Variable modulus orthodontics advanced through an auxiliary archwire attachment

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The use of low load deflection rate orthodontic springs is generally preferable because they tend to produce a more constant force system with related, forecastable centers of rotation. Required reactivations are reduced while providing increased patient comfort. The likelihood of undermining resorption and related tissue damage is also reduced.[1-3] In order to lower the spring rate, clinicians often increase the interbracket wire length through the use of various loop configurations,[4] and/or by altering the wire cross-section,[5] and more recently, by using variable or low modulus wire.[6-8]

Configuring loops is time-consuming and may cause patient discomfort along with difficulty in maintaining oral hygiene. A potential increase in the incidence of appliance failure must also be considered. This is related to increased internal wire stresses caused during loop forming.[9] By using reduced wire cross-sections to lower the load deflection rate, clinicians often must accept less third-order control, risking the force system delivery in inappropriate directions. As a consequence of using reduced wire cross-sections, an increased number of wire changes are necessary to eventually fill the brackets more completely.[10] Wire of reduced cross-section also exhibits a reduced elastic limit and therefore optimal force systems generated may be limited. Low modulus wire takes advantage of different alloys to produce lower force systems while maintaining nearly full bracket engagement

Abstract

Reducing the load deflection rates of orthodontic springs is important, for it provides relative constancy of the moment-to-force ratio applied to the teeth with concomitant, forecastable dental movement. Increasing patient comfort and reducing the number of office visits while lowering potential tissue damage are additional features of lower load deflection rate springs. A simple auxiliary attachment, which can be crimped into position on an archwire or onto segments of an archwire, is described. This attachment permits the clinician to incorporate a relatively high rate stiff wire to enhance the anchorage of the reactive teeth in one area of the dental arch, while allowing the use of wire of lesser stiffness (lower load deflection rate spring) to engage teeth targeted for movement. The auxiliary allows the clinician to choose various stiffnesses through the use of wire of one modulus (stainless steel, for example) in one area of the arch, and wire of a differing modulus (NiTi, for example) in another area of the same arch. The advantages and disadvantages of choosing wires of differing moduli are reviewed. Alternative methods of transforming the spring rate through changes in wire cross-section or length are also reviewed. Practical clinical applications of the auxiliary attachment are shown.

Key Words

Auxiliary attachment • Variable modulus • Low load deflection rate spring • Anchorage enhancement

Submitted: February 1996 **Revised and accepted:** August 1996 Angle Orthod 1997; 67(3):219-222.

Table 1
Relative stiffness of selected orthodontic wires as related to stainless steel

Material	Relative stiffness or relative spring rate
Stainless steel	1.00
Blue Elgiloy*- heat treated	1.00
TMA**	0.36
Austenitic Ni-Ti***	0.41
NiTinol***	0.17
Twist-flex**	0.19
Martensitic Ni-Ti***	0.17
Force 9**	0.05
Respond**	0.04
D-rect**	0.04

Based on stainless steel modulus of 29 x 10^6 psi/in/in
From Proffit WR, Fields HWJr. Contemporary Orthodontics, 2d ed, St. Louis: Mosby, 1993.

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through larger cross-sections, offering greater control in the delivery of the desired force system.[6] Additionally, low modulus wire permits a simplified appliance design. However, low modulus wire also exhibits a reduced elastic limit.[11]

Table 1 lists the relative moduli (compared with stainless steel) for identical springs of differing materials. It should be noted that when all other factors are equal, the wire modulus is proportional to the force per unit of activation or spring rate. TMA wire with a modulus of 0.36 will deliver approximately 40% as much force as an identical wire configuration of stainless steel for the same elastic deflection, while Force 9 wire will deliver 5% of the force of an identical stainless steel spring for the same elastic deflection. The advantage of altering the modulus of an orthodontic spring is that it allows for a relatively constant force system delivery to the teeth.

If low modulus wire is used indiscriminately, reactive anchor teeth will move as well as the active teeth. An example of this is seen in Figure 1, where a partially erupted maxillary canine and adjacent teeth are engaged by an archwire of low modulus. After some time the incisors and premolars have tipped off the plane of occlusion. This "wiggle" of the reactive teeth is undesirable because of attendant, uncontrolled periodontal stress, and an increased potential of tissue resorption related to "round-tripping" the reactive teeth. Burstone and others have demonstrated the advantage of engaging a relatively large number of teeth on a comparatively stiff wire to improve anchorage, while using lower rate spring wire to engage the teeth targeted for movement.[12,13] Specifically, variations in spring stiffness can be obtained by using wire of increased cross-section in one area of the dental arch in combination with wire of reduced modulus in another area of the same arch. An improved approach to correcting a partially erupted canine is seen in Figure 2. An .016 x .022 stainless steel archwire engages the reactive anchor teeth. (An .017 x .025 archwire may be used in an .022 slot system.) The archwire is stepped occlusally to clear the canine when it is brought into final position. Two auxiliary fittings (American Orthodontics, Sheboygan, Wisc. Part No. 851-180 "Special") have been slipped onto the archwire and crimped in the positions shown. An 0.016 round nickel titanium (NiTi) wire is free to slide through the unoccupied tubes of the auxiliary fittings. This NiTi wire is pulled maximally with a steel tie to the unerupted canine. Any excess NiTi wire protruding through the mesial and/or distal tubes of the auxiliary fittings is clipped. As the canine erupts under the influence of the straightening NiTi wire, any excess wire at the auxiliary fittings is periodically clipped. Retying of the canine is seldom required. A detailed drawing of the auxiliary fitting is seen in Figure 3. As the coronal portion of the canine becomes available, a bracket is attached and a heavier cross-section, low modulus wire—as 0.016 x 0.022 NiTi—is similarly placed through each of the auxiliary fittings while fully engaging the canine bracket. This allows for relatively early third-order control. As the canine approaches its final position, a TMA wire of suitable rectangular cross-section may be placed through the auxiliary fittings. This wire of increased modulus (2.1:1, relative to Martinsitic NiTi) allows for more precise canine positioning, and may be followed by a final finishing archwire. This approach has minimized the risk of anchor teeth moving while taking advantage of the properties of various low modulus wires. Similar use of the auxiliary fittings to recover a palatally impacted canine is shown in Figure 4.

The auxiliary fittings may be used in many other applications. Figure 5 illustrates a fitting located on an anterior group of teeth. The bracket/tube combination at the molar is the posterior fitting. Each group of teeth is engaged separately on a relatively stiff wire; in effect, each group becomes one large multirooted tooth. A TMA T-loop shown joining the two groups of teeth is activated to produce the appropriate

Figure 1

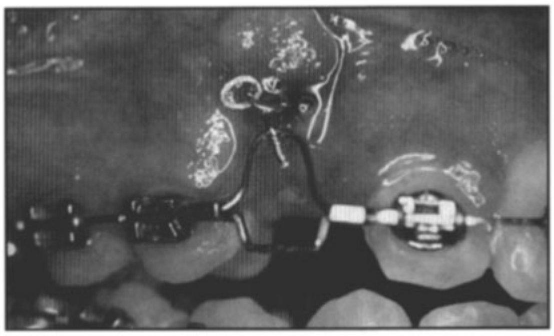

Figure 2

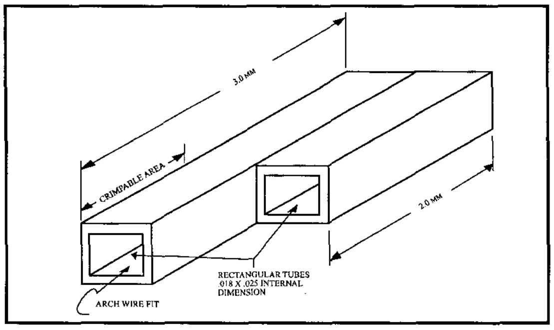

Figure 3

Figure 4

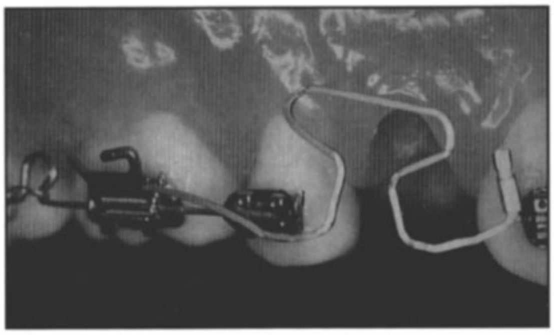

Figure 5

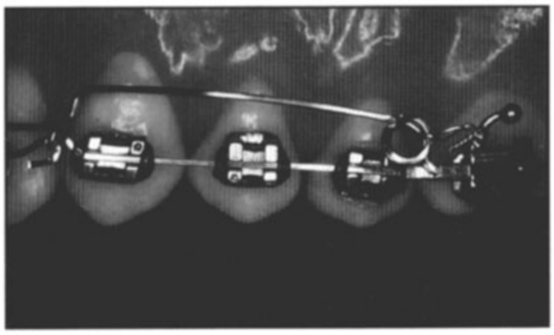

Figure 6

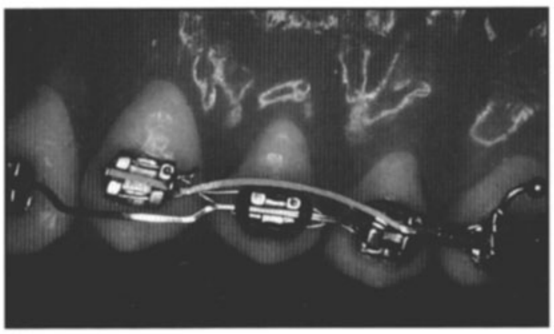

Figure 7

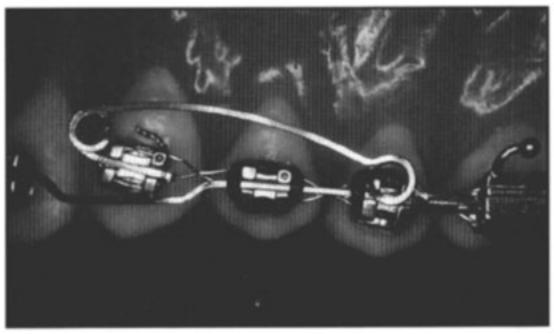

Figure 8

Figure 1
Improper use of low modulus wire to erupt a high canine

Figure 2
Auxiliary attachment joining wire of different moduli to retrieve an impacted canine

Figure 3
Auxiliary attachment dimensions

Figure 4
Auxiliary attachments joining wire of differing moduli to retrieve a palatally impacted canine

Figure 5
Auxiliary attachment associated with controlled extraction site closure

Figure 6
Auxiliary attachment used with an intrusion arch

Figure 7
Auxiliary attachments used with a TMA root spring

Figure 8
Auxiliary attachments used with a stainless steel root spring

force system to close the extraction site in a predetermined manner.[14,15] Use of the lower modulus TMA wire, as compared with stainless steel, allows a more constant moment-to-force ratio and a longer range of activation. In Figure 6 the auxiliary attachment is seen crimped to the wire segments of the posterior teeth bilaterally distal to the helices. An intrusion arch [16] acting on the appropriate incisors through their centers of resistance engages the posterior anchor teeth through the auxiliary fittings. It is important to note in this example that the spring rate is effectively lowered due to the relative length of the intrusion arch. (Spring rate varies inversely as the length of the wire cubed.) For this reason, stainless steel may be used for the intrusive arch, particularly if helices are incorporated mesial to the auxiliary fittings. This not only provides for a further increase in spring length, but also provides for additional wire at the most highly stressed region of the spring. An alternative design may employ lower modulus TMA wire of the same cross-section. This will further reduce the spring rate by approximately 60% relative to the same stainless steel spring design. In Figure 7, the auxiliary fitting crimped mesial to the molar permits the placement of a TMA root spring to correct the axial inclination of the canine.[9] Posterior anchorage is significantly enhanced by engaging all the remaining teeth in the arch with a stainless steel wire filling each of the brackets. An adjunctive lingual arch may also be used to further enhance anchorage. Note that the root spring bypasses all of the intervening premolar brackets, increasing the effective spring length, thereby decreasing the rate of the spring. A stainless steel root spring may also be used since the intervening premolars are not engaged. It is recommended, however, that the length of the root spring be further increased by incorporating helices in the root spring as seen in Figure 8. These helices also serve to reduce the stress induced in the critical areas of the root spring. By using a lower rate root spring, the magnitude of vertical forces attendant to canine root uprighting is reduced, requiring fewer activations. Anecdotal evidence indicates that effective root movement occurs with an applied moment in the range of 29.4 to 35.3 Newton millimeters to the canine. The elastic limit of TMA wire is approximately 60% that of stainless steel. Thus it is virtually impossible to sustain this moment without the possibility of permanent spring deformation. The auxiliary fittings may be used in many other applications too numerous to illustrate in this manuscript. These fittings afford the clinician the opportunity to apply sound biomechanical principles for the planned movement of teeth, while maintaining anchorage of the reactive teeth without requiring rebracketing.

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