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The MH-WIRE, a novel coil-spring wire system: A prototype design

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Abstract

OBJECTIVE: The authors introduced a novel wire system aiming to achieve optimal goals of tooth movement without multiple wire changes or sophisticated wire bending.

MATERIALS AND METHODS: The system was composed of a single wire for all phases of treatment. The archwire was composed of NiTi coil springs connecting delta-shaped segments of 0.018" × 0.025" Titanium Molybdenum Alloy (TMA) segments to fit the 0.018" × 0.025" bracket slot, or 0.022" × 0.028" TMA segments to fit the 0.022" × 0.028" bracket slot. The coil spring was closed and packed in design. The coil-spring loops were constructed with 3 mm lumen. The wires were designed in three sagittal forms and the system provided nine forms of archwires.

RESULTS: The wire systems have been an important component of treatment since the development of orthodontic science. Over time, the philosophy has evolved from endorsing wire bending to straight-wire treatment and then to custom-made archwires.

CONCLUSION: This wire system was designed to be used as a "single-wire for the case" across all stages of treatment to achieve the ideal goals without any biological damage.

Keywords:

Novel design, prototype, single-wire system, treatment stages, wire system

Introduction

The archwires were part of the fixed appliances systems since the evolution of the art and science of orthodontic treatment by Dr. Angle himself. The philosophy of treatment was swinging between focusing to improve the brackets systems or improving the wire systems.^[1]

The wires used in orthodontics were classified according to different methods. According to the material, the archwires were classified into Gold, Stainless Steel, Nickel Titanium, Titanium Molybdenum, Cobalt Chromium, Titanium Niobium, fiber reinforced composite, and polymeric archwires.^[2]

Moreover, the orthodontic wires could be classified according to cross-section into

rounded, half rounded, rectangular, and square cross-sections. Archwires sizes were graded using the diameter into 0.012", 0.013", 0.014", 0.016", 0.018", and 0.020" for the rounded cross section wires.^[3] But for the square and rectangular cross section wires, they were classified into 0.014'x0.014", 0.016'x0.016", 0.016'x0.022", 0.016'x0.025", 0.017'x0.025", 0.018'x0.025", 0.019'x0.025", and 0.021'x0.025".

From another prospective, discriminating the archwires according to the shape had vague varieties. We could group the archwires into upper and lower archwires. We could classify them into narrow, medium, and wide forms. Some archwires had normal inter-premolar widths but increased inter-molar widths. Others had increased inter-premolar and inter-molar widths. Moreover, some wires had catenary, Brader, parabola, trifocal ellipse or elliptic arch form. Some archwires had parallel sided but others had convergent sided arch forms.^[4]

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The desired properties of the ideal wire that every orthodontist dreamed of were ideal constant force, log range of action, shape memory, super-elasticity, weldability/joinability, formability, biocompatibility, low price, low friction, high esthetics, and high corrosion resistance.^[5,6]

The introduction and use of NiTi material achieved most of the previous properties, but unfortunately, not all. The originally introduced NiTi was named NiTiNOL of Naval Ordnance Laboratories. It lacked the super elasticity but it had good properties much better than St-St regarding the resilience and the elastic range. The stress strain curve of the material was linear and it opened the doors for better levelling and alignment of teeth without the need of loops or bends in the archwires. Still, the wire had to be tied lightly in the dentition without full engagement or else heavy forces will be produced and the biological damage could be more than St-St. Many cases of root resorption were recorded due to the rush of use in such NiTi wires.^[7]

The second generation of NiTi was the Chinese then the Japanese NiTi. Their inventors were able to produce the super elasticity phenomenon. That allowed for phase transformation to happen within the working environment which produced almost flat stress strain curve. Through that, wire could level and align teeth without excessive forces. Better protection of the biology and lesser pain and discomfort were produced. The light consistent forces were almost ideal for control over teeth positions. The Japanese NiTi was superior that force could be light, medium, or heavy and that it does not break as easy as the Chinese NiTi in clinical use.^[7,8]

The third generation of NiTi alloys was the thermal NiTi or what was known as heat-activated NiTi. Those wires were able to go through phase transformation by heating the wire to a certain level. The wires were manufactured into different transformation temperatures of 25°, 35° and 45° Centigrade. The higher the temperature range, the lower the delivered force was and the wider the range of action of the wire, but the lesser the movement of teeth. The incorporation of Cu into NiTi wires allowed for more control over the delicate manufacturing process and better force range and higher elastic properties together with stability.^[8,9]

In this paper, we select name (MH-WIRE) as it reflects the initials of authors names. The authors were able to design a novel archwire that combined the desired properties of the NiTi wires together with the ability of formability and low friction for space closure. Hence, the same archwire could be used for levelling/alignment, space-closure, and finishing phases of treatment.

Materials and Designing

Design

The system composed of single wire for all phases of treatment. The archwire was composed of NiTi coil springs connecting delta-shaped segments of 0.018" x 0.025" TMA segments to fit the 0.018" x 0.025" bracket slot, or 0.022" x 0.028" TMA segments to fit the 0.022" x 0.028" bracket slot. The coil spring was closed and packed in design. The coil spring loops were constructed with 3 mm lumen [Figure 1].

Metallurgy

The composition of the wire segments was made of Titanium Molybdenum Alloy to allow for any necessary wire bending. The coil-spring loops were designed with different thread thickness in different areas of the arch. They provided the safe range of force while stretched till their triple the original lengths. 80 g were applied to incisors and premolars, while 120 g were applied to canines. The upper molars received 240 g. and the lower molars receive 160 g.

The arch form in the sagittal plane

The wires were designed in three sagittal forms. The first form was the flat plain. The second form was the half circle (rocking chair) design. The curvature started from the last molar till the midline. The third form was designed to show flat design for the posterior teeth from premolars till molars, while the curvature started from canines till the midline [Figure 2].

The arch form in the horizontal plane

The system provided nine forms of archwires, the Yellow Set, the Blue Set, and the Red Set. Each of these sets was composed of three arch forms [Figure 3].

The difference between the sets was designed to show that each set had one millimeter wider on each side of the inter-canine width; that was a total of two millimeters increase in the inter-canine width. The Blue Set was two millimeters wider than the Yellow Set and the Red Set was two millimeters wider than the Blue Set in the inter-canine width.

The difference between the wires within a single set was that each wire is wider than the previous one in the inter-molar width by a total of four millimeters, two millimeters on each side. The Yellow Set was composed of wires "ONE", "TWO", and "THREE", while the Blue Set was represented by wires "FOUR", "FIVE" and "SIX". On the other hand, the Red Set was composed of wires "SEVEN", "EIGHT" and "NINE".

Hence, wires number "THREE" and "TWO" were wider than number "ONE" by total eight and four millimeters

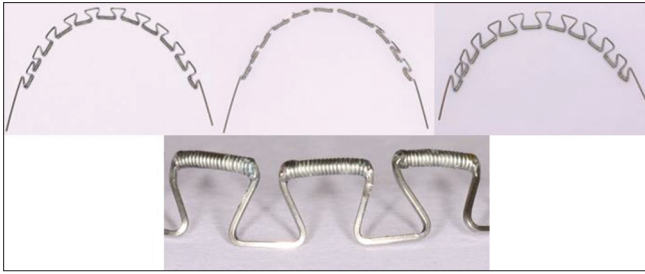


Figure 1: MH-WIRE novel design

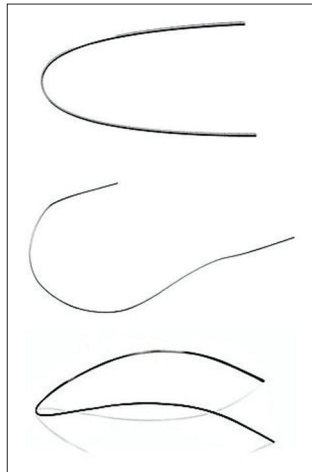


Figure 2: MH-WIRE form in the sagittal plane

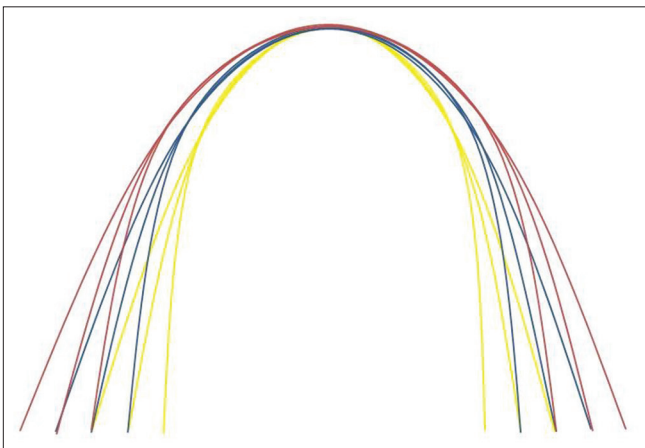


Figure 3: MH-WIRE form in the horizontal plane

respectively in the inter-molar width, but identical in the inter-canine width. Same could be mentioned comparing wires "SIX", "FIVE", and "FOUR". Likewise, the same concept applied to wires "NINE", "EIGHT", and "SEVEN".

Discussion

To plan a movement of an object you needed to define three items of importance, the amount of force, the point of force application, and the direction of movement. If one applied the same concept on a moving train, the

example would be simple and obvious. A train needed an engine to provide the force, that engine could be at the front or at the end as a point of force application. The metal tracks on the other hand provided the direction of movement and delineate the path.^[10,11]

The fixed appliances in the old days used the exact same concept. The use of brackets was to provide a point of force application. The elastics, magnets, loops, and coil springs provided the forces necessary to move teeth. Last but not least, the wire systems delineated the direction of force and the type of movement. That was the same era to use Gold and St-St archwires in treatment. The wire just had to be stiff and strong enough to provide safety and control for the teeth and arches while elastics and coil springs provided the forces needed.^[11]

Later on, after the invention of the NiTi and the TMA wires, the wires were used to apply forces to move teeth. That helped the clinician to make the mechanics and the treatment much simpler, but the ability of the wire to guard the movement and preserve the arch shape was greatly affected.^[12,13]

Trying to combine both concepts together, using the elastics and the coil springs over the soft archwires as NiTi or TMA, was like surfing the waves or walk on the rope over twenty-story buildings. While those techniques were excellent for some orthodontists to practice and decreased the treatment time, most of the other clinicians were not able to practice them safely then biological damage or orthodontic failure occurred. Root resorptions, recessions and pain were recorded in multiple studies.^[14] The roller coaster effect with bowing in the arches, developed deep bites anteriorly, and open bites in premolar areas.^[15,16] That happened due to higher forces applied than the ability of wires to withstand. Retroclination of incisors and reverse tipping of canines together with loss of anchorage were recorded with such mechanics.

Different systems and mechanics were suggested trying to solve the ancient riddle, how to combine the levelling phase with the working phase to help decreasing the treatment total time and simplifying the finishing phase. The use of single wing brackets such as Alexander bracket and the use of passive self-ligating brackets as Damon system were provided as a way to simplify the treatment steps and solve the problem.^[17]

On the other hand, different wire systems were produced trying to control the tooth movement. For example, the bi-graded NiTi wires to deliver different amounts of forces on different teeth in the arch were suggested. Moreover, the use of Sure-Smile technology allowed a

robot arm to bend a series of wires helping the clinician to drive teeth into positions that were previously determined by a digital computer setup.^[18,19]

For the MH-WIRE system, the authors tried to invent a wire system to solve the previously discussed issues. A wire system was robust in design that could do the job, without sophisticated machinery or expensive equipment or multiple wire changes.

The MH-WIRE was designed to be attached to the slots in any case and the wire would be able to align it. Even in severely crowded arches with extractions plan, the clinician just had to attach the wires after performing the extractions and “let them cook”. The coil spring segments were stretched, and that allowed for maximum flexibility and long range to engage every tooth without causing high pressure, tipping, or roller coaster effects.

The wire was designed to drive teeth together while controlling teeth-positions 3D through the use of full engagement 0.018”x0.025” wire segments or 0.022” x 0.028”. The teeth would move into predetermined positions without any heavy forces because the wire was designed to deliver just the optimum and safe working range for every tooth [Figure 4]. Even if the case was an extraction case, the clinician just had to attach the wire to all teeth but careful to use the second premolar segment into the first molar slot, and the first molar segment into the second molar slot. That way, the anterior segment

was driven toward the posterior segment to close any spaces [Figures 5 and 6].

The clinician had to choose the form of the archwire to use. If the case was a skeletal deep bite, the use of the rocking-chair design would help massively to improve the bite. The combination of incisors intrusion together with premolars extrusion would take immediate effect. On the other hand, if the case was a dental deep bite or dental open bite, the use of the flat-posterior/curved-anterior archwire is mandatory. No excessive forces would be of effect on the posterior teeth, while the anteriors suffer intrusion or extrusion to complete the levelling.

The transverse arch form was provided in nine different designs. The clinician had to go through selective steps to decide the proper form to use in his patient. First step, one should consider the pretreatment cast of the patient and compare it to the template of widths provided. Measuring the width of the smile from the corner-to-corner of mouth in maximum spontaneous smile is very important. For the best esthetics, the arch width should represent 75% of that width and both buccal corridors would be of 25%. If the smile width was very different from the original arch form on the cast, the clinician had the choice to favor esthetics or stability, or use an intermediate archwire width to combine both.



Figure 4: Mild crowding treated with single MH-WIRE



Figure 5: Moderate crowding with extraction of 2nd premolars treated with single MH-WIRE



Figure 6: Severe crowding extraction 1st premolars treated with single MH-WIRE

For the second step, the clinician was to decide if he needed to change the inter-canine width of the case. For example, while camouflaging class three skeletal cases; one should consider expanding the upper inter-canine width while contracting the lower inter-canine width to avoid any cross-bites. The reverse was true for skeletal class two cases.

Last step, the clinician had to choose whether to use wider, narrower, or similar archwire for the upper arch than the lower arch. In buccal cross bite cases, the patient would benefit of a one-step wider archwire in the upper arch and one step narrower archwire in the lower arch. While in lingual cross bites, the reverse phenomena applied.

Regarding the finishing phase, provided that the clinician had bonded the brackets in ideal positions and that wire shape selection was ideal, no further steps would be needed and the case would be in ideal finished occlusion. If the clinician discovered that a certain tooth had to be adjusted for bracket positioning, he had the choice of either debonding/rebonding the bracket in ideal position or making a bend in the TMA wire segments. The authors preferred the bracket adjustment technique, because it was simple and the wire could accommodate any changes required without any obvious reactive effects on the rest of the arch. But the TMA segments are always available for the clinician who preferred to bend the wires and will accommodate any desired needs

without the classical reactive side effects on the rest of the arch. That was because of the stress-breaking effect of the coil spring segments that prevented the reactive forces from affecting other teeth in the arch.^[20]

Among many considerations, an important point is that dental hygiene is the key factor for treatment success in periodontally compromised patients. The presence of plaque along with orthodontic movement may cause angular defects and significant bone loss but it should be noted that in patients with advanced periodontal disease and good hygiene, orthodontic treatment does not have significant effects on the periodontium or bone level in the long run. Therefore, before beginning orthodontic treatment it is important that the orthodontist identifies periodontal problems, determines the correct treatment plan and correctly establishes the sequence for orthodontic and periodontal treatment to improve the patient's periodontal health. Nowadays, periodontal patients are not doomed to not be treated orthodontically. Once periodontal disease is under control, certain orthodontic movements can enhance periodontal health while also improving function and esthetics.^[21] As the wire apply light continuous force within optimal level and well controlled teeth movement due to its engagement within bracket slot, periodontitis if controlled we can used.

In that way, the use of only single archwire for alignment/levelling and working/finishing allowed the clinician to reach the optimum goals of treatment with almost ideal forces to preserve the biology of the case and with the least effort and treatment time.

Limitation

1. The wire dose not used for lingual or tip edge orthodontic appliances.
2. Not used with bad oral hygiene patients.
3. No impact on oral hygiene but need more attention by the patient.

Conclusion

- The MH-WIRE system allowed for revolutionary control over tooth movement during treatment.
- The MH-WIRE was effective in alignment of the arches even in severely crowded cases without the need to change into sequential wires.
- The MH-WIRE was able to complete the levelling and flattened the occlusal plain while driving the teeth together to close any residual spaces.
- The occlusion would be finished in ideal positions by clever selection of the proper arch form and gave it time for expressing its built-in forces.
- The MH-WIRE system could be used with any labial bracket system but the clinician still had to bond the brackets in the proper positions.

- Simple, robust, and non-expensive way was produced in that system that allowed for better reach for the goals of treatment and ideal occlusion.

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Conflicts of interest

There are no conflicts of interest.

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