deflection range of 1-3 mm. Supercable wire thus supplies the periodontium with an optimum orthodontic force [2, 10, 18]. The results of a study conducted by Berger and Waram (2007) [16] showed that at a 3 mm deflection, the unloading force of the multistranded coaxial NiTi archwire was much lower than that of any of the other wires, the 0.016" wire exerted the lowest force (55 g) in the entire study and only (105 g) of force exerted by the 0.020" wire. While the unloading force of the smallest copper nickel titanium archwire (0.013") was found to be around three times greater than that of the smallest multistranded coaxial nickel titanium archwire (0.016") (FIGURE 1).

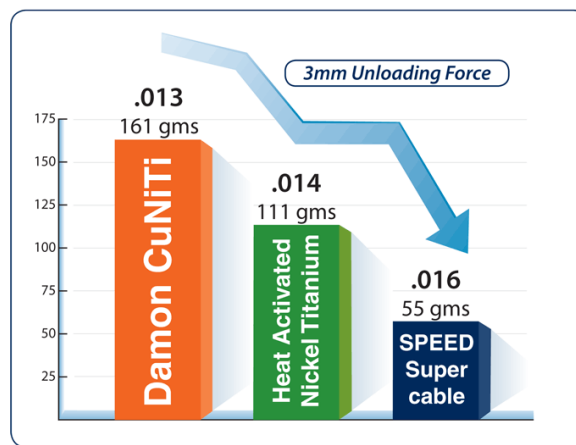


FIGURE 1. - Force levels of nickel-titanium initial archwires [16]

Advantages of supercable archwire include: simplified mechanotherapy with increased treatment efficiency, flexibility and elimination of wire bending, engagement of the wire into the bracket slot is easy regardless of the degree of crowding, minimal loss of anchorage, light continuous force which prevents any side effects on the surrounding periodontal tissue, less discomfort after insertion of the initial archwires, and longer activation periods with consequent reduction in patient visits [7, 9, 19].

But these wires are not without any disadvantages. Disadvantages of supercable archwires include: the tendency of the ends of the wire to unravel if not cut with a sharp cutter, in extraction spaces the wires tend to untangle and split, bends, helices, or steps cannot be made with this wire, and as teeth alignment begins, wire ends may migrate distally irritating the soft tissue [7, 9, 17].

Speed six-stranded coaxial tubular superelastic NiTi has been recently released and introduced. It surpasses single-stranded superelastic NiTi in several ways such as shorter treatment duration, greater springback, resistance to permanent deformation, and a low-force delivery [20]. The flexibility of the wire is increased by a "hollow center" design that allows the archwire to fold on itself so full engagement in the severe malalignment can be performed while applying less amount of force than the conventional initial archwires [21].

3) Titanium Niobium archwires (Ti-Nb)

Dr Rohit Sachdev was the first who introduce this wire in early 1995. Although Ti-Nb wire is flexible and formable, its working range is similar to stainless steel wires. Its stiffness is 20% less than TMA and 70% less than stainless steel. Ti-Nb archwires have a broader plastic range, comparable curves of activation and deactivation, and a low springback [1, 4]. Finishing bends are possible owing to the low springback and high formability of this wire. As a result, this wire can be utilized as a finishing archwire [9, 22].

4) Timolium archwires

These archwires are alpha-beta alloys made up of titanium, aluminum, and vanadium. This archwire has a smoother surface, less amount of friction, and more strength than conventional titanium-based alloys, with few surface defects and high yield strength. Timolium archwires are ideal for all stages of treatment such as the alignment stage, space closure, bite opening, and for torque control [10].

5) Bioforce wires

Force delivery of archwires can be controlled by changing the composition of archwire material or its structure. The incorporation of different transition temperatures within the same archwire can result in an archwire with a graded force delivery. Such graded thermally activated nickel titanium wire which provides a light force (80 g) in the anterior segments and a heavy force (300 g) in the posterior segments is known as "Bioforce" archwire [1, 7, 10, 23].

6) Dual flex (Combined) archwires

Combined wire is made of two materials; the anterior part is made of titalanal while the posterior portion is made of stainless steel. Titalanal is a nickel titanium alloy produced by Lancer Pacific company. It is divided into three categories [7, 9, 24]:

- A. **The dual flex-1:** anterior portion of this type is made of 0.016" round titalanal and the posterior part is made of 0.016" round stainless steel. Such a combination made the anterior segment flexible enough to allow engagement of wire in the crowded anterior while rotation movements are controlled by the rigid posterior segment. This type is best used for alignment when interbracket width is small as in lingual orthodontics.
- B. **The dual flex-2:** anterior portion of this type is made of a flexible rectangular 0.016" × 0.022" titalanal and the posterior portion is made of a rigid round 0.018" stainless steel. Movement of the anterior teeth is restricted by the engagement of rectangular nickel titanium wire anteriorly while the remaining extraction spaces are closed by movement of the posterior teeth mesially.
- C. **The dual flex-3:** The anterior portion of this type is made of a flexible rectangular 0.017" × 0.025" titalanal wire and the posterior portion is made up of 0.018" square stainless steel wire. Considerable anterior torque can be initiated by dual flex type 2 and type 3 wires; they also provide anchorage anteriorly while controlling molar rotation during posterior space closure.

7) Smart arch laser-engineered CuNiTi archwires

This archwire is designed with seven specific preprogrammed zones that exert an appropriate force for each individual maxillary and mandibular teeth. Smart arch applies physiologically optimum forces for a prolonged period. When such wire is used with careful orthodontic mechanics, it can reduce the lag phase, reduce the need for frequent adjustment and reactivation, and lead to avoidance of indeterminate mechanics, thus improving orthodontic efficiency [25].

8) Optiflex archwire

Optiflex is an esthetic non-metal archwire, constructed from clear optical fiber with specific mechanical properties, high esthetic, and it is completely resistant to stain. Dr. Talass designed this archwire in 1992, and Ormco company produced it [10, 26].

9) **Fiber-reinforced composite archwire**

These archwires are manufactured by a procedure known as pultrusion in which bundles of fibers are pulled through an extruder that contains monomer resin which acts to wet these fibers. Next, the curing of the monomer is done by heat and pressure. During curing, the desired cross-section is made from the wetted fiber, which could be round or rectangular [27]. Fiber-reinforced composite wires have advantages over conventional metal wires which include: improved esthetics, as these translucent wires transmit the color of the teeth. A more important advantage, however, is the capacity to change the stiffness of composite wires without affecting their cross-sectional profiles [28].

10) **Teflon-coated stainless steel archwires**

Coating archwires has been developed to maximize esthetics and minimize friction. Coated archwires are aesthetically more accepted by patients [29]. The coating is usually given plastic tooth color so that it blends with the color of the teeth and the color of ceramic brackets. The coating is usually 0.002" thick and "Teflon" is frequently used for coating archwires [10].

11) **Marsenol archwires**

A tooth-colored NiTi wires coated with an elastomeric poly tetra fluoroethyl emulsion that performs identically to an uncoated superelastic NiTi wires, manufactured by Glenroe technologies [3, 7, 9].

2. **CONCLUSION**

Archwires are the primary force system in orthodontics. By acquiring good knowledge about the recent orthodontic archwires, specialists can choose the most effective treatment approach for each patient. Despite the evolution in orthodontic materials and techniques, it is important to remember that no archwire is optimal or appropriate for all stages of treatment, however, they have been produced as an attempt to improve esthetic, increase patient comfort, reduce chair time, and shorten treatment duration.

Funding

None

ACKNOWLEDGEMENT

The authors would like to thank the anonymous reviewers for their efforts.

CONFLICTS OF INTEREST

The authors declare no conflict of interest

REFERENCES

- [1] R.P. Kusy, "A review of contemporary archwires: their properties and characteristics," *Angle Orthod.*, vol. 67, pp.197-207, 1997.
- [2] N. Malik, R. Dubey, A. Kallury, A. Chauksye, T. Shrivastav, B.R. Kapse, "A review of orthodontic archwires," *J. Orofac. Res.*, pp. 6-11, 2015.
- [3] A. Agwarwal, D. K. Agarwal, P. Bhattacharya, "Newer orthodontic wires: A Revolution in orthodontics," *Orthodontic Cyber J.*, pp. 1-17, 2011.
- [4] R. Harini and M. S. Kannan, "Orthodontic arch wires-a review," *Eur. J. Mol. Clin. Med.*, vol. 7, pp. 1804-10, 2020.
- [5] A. M. Al-Attar, S. Al-Shaham, M. Abid, "Perception of Iraqi Orthodontists and Patients Toward Accelerated Orthodontics," *Int. J. Dent.*, pp.1-7, 2021.
- [6] H. D. Abaas and A. F. Al-Huwaizi, "Load-deflection characteristics and force levels of coated nickel titanium orthodontic archwires," *J. Baghdad Coll. Dent.*, vol. 27, pp. 154-7, 2015.
- [7] S. K. Shetty, "Newer Archwires in Orthodontics," *Sch. J. Dent. Sci.*, vol. 7, pp. 217-9, 2021.
- [8] S. A. Nabbat and Y. A. Yassir, "A clinical comparison of the effectiveness of two types of orthodontic aligning archwire materials: a multicentre randomized clinical trial," *Eur. J. Orthod.*, vol. 42, pp. 626-34, 2020.
- [9] N. Philip, S. Sunny, L. A. George, P. Antony, "Newer orthodontic archwires: Imparting efficacy to esthetics," *Int. J. Oral Health Dent.*, vol. 2, pp. 102-5, 2016.

- [10] N. Modi, R. Gupta, M. Borah, "Newer orthodontic archwires-a review," *Int. J. Appl. Dent. Sci.*, vol. 6, pp. 90-4, 2020.
- [11] J. Gilbert, "Thermal properties of Copper Nickel-Titanium orthodontic archwires," Doctoral dissertation, Marquette University, Milwaukee, Wisconsin, 2016.
- [12] R. Sachdeva, "Sure-Smile: technology-driven solution for orthodontics," *Texas Dent. J.*, vol. 119, pp. 608-15, 2002.
- [13] M. A. Gravina, I. H. Brunharo, C. Canavaro, C. N. Elias, C. C. Quintão, "Mechanical properties of NiTi and CuNiTi shape-memory wires used in orthodontic treatment. Part 1: stress-strain tests," *Dental Press J. Orthod.*, vol. 18, pp. 35-42, 2013.
- [14] B. Aydın, N. E. Şenşık, Ö. Koşkan, "Evaluation of the alignment efficiency of nickel-titanium and copper-nickel-titanium archwires in patients undergoing orthodontic treatment over a 12-week period: A single-center, randomized controlled clinical trial," *Korean J. Orthod.*, vol. 48, pp. 153-162, 2018.
- [15] J. Berger, F. K. Byloff, T. Waram, "Supercable and the SPEED system," *J. Clin. Orthod.*, vol. 32, pp. 246-53, 1998.
- [16] J. Berger and T. Waram, "Force levels of nickel titanium initial archwires," *J. Clin. Orthod.*, vol. 41, pp.286-92, 2007.
- [17] J. L. Berger, "The SPEED system: an overview of the appliance and clinical performance," *Semin. Orthod.*, vol. 14, pp. 54-63, 2008.
- [18] B. Sebastian, "Alignment efficiency of superelastic coaxial nickel-titanium vs superelastic single-stranded nickel-titanium in relieving mandibular anterior crowding: a randomized controlled prospective study," *Angle Orthod.*, vol. 82, pp. 703-8, 2012.
- [19] C. C. Quintão, J. P. Cal-Neto, L. M. Menezes, C. N. Elias, "Force-deflection properties of initial orthodontic archwires," *World J. Orthod.*, vol. 10, pp. 29-32, 2009.
- [20] J. Joseph, V. S. Ninan, M. E. Abraham, J. John, K. K. Cherian, R. M. Thomas, "Arch Expansion Efficiency of Coaxial Tubular Superelastic Nickel-Titanium in Comparison to Single-Stranded Superelastic Nickel-Titanium While Relieving Mandibular Anterior Crowding: A Randomized Controlled Study," *J. Int. Soc. Prev. Community Dent.*, vol. 9, pp. 60-64, 2019.
- [21] B. Sebastian, M. E. Abraham, P. S. Sarma, K. K. Cherian, "Alignment efficiency of coaxial tubular superelastic nickel-titanium vs single-stranded superelastic nickel-titanium in relieving mandibular anterior crowding in extraction cases: A single-centre randomized controlled clinical trial," *Orthod. Craniofac. Res.*, vol. 22, pp. 105-111, 2019.
- [22] N. Dalstra, G. Denes, B. Melsen, "Titanium-niobium, a new finishing wire alloy," *Clin. Orthod. Res.*, vol. 3, pp. 6-14, 2000.
- [23] M. Iijima, T. Muguruma, W. Brantley, H. C. Choe, S. Nakagaki, S.B. Alapati, I. Mizoguchi, "Effect of coating on properties of esthetic orthodontic nickel-titanium wires," *Angle Orthod.*, vol. 82, pp. 319-25, 2012.
- [24] J. L. Cannon, "Dual-flexarchwires," *J. Clin. Orthod.*, vol. 18, pp. 648-9, 1984.
- [25] M. E. Olsen, "SmartArch multi-force superelastic archwires: a new paradigm in orthodontic treatment efficiency," *J. Clin. Orthod.*, vol. 54, pp.70-81, 2020.
- [26] M. F. Talass, "Optiflex archwire treatment of a skeletal class III open bite," *J. Clin. Orthod.*, vol. 26, pp. 245-52, 1992.
- [27] A. Valiathan, S. Dhar, "Fiber reinforced composite arch-wires in orthodontics: function meets esthetics," *Trends Biomater. Artif. Organs.*, vol. 20, pp. 16-9, 2006.
- [28] S. W. Zufall and R. P. Kusy, "Sliding mechanics of coated composite wires and the development of an engineering model for binding," *Angle Orthod.*, vol. 70, pp. 34-47, 2000.
- [29] I. I. Al-Sheakli and S. K. Mohsin, "An Evaluation of Corrosion Pits in Esthetic Coated Stainless Steel Orthodontic Archwires in Dry and Wet Environment at Different Intervals (An in Vitro Study)," *J. Baghdad Coll. Dent.*, vol. 28, pp.153-7, 2016.