Efficient Tx Mechanotherapy

Part-I: Efficient Orthodontic Archwires

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This is the first in a series of methods for improving “Treatment Efficiency” in the orthodontic practice. In general, Tx Efficiency involves using the least amount of chairtime and the optimum number of appointments (not too many and not too few) to effectively treat a case. Many factors effect Tx Efficiency (numbers of appointments per start, minimal chairtime per visit, and minimal time lost to SOS/emergencies, failures/cancellations and run-on cases) as noted in the handout “Comparison of Super Practices – 2005” that you received. All factors will be reviewed starting with what I call “Tx Mechanotherapy Efficiency”. To maximize treatment mechanotherapy efficiency, you need to minimize the average minutes of chairtime per start, by maximizing the amount of tooth movement per visit, which is highly dependent on the forces produced by the wires and brackets used. Since many brackets are available, since you have become comfortable with what you use, and since their effectiveness is highly dependent on the wire used in them, we will focus on the most appropriate wires to deliver the most appropriate forces in this Part-I. I do no pretend to know how to, nor pretend to tell you how to, treat a case. I do though, know to organize the excellent thoughts and experiences of others to produce systems to more efficiently treat a case (past examples are: scheduling, run-on control, SOS control, recall control, etc.): your feedback on this series will be much appreciated.

Most orthodontists are very familiar with the properties and effects of “Nickel-Titanium Alloys” used in orthodontic archwires, but some are not and thus, tend not to use them as advantageously as possible. Dr. Keith Hilliard directed me to what I feel are excellent reviews of these wires and I would like to share them with you. Although the reviews are a little dated (2000), the wires have probably not changed much, if at all, and this information should be a helpful review of their value in effectively and efficiently treating orthodontic patients. It is recommended that you review the references listed at the end of this article for your own interpretation of their results! In the reviews, terms such as *martensite* (cool, pliable extraoral wire state) and *austenite* (warm, elastic intraoral wire state) etc., are used, but will be ignored here, along with the physical details of the lab studies. We are only interested in their findings, as to how they effect efficient treatment.

As you know, each manufacturer’s nickel-titanium alloy has a specific “Temperature Transition Range” (TTR), comprised of a lower extraoral temperature range (where the wire is pliable) and a higher intraoral temperature range (where the elastic wire stiffens and recovers its original shape). Extraoral room temperature of 21–24 °C (70–75 °F) allows the preformed wire to be deformed from its original shape so that it will fit comfortably into all of the brackets. Intraoral mouth temperatures range from 35–37 °C (95–99 °F) causing the deformed wire to return to its original shape, moving the brackets toward a more ideal shape. These intraoral mouth temperatures change if cold liquids bathe the brackets/wires (making the wire more pliable and causing lower forces on the brackets) or if hot liquids bathe the brackets/wires (making the wire go to its original shape and causing higher forces on the brackets). The amount of force applied to the brackets at normal mouth temperatures is a function of the characteristics of the wire determined by the manufacturers. Manufacturers that have wire temperatures higher than 37 °C (for example, *40* °C Thermo-Active Copper NiTi wire by Ormco), will be softer and apply lower forces at 37 °C, while a wire with a lower temperature (for example, *35* °C Thermo-Active Copper NiTi wire by Ormco), will be stiffer and apply higher forces at 37 °C. Thus, it is important to know the forces applied by the manufacturer’s wires at mouth temperature so that the optimum force (for quickest tooth movement) can be applied at a particular stage of treatment (for example, unraveling teeth, retraction, final alignment, etc).

The intraoral temperature is not the only thing that affects the forces applied to the brackets; the *stress* on the wire also has an effect. Teeth that are farthest from their ideal positions cause higher deformations of the wire (stress), which has the same effect as lowering the intraoral temperature and thus, making the wire more pliable at each stress point. This causes lower bracket forces at these stress points, but as the tooth moves closer to its ideal position the stress is reduced, increasing towards the maximum forces on the brackets programmed in by the manufacturer. The lower stress-point forces may or may not be advantageous depending on their magnitude as compared to the ideal forces required to quickly move the teeth. Applying too low a force might not effectively move the tooth and applying too high a force tends to move teeth slower. Thus, it is important to choose a wire that will produce the range of force required for the degree of deformation of the wire in the bracket.

Another factor is the manufacturer's ability to produce a wire at the designated temperature without having a wide variation between and within batches; this is especially prevalent when the same "brand name" wire is manufactured by different companies, although the ability to home in on the desired temperature has been improved through heat-treating and other means. The wrong temperature can have disastrous effect on treatment, for example, if you use a wire that is suppose to stiffen at 35 °C, but does so at 45 °C, it will produce little if any force. Or, if you use a wire that is suppose to stiffen at 35 °C, but does so at 27 °C, it will produce a higher force than desired, possibly causing patient discomfort. Also, the manufacturers do not use a standard method of measuring their forces, since none has been established, although the reviews reference the use of a more accurate *3-bracket bending test* (vs. the less accurate *3-point bending test*) under controlled temperatures, to standardize measurement of these forces. It is best to inquire into the reliability of the various manufacturers before relying on their ratings: the findings of the research reviewed are summarized below, although there are other products with inconclusive data that were not included.

Product	Manufacturer	Temperature		Wire Size (inches)	3-bracket test Force In grams/mm for > 2mm deflection @ X °C (In large deflections the "Stressed Temp" is reached)
		Unstressed	Stressed		
27°C Superelastic Cooper NiTi	Ormco	31 °C	33 °C	016 x 022	137 gr./mm @ 37 °C (with lower forces for smaller diameters, preferably round)
35°C Thermo-Active Cooper NiTi	Ormco	33 °C	39 °C	016 x 022	<100 gr./mm @ 37 °C
40°C Thermo-Active Cooper NiTi	Ormco	39 °C	39 °C	016 x 022	<100 gr./mm @ 37 °C
Neo Sentalloy (F240)	GAC	28 °C	36 °C	016 x 022	36 gr./mm @ 37 °C
Bio-Force Sentalloy	GAC	28 °C	36 °C	016 x 022	100 gr./mm (ant) and 300 gr./mm (post)
Sentalloy	GAC	22 °C	28 °C	016 x 022	695 gr./mm @ 35 °C (with lower forces for much smaller diameters, preferably round)
Reflex	TP Orthodontics	27 °C	NA	O16 x 022	160 gr./mm @ ? °C @ 1 mm deflection
				O18 x 025	178 gr./mm @ ? °C @ ? mm deflection
Nitinol Heat Activated	3M Unitek	36 °C	38 °C	SE: 016 x 022	203 gr./mm @ 35 °C
				Classic: 016 x 022	215 gr./mm @ 35 °C
Heat Activated NiTi	Highland Metals	24 - 68 °C	NA	016 x 022 ?	480 gr./mm @ 36 °C
Stainless Steel Multistranded Comparison	All	NA	NA	17x25, 8-strand	171 gr./mm
				0175, 6-strand	43 gr./mm

For a heat sensitive wire to sufficiently stiffen, it must have an *unstressed* temperature below intraoral temperatures, but not much lower than the higher *stressed* temperature or else it will not stiffen enough to move the teeth into their ideal positions; a true 35 °C wire would accomplish this. It is also important to avoid too high a force (produced by wires way above 37 °C), avoiding patient discomfort, bone hyalinization, root resorption and delayed treatment time. There's an advantage to using a 40 °C wire for gross misalignments, providing less stiffness (lower forces) at the bends until the teeth are better aligned, the stress bends are removed, and higher aligning forces prevail.

It seems that the ideal amount of force delivered to the periodontal membrane should be between 70 and 80 grams in the anterior and gradually increase to about 300 grams in the posterior. Forces below 100 grams are best delivered by small, multistranded stainless steel wires and by *small-diameter* nickel-titanium alloys within the proper temperature range for that wire. For large deformations (moderate to severe crowding) though, stainless steel multi-strand is too stiff and suffers permanent deformations, limiting its use for long periods of time, which does not occur in heat sensitive wires: Ormco Copper NiTi 35 °C or 40 °C seems the most ideal. It also seems that the *torque* delivered by stainless steel wires (3,000 grams/mm for a 019x025 wire) is two to three times higher than that delivered by similar heat sensitive wire, although, the use of Ormco Copper NiTi 40 °C produces much lower forces in the range of 200 grams/mm at 37 °C intraoral temperature. Clinical tests have also shown that for lower anterior crowding that there is little difference between small diameter SS wire and heat sensitive wire, negating the need for expensive wire when you can get the same result with inexpensive wire.

Conclusions reached:

The authors suggest that for quicker tooth movement with less pain and resorption, that incisal forces be kept below 100 grams, that molar forces be kept below 300 grams, inferring that cuspid/bicuspid forces be kept below 200 grams. To unravel the lower anteriors, the authors suggest using inexpensive small-diameter or multistranded SS wire, except with gross misalignments where small diameter heat sensitive wire is best because SS becomes permanently deformed and useless. Elsewhere, especially where torque control is needed, it is suggested that you use round or rectangular Thermo-Active Copper NiTi 35 °C or 40 °C, Nitinol SE or XL, and Neo Sentalloy F240, of appropriate size, during the alignment phase of treatment. If using SS or other brands of NiTi wires during the alignment phase, use non-rectangular, small diameter wires to deliver lower forces; later, in the detailing phase use larger diameter round and rectangular wire. In any phase of treatment, the appropriate heat sensitive wire delivers more *continuous forces over longer periods of time* than does SS wire, thus allowing for longer intervals between appointments and fewer wire changes. I hope that these suggestions help you to reduce your treatment time and chairtime, thus increasing your overall Tx Efficiency.

Reviews:

Margherita Santoro, DDS, MA, Oliver F. Nicolay, DDS, MS and Thomas J. Cangialosi, DDS:
"Pseudoelasticity and thermoelasticity of nickel-titanium alloys: A clinically oriented review. **Part I:** Temperature transitional ranges"

"Pseudoelasticity and thermoelasticity of nickel-titanium alloys: A clinically oriented review. **Part II:** Deactivation forces"