

Wire Selection for Optimal Biomechanic Efficiency in the MBT™ Versatile+ Appliance System

by Dr. Dietmar Segner



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his PhD from that institution. He worked as professor of orthodontics at the university clinic and now works in his private practice in Hamburg specializing in the treatment of adults using aesthetic appliances. For two decades he has lectured all over the world on adult orthodontic treatment, and results of his research into biomechanical and ortho materials.

It is the wire that drives or guides the teeth, no matter how advanced the brackets may be, or whether they are self-ligating or not. The sensible selection of the archwires during the different treatment phases has therefore a major influence on the treatment efficiency.

This article will show the principle and give the clinician a guide to select the right wire at the right time. It should be pointed out that due to the variety of malocclusions and the variability of individual tissue reaction, it is not possible to give fixed time frames for changing to the next archwire. Rather, it is an important clinical decision if the tasks of a certain treatment stage are resolved and the treatment can progress to the next stage and next archwire.

What is the Archwire's Task?

The tasks of archwires during an orthodontic treatment can be split into two, which I will call Mode 1 and Mode 2 (Figure 1-2). In the first mode, the wire is in its active state. Activation of the wire is carried out by ligating the archwire to the irregularly positioned teeth. Energy is stored by pushing the elastic wires into the bracket slots. After this activation, the archwire uses this energy to move the teeth. Such an operating mode is typical for the aligning and leveling stages. It would also be relevant in all situations where the orthodontist inserts loops or other active elements into the archwire through bends, as for example retraction loops. As these applications are not used on a regular basis in the MBT™ Versatile+ Appliance System, they will be excluded from the further deliberations.

In the other application of an archwire (Mode 2), the archwire is used as a guiding track for the mesial or distal movement of teeth along the arch. Here the archwire is initially passive and its stiffness and elasticity only comes into play when the teeth start to show side effects such as tipping or rotations. Then the wire creates corrective forces and moments and assures that the teeth do not deviate from the intended track and angulations. The activation is achieved by elastomeric chains, super-elastic springs, inter-maxillary elastics or similar. These auxiliaries store the energy for the tooth movement. This application mode is typical for the working and retraction phases. In this mode the wire should have a significant stiffness in order to keep the undesired rotations or tipping to a minimum.

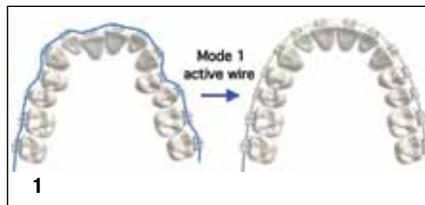


Figure 1: Wire in an active state.

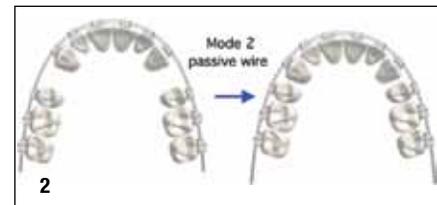


Figure 2: Wire in a passive state.

Dimension

During the alignment phase there is no need for a tight fit of the archwire in the bracket slot, as the differences between the archwire dimension and the slot dimension are up to 0.15 mm, while the positioning precision during the first alignment stage needs to be only about 0.5 mm. For a number of reasons, it is even desirable to have undersized wires in the alignment stage. The play between archwire and bracket slot reduces friction and potential binding with severely irregularly positioned teeth. Also the force-deflection curves of thin super-elastic wires are usually better because they show the correct force level immediately

at the beginning of the deactivation while thicker super-elastic archwires can show rather high forces during the first days after the ligation. It is also important to note that the slot dimension does not play a major role in selecting the first aligning wire. The same dimension is suitable for the 18 and 22 slot system.

During the leveling stage and also later in treatment the wire dimension becomes important. For de-rotation in self-ligating brackets and for effective torque effect, the wire dimension needs to be adjusted to the slot size. To get the standard designed torque effect the vertical dimension of the (rectangular) archwire needs to be 16 in the 18 slot and 19 in the 22 slot. Another requirement is that the horizontal slot dimension needs to be 25 in both the 18 and 22 slot systems for good rotational control. It is therefore clear that in the MBT™ Versatile+ Appliance System, the standard working wire as well as the finishing wires should be 16×25 in the 18 system and 19×25 in the 22 system.

It should be kept in mind that an increase in wire dimension results in a stronger expression of the torque built into the prescription of the MBT system, resulting in additional torque angulation. Using a 17×25 wire instead of a 16×25 in the 18 system or a 20×25 instead of a 19×25 in the 22 system increases the torque value by about 3°. Of course the same is true for undersized archwires: using a 14×25 wire instead of a 16×25 wire in the 18 system decreases the torque angle by 6°, using a 17×25 instead of 19×25 in the 22 slot system will decrease the torque effect by 7°.

Stiffness and Force Levels

In the active Mode 1 of archwires, the force acting on the teeth depends mainly on the archwire used. Super-elastic archwires have a major advantage in that the force is almost constant no matter how irregularly the teeth are positioned or how short the inter-bracket distance is, in clear contrast to the twisted wires, braided wires or non super-elastic Nickel-Titanium wires. In the graph (Figure 3) we compare a 16 super-elastic nickel-titanium wire (Nitinol HA) and a 16 non super-elastic Nickel-Titanium wire (Nitinol Classic). We easily see that the super-elastic wire develops significantly less force. The difference is shown by the combination of the red and yellow areas in the graph.

But even if we try to reduce the force of the non super-elastic archwires by selecting a thinner wire (14 Nitinol Classic) we see that for all deflections above 1.2 mm, the thicker but super-elastic wire develops lower forces that are also constant over much of the deflection range. Below 1.2 mm deflection, the force of the non super-elastic wire, decreases so much that it becomes less than the super-elastic wire, and eventually it would not move the teeth any more, and an archwire change needs to be conducted. On the other hand, the super-elastic archwire continues to exert constant forces

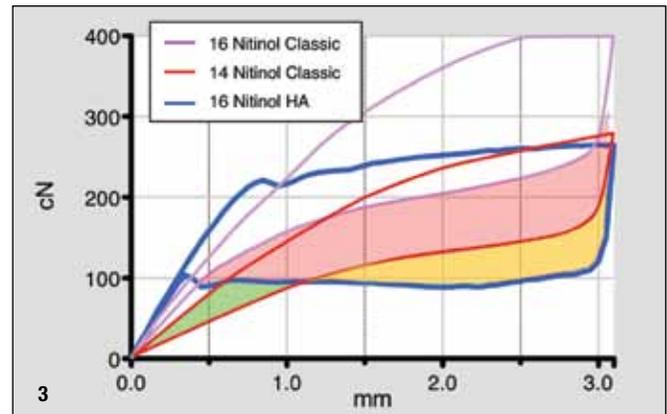


Figure 3: Force associated with 3 archwires.

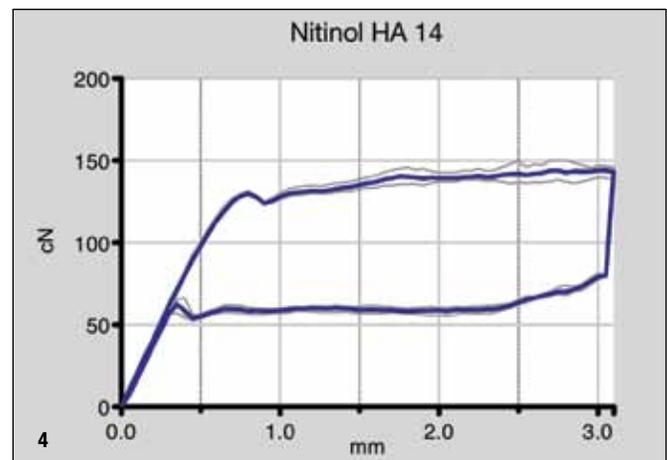


Figure 4: Force characteristics of Nitinol HA (HANT) in dimension 14 round.

until the deflection falls below 0.35 mm, so with one single archwire we achieve almost perfect leveling if we just leave the wire in and give it a chance to express itself fully, which might take anywhere from 5 weeks to 5 months.

In order to optimize the biological response, and avoid the risk of force that is too high, the initial archwire should be super-elastic and its force level should be significantly below 100 g of force. The optimal wire therefore is the 14 Nitinol Heat Activated both for the 18 system and the 22 system (Figure 4).

After the alignment phase, the slots will be quite well aligned. If a second archwire is necessary for the leveling stage, the deflection of that archwire due to misaligned bracket slots will be below 0.5 mm. Since none of the super-elastic archwires has a plateau of constant force below 0.5 mm, the aspect of superelasticity becomes unimportant for the second and all following wires of the treatment. Now it becomes crucial that the wire has the correct dimension to get full expression of the bracket prescription as described above.

During the working stage the wires operate in the passive Mode 2. They should have sufficient stiffness to counteract any undesired movements or rotations. Since the leveling phase achieved perfect alignment of the bracket slots, insertion of such a stiff archwire should not present a problem. Only wires of Beta III Titanium or stainless steel provide sufficient stiffness. Especially in extraction cases, steel is to be given preference.

Making Bends

Although the philosophy of the MBT appliance system is to avoid bending as much as possible, by achieving perfect bracket positioning through indirect bonding and – if required – early repositioning of brackets in the leveling phase, it sometimes might be necessary to implement bends, especially during the finishing phase.

When a corrective bend is applied, it is usually to achieve a change from the previous situation. This means that in this moment the archwire is changing into Mode 1 again, the active mode. In addition to the property of accepting precise bends, the archwire material should also deliver the stored energy with physiologic forces. Especially in the 22 system even small corrective bends in a stainless steel wire exert significant amounts of force. To decrease the force level and associated pain for the patient, it is of benefit to use the lower modulus of elasticity of the Beta III Titanium material. The same corrective bend in the same dimension archwire will exert only 50% of the force in comparison to a stainless steel wire. Therefore, the Beta III Titanium material is the recommended material for finishing wires.

Self-Ligating Brackets

In principle, treatment with self-ligating brackets in the MBT system can proceed with the same wires as with conventionally ligated brackets. The only difference of significance is the rotational control in the leveling phase. All self-ligating brackets have a fixed slot depth of 0.0275" (0.027" for the lower anteriors) defined by the clips or slides. In order to be able to effect de-rotation or control undesired rotation, the archwire needs to fill this slot depth with a play of not more than 0.0025". Therefore a single round wire will not give perfect rotational control without adding a ligature on the tooth in question.

Two options are available to the orthodontist: the first is to finish the leveling with an archwire that has a 25 for the horizontal dimension. For the 18 slot dimension, archwires of the dimension 14×25 and 16×25 were introduced, while in the 22 system 17×25, 18×25, and 19×25 wires have been available for a long time. The second option is to fill the slot in the buccolingual direction using two round archwires, which is called the Tandem Archwire Technique. For the 18 slot system this would be two 14 Nitinol HA archwires, while in the 22 slot system it could either be also two 14 dimension wires or a 14 and a 16 Nitinol HA wire used in tandem. The latter variant might activate the clip a bit, leading to some pressure of the clip on the wire(s) (Figure 5).

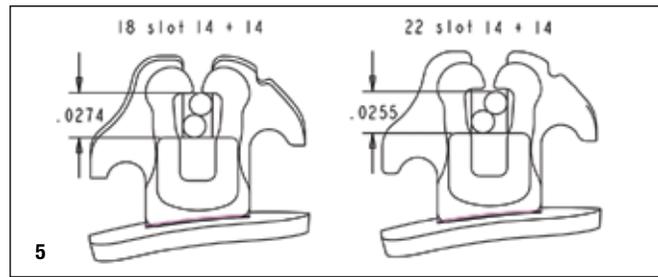


Figure 5: Tandem Archwire Technique examples.

In many cases, the initial alignment wire from the upper jaw can be transferred to the lower jaw and added to the alignment wire already present there. Often it would also be possible to transfer a lower alignment wire to the upper jaw and let this second wire run only up to the first molar.

Special Treatment Objectives

If there are special tasks during the leveling stage, the use of additional archwires may increase treatment efficiency. Typical examples would be the leveling of a pronounced Curve of Spee. Here round stainless steel archwires of the dimension 18 in the 18 slot system, or of the dimensions 18 or 20 in the 22 slot system, might enhance the efficiency. A number of orthodontists like to use a Nitinol SE reversed curve archwire of the dimension 16×22 (18 slot) or 19×25 (22 slot) for the same task. For transverse arch form adaptations, stainless steel wires would also be beneficial.

If the special application of torque is required, the use of non super-elastic nickel-titanium should be preferred over the super-elastic nickel-titanium variant. With super-elastic rectangular wires, the torsional moments are in the range of 200 to 500 gmm, which is on the low side of effective torque application. With non super-elastic wire materials, the torsional moment depends on the amount of activation and can be adjusted to up to about 1500 gmm. For the 18 slot system, a 16×25 Nitinol Classic, and for the 22 slot system, a 19×25 Nitinol Classic left in the mouth a sufficient amount of time will effect the specific torque requirements efficiently. Up to 2.5° per month can be achieved.

Wire Selection

To make the selection of wires for an optimal biomechanic efficiency easier, a table has been assembled that lists the recommended wires for the different treatment stages in the MBT appliance system (Table 1). The table has columns for the 18 system as well as the 22 system. Also, the special requirements of self-ligating brackets in the MBT system are addressed in the table. In the rightmost column, suggestions for special treatment tasks are given. These wires are only needed in certain cases to make the treatment easier and more efficient for the patient. Listing a strict, non-negotiable order of archwires or recommended time intervals for the archwires to reside in the mouth has been purposely avoided. Such inflexible cookbook-style recommendations violate clinical experience as well as common sense and would be contrary to the philosophy of the MBT system.

MBT™ Versatile+ Appliance System

Treatment Phases and Wire Requirements

Treatment Stage	Recommended Wire Products and Variations			
	MBT™ System Brackets 18 Slot		MBT™ System Brackets 22 Slot	
<p>Aligning Stage</p> <p>Tasks:</p> <ul style="list-style-type: none"> • Activating cellular reaction • Initial slot alignment • Initial de-rotation <p>Requirements for Wire:</p> <ul style="list-style-type: none"> • Low forces, especially with large irregularities • Force limitation desirable (force limitation by superelastic plateau) • Avoid binding • Torque effect initially usually not desirable 	<p>14 HANT</p>	<p><i>Variations:</i></p> <p>14 NCL with push coil and not all teeth ligated</p>	<p>14 HANT</p> <p><i>then for self-ligating only:</i></p> <p>14+16 HANT Tandem</p>	<p><i>Variations:</i></p> <p>14 NCL with push coil and not all teeth ligated</p>
<p>Leveling Stage</p> <p>Tasks:</p> <ul style="list-style-type: none"> • Final de-rotation/re-establishing correct contact points • Establishing torque • Correcting angulations • Leveling Curve of Spee <p>Requirements for Wire:</p> <ul style="list-style-type: none"> • Not too high forces • Elasticity to correct angulations/tip • Good rotational control • Dimension needs to fill slot height for torque effect • Stiffness to level Curve of Spee 	<p><i>Self-Ligating:</i></p> <p>14×25 HANT or 14+14 HANT Tandem</p> <p><i>Non-Self-Ligating:</i></p> <p>16 Australian then 16×25 Beta III Titanium</p>	<p><i>Variations:</i></p> <p>If torque matters</p> <ul style="list-style-type: none"> • 16×25 NCL <p>For additional vertical leveling:</p> <ul style="list-style-type: none"> • 18 SS • 16×22 NSE reversed curve 	<p><i>Self-Ligating + Non-Self-Ligating:</i></p> <p>19×25 HANT</p>	<p><i>Variations:</i></p> <p>If torque matters</p> <ul style="list-style-type: none"> • 19×25 NCL instead of 19×25 HANT <p>For additional vertical leveling:</p> <ul style="list-style-type: none"> • 18 SS • 20 SS • 19×25 NSE reversed curve • 19×25 Beta III Titanium
<p>Working Stage</p> <p>Tasks:</p> <ul style="list-style-type: none"> • Closing of extraction spaces • Closing of other spaces • Retracting anterior teeth with torque control <p>Requirements for Wire:</p> <ul style="list-style-type: none"> • Enough stiffness to avoid vertical and horizontal bowing • Dimension needs to fill slot height for torque effect • Good rotational control • Low friction 	<p>16×25 SS or 17×25 SS Hybrid (with crimp hooks)</p>	<p><i>Variations:</i></p> <p>If no space closure required:</p> <ul style="list-style-type: none"> • 16×25 Beta III Titanium 	<p>19×25 SS (with crimp hooks)</p>	<p><i>Variations:</i></p> <p>Optional: 21×25 hybrid</p> <p>If no space closure required:</p> <ul style="list-style-type: none"> • 19×25 Beta III Titanium
<p>Finishing Stage</p> <p>Tasks:</p> <ul style="list-style-type: none"> • Correct midlines • Root alignment • Overbite/overjet • Functional occlusion <p>Requirements for Wire:</p> <ul style="list-style-type: none"> • Corrective bends possible without too high forces • Good rotational control • Dimension needs to fill slot height for torque effect • Enough stiffness to hold or fine-tune arch form and overbite 	<p>16×25 Beta III Titanium</p>	<p><i>Variations:</i></p> <p>If already in place:</p> <ul style="list-style-type: none"> • 17×25 SS hybrid • 16×25 SS 	<p>19×25 Beta III Titanium</p>	<p><i>Variations:</i></p> <p>If already in place:</p> <ul style="list-style-type: none"> • 19×25 SS
<p>Settling Stage</p> <p>Tasks:</p> <ul style="list-style-type: none"> • Maximizing intercuspitation <p>Requirements for Wire:</p> <ul style="list-style-type: none"> • Allows minor tooth movement by occlusion and elastic traction 	<p>16×22 Braided</p>	<p>Alternative would be using a positioner</p>	<p>19×25 Braided</p>	<p>Alternative would be using a positioner</p>

Table 1: Recommended wires by treatment phase, MBT™ Versatile+ Appliance System. **Note:** Wire selection should be made on a case-by-case basis. NCL: Nitinol Classic; NSE: Nitinol Super-Elastic; HANT: Nitinol HA; SS: Stainless Steel.