Reprogramming the Memory of Superelastic Nickel Titanium Archwires

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Superelastic nickel titanium archwires can be used effectively in many orthodontic patients.[1-6] The major disadvantage of these wires is their inability to be adjusted during the course of treatment. In 1990, Sander introduced a pulsed-heat-induction method for reprogramming the memory of superelastic nickel titanium wires for specific clinical purposes.[7] This is now easily accomplished at the chair with a commercially available device, the Memory-Maker* (Fig. 1). In a previous article (JCO, October 2008), we described the theory behind the reprogramming. This article shows two common clinical applications.

Bending Nickel Titanium Wires with the Memory-Maker

The Memory-Maker can be used to customize nickel titanium archwires and arch segments for individual patients.[2,3,6] Before bending the

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Fig. 1 Memory-Maker with two electrically connected pliers and rectangular foot switch.

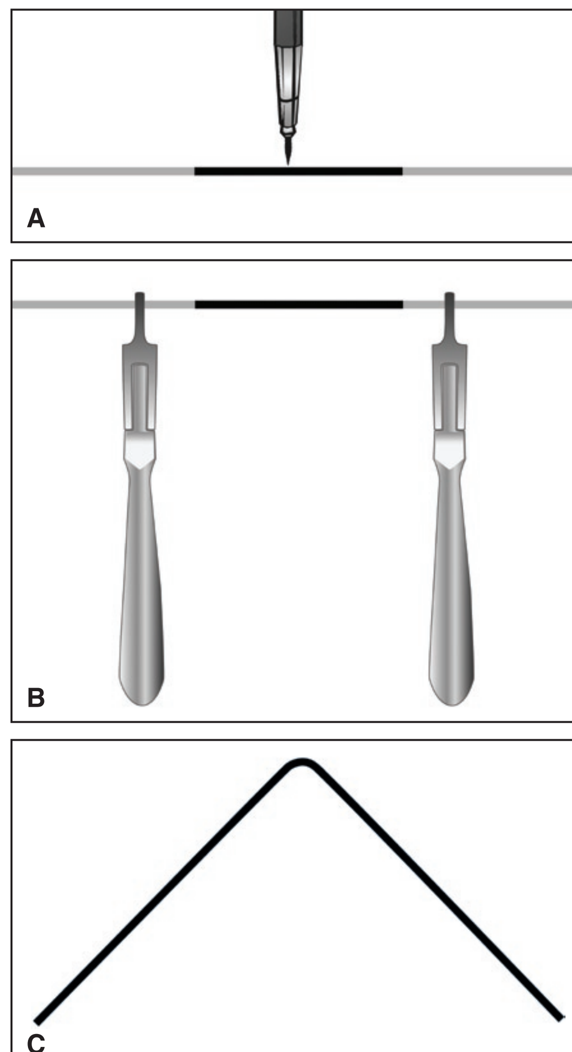

Fig. 2 Placing right-angle bend in .018" × .018" superelastic nickel titanium wire. A. Site of bend identified with waterproof marker. B. Wire grasped with orthodontic pliers connected to Memory-Maker. C. Bent wire.

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actual wire with the Memory-Maker, a similar piece of test wire should be used to adjust the current and frequency of the device. The first step is to indicate the area to be bent with a waterproof marker (Fig. 2A). Next, the wire is grasped with the pliers attached to the electrodes of the Memory-Maker (Fig. 2B). The pliers should be placed in the same locations on the test wire as will be needed for the required bend in the actual wire. To make a right-angle bend, the wire is held with the pliers about 10mm apart, equidistant from the marked area. A pulsed electric current with a frequency of about 1-3Hz is applied until a small amount of smoke appears from the waterproof ink, and the wire turns a golden color as it is heated to 360-500°C. If the wire is overheated and annealed, its color will change to blue or black, and it will lose its superelastic properties. After placing the desired bend in the archwire, pulsed electric current is applied and a recoil force is generated in the opposite direction of the bend. To program the memory in the desired configuration, this recoil must be resisted by repositioning the bend and applying more pulsed current until the desired temperature is reached (Fig. 2C).

Case 1: Segmental Mechanics for Maxillary Canine Rotation and Torque

In routine rotation cases, a small-diameter nickel titanium wire can be deflected into the bracket slot and secured with a firm or asymmetrical figure-8 ligature.[1] In cases of severe horizontal and vertical displacement, however, the

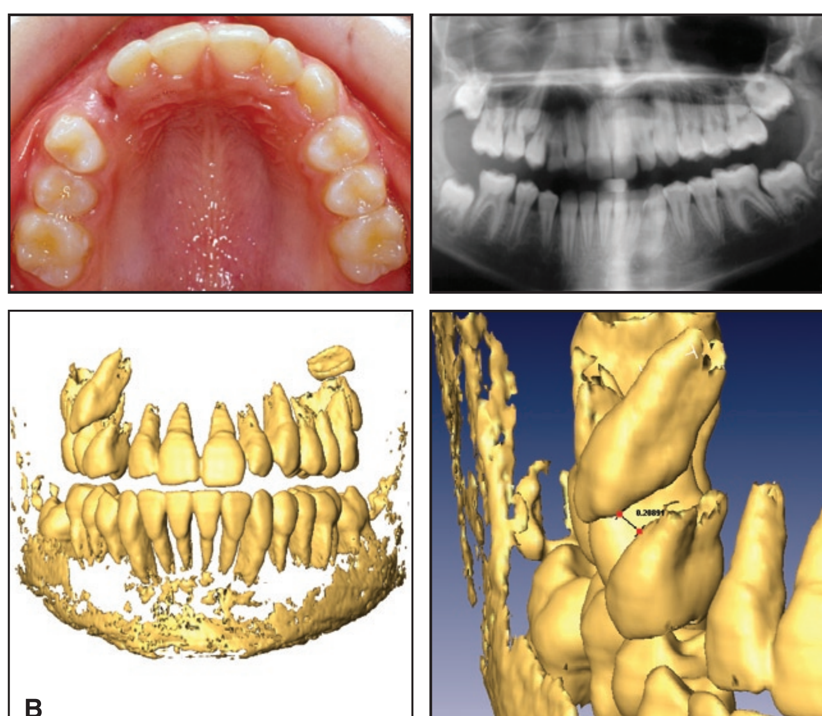

Fig. 3 Case 1. A. 15-year-old female patient with impacted maxillary right canine encroaching on buccal root of first premolar before treatment. B. Cone-beam computed tomographic radiographs showing transposition of canine, with 2mm between canine and first premolar.

Fig. 4 Case 1. A. Horizontal traction applied from power arm on archwire. B. After canine rotation of nearly 90°, elastomeric ligature attached to archwire to move canine mesially and occlusally.

archwire may not be flexible enough to accomplish the rotation efficiently, or it may cause undesirable side effects. Teeth that are impacted or ectopically erupted usually require substantial rotation and torque for proper alignment. Customized nickel titanium auxiliary segments can perform such complex tooth movements effectively without overloading adjacent teeth.

Fig. 5 Case 1. Vertical-slot bracket bonded to exposed canine.

A 15-year-old female presented with an impacted maxillary right canine that was displaced distally, encroaching on the buccal root of the right first premolar (Fig. 3). The canine was surgically exposed, and an eyelet was bonded to its buccal surface. Space for the canine was opened with a coil spring, and mesial traction was applied with an elastomeric ligature from a power arm distal to the maxillary right lateral incisor (Fig. 4A). This rotated the canine so that the smallest diameter of its root could pass by the first premolar root. After the canine penetrated the mucosa, it was moved mesially and occlusally with an elastomeric ligature (Fig. 4B).

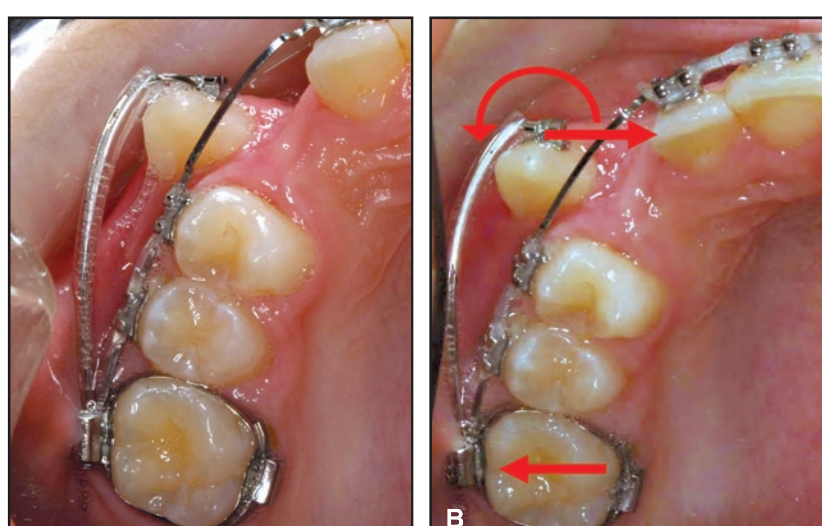

Fig. 6 Case 1. A. Nickel titanium .018" × .018" cantilever wire bent by Memory-Maker, forming segmental arch from canine to first molar. B. Derotation and palatal movement of canine, accompanied by buccal molar movement.

A bracket with an .018" × .018" vertical tube was then bonded to the buccal surface of the canine (Fig. 5), and a superelastic derotation spring was bent with the Memory-Maker from a segment of .018" × .018" nickel titanium wire. The end of the spring with a right-angle bend was inserted into the vertical tube of the maxillary canine bracket, and the cantilever portion, covered with a clear plastic sleeve, was pushed palatally and inserted into the buccal tube of the maxillary first molar (Fig. 6A). The resulting moment rotated the canine distally, thus moving it into the prepared space while the molar was moved buccally (Fig. 6B).

The rotation was achieved in four months, with canine extrusion controlled by contact with the archwire. An occlusal step bend was placed in the nickel titanium archwire with the Memory-Maker, and an .014" nickel titanium wire was secured labially, piggyback style, to align the canine (Fig. 7). Differential palatal root torque for the right maxillary canine was then programmed into the rectangular archwire with the Memory-Maker (Fig. 8A), and the maxillary dentition was detailed as needed (Fig. 8B). At debonding, an almost ideal alignment of the maxillary arch had been achieved (Fig. 9).

Fig. 7 Case 1. Alignment of canine using piggyback technique.

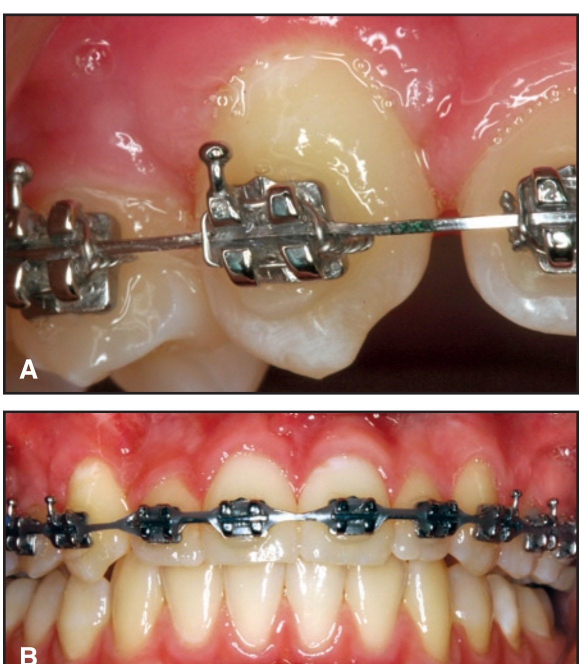

Fig. 8 Case 1. A. Torque adjustment made in rectangular nickel titanium archwire to prevent root resorption. B. Properly torqued canine.

Case 2: Labial Root Torque of a Palatally Displaced Incisor

Palatally displaced maxillary incisors require considerable labial root torque to align once the crossbite has been corrected. It is a challenge to deliver a sufficient moment with a desirable range of activation using a stainless steel or TMA** archwire. Because an .016" × .022" archwire in an .022" bracket has about 22° of freedom before engagement, it is difficult to measure the torque delivered to the tooth, even with an activa-

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Fig. 9 Case 1. Final treatment result, showing almost ideal alignment of maxillary arch.

tion chart (Fig. 10). Overactivation of a stainless steel or TMA archwire makes insertion problematic and may lead to bracket debonding or patient discomfort.

A superelastic nickel titanium archwire has superior properties because of its low modulus of elasticity. Using the Memory-Maker, a differential torsion activation of 45-90° can be placed in an .016" × .022" nickel titanium archwire, providing a wide range of activation for efficient correction of a palatally displaced maxillary lateral incisor with an .022" bracket.[4]

A 13-year-old female presented with maxillary arch constriction and crowding and palatal displacement of the maxillary left lateral incisor (Fig. 11). To gain space, the maxillary arch was rapidly expanded with a jackscrew (Fig. 12). Initial alignment was carried out with an .016" nickel titanium segmental wire (Fig. 13). Space for the blocked-out lateral incisor was then opened with a nickel titanium compressed-coil spring (Fig. 14).

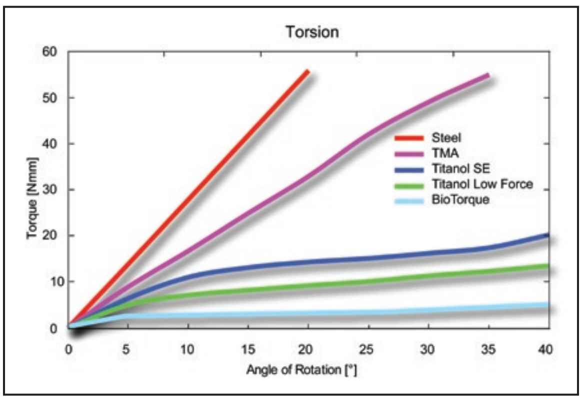

Fig. 10 Single-tooth torsion with five .016" × .022" wires: stainless steel, TMA, Titanol* Superelastic (SE), Titanol Low-Force, and BioTorque.***

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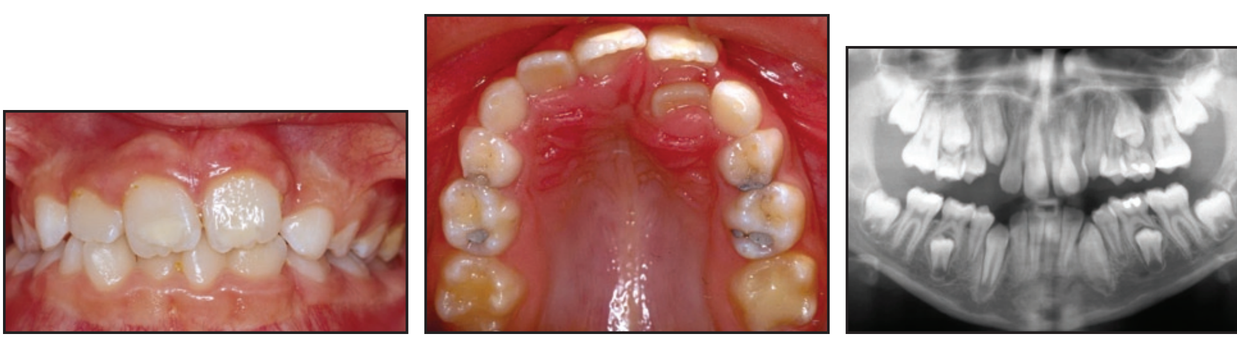

Fig. 11 Case 2. 13-year old female patient with maxillary arch constriction and crowding and palatal displacement of maxillary left lateral incisor before treatment.

Fig. 12 Case 2. Patient after 18 days of rapid palatal expansion at .5mm per day, with acrylic coverage of buccal segments.

A bracket was bonded upside-down to the displaced incisor, changing the bracket torque from +7° to –7°. An .012" BioStarter* nickel titanium archwire was used for initial alignment of the maxillary arch (Fig. 15). Labial root torque was then applied to the lateral incisor with a straight .017" × .025" stainless steel archwire until the tooth position could not be improved further, due to the interbracket play of more than 15° (Fig. 16). The lateral incisor bracket was rebonded in the prescribed position, and the Memory-Maker was used to place about 20° of labial root torque in the appropriate segment of an .017" × .025" BioTorque* nickel titanium archwire (Fig. 17). This wire produced the desired torque in three months. The total treatment time was 18 months (Fig. 18).

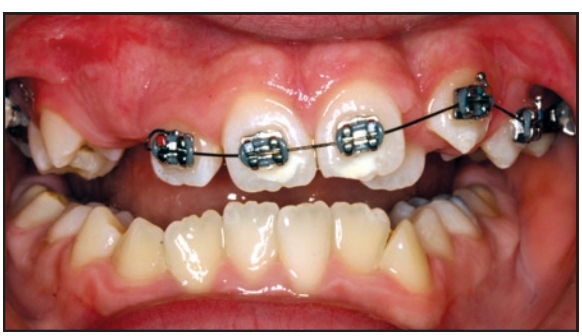

Fig. 13 Case 2. Initial alignment with .016" nickel titanium segmental archwire.

Fig. 14 Case 2. Space gained for maxillary left lateral incisor with superelastic compressed-coil spring.

Fig. 15 Case 2. Alignment of maxillary arch with .012" BioStarter* nickel titanium archwire.

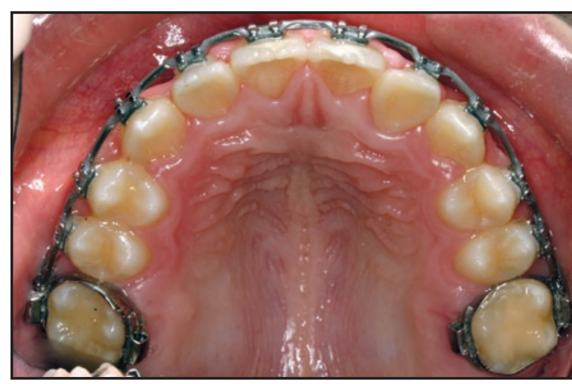

Fig. 16 Case 2. Inadequate labial root torque of maxillary left lateral incisor with rectangular stainless steel archwire.

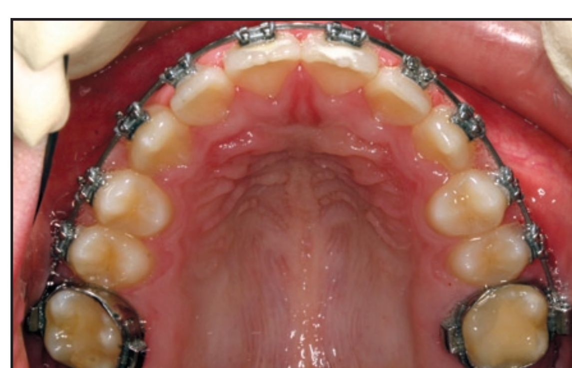

Fig. 17 Case 2. Labial root torque placed in maxillary left lateral incisor segment of BioTorque* nickel titanium archwire using Memory-Maker.

Fig. 18 Case 2. Treatment results after 18 months of fixed appliances.

Conclusion

The Memory-Maker permanently changes the conformation of superelastic nickel titanium wires without destroying their superelastic properties, allowing them to be used for a wide variety of specific clinical applications that are not easily addressed with preformed commercial archwires. The wires can be reprogrammed repeatedly as long as they are not overheated. Customized auxiliaries can be constructed and segments of nickel titanium archwires adjusted to achieve desired movements of individual teeth. Exploiting the superelastic properties of nickel titanium wires can help achieve optimal outcomes while reducing costs and treatment times.

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