Uprighting Molars with Twisted Superelastic Nickel Titanium Wires

YON LAI, DDS
MAY P. CHU, DDS
T.V. VIJAYARAGHAVAN, PHD

Buccally or lingually tipped molars are traditionally uprighted by torquing them in small increments of 10-25° on rectangular stainless steel archwires. Heat-treated Elgiloy* (CoCr) wires have better physical properties, but require careful manipulation and wire-bending.[1,2] Furthermore, the considerable force exerted by these wires may cause initial patient discomfort, and the force decays rapidly as the teeth move.

Such problems can be overcome by using superelastic nickel titanium wires to torque and upright buccally or lingually tipped molars. Nickel titanium alloys exhibit excellent springback, shape memory, and flexibility, producing light, continuous forces for optimal physiologic tooth movement.[3-12] Patient discomfort is minimized, chairtime for archwire placement is reduced, and the appointment interval can be lengthened, improving treatment efficiency and control.

The mere engagement of a superelastic nickel titanium wire into the molar tube produces molar root torque because of the shape memory of the wire.[13] We found that this torsional force can be amplified by twisting the long axis of the wire 180°. An interbracket span of 25-40mm from the canine bracket to the molar tube optimizes the activation at the molar and avoids debonding of premolar brackets. The advantages of superelastic nickel titanium wires can be used early in treatment to upright buccally or lingually tipped molars, as this article demonstrates.

Materials and Methods

A typodont investigation was conducted to accurately measure the amount of force generated on a maxillary molar by twisted superelastic nickel titanium wires. This approach eliminated the effects of individual variations such as periodontal bone loss, degree of molar tipping, occlusal forces, and extremes of temperature in the mouth.

The typodont was attached to a Lucite acrylic base, and two additional Lucite pieces anchored the Accuforce Torque-Chek digital static torque gauge with RS232 serial interface** (Fig. 1). This gauge, which measures a torque range of 0-50oz-in within the manufacturer's reported accuracy of .25, was originally designed to test the strength of endodontic files and was deemed suitable to measure the torque of orthodontic wires. The gauge was modified so that an .022" molar tube could be mounted in the center and the instrument could simulate a tipped molar. The typodont's maxillary right molars were removed to allow easier manipulation of the gauge.

A set of .022" twin brackets were bonded in a straight line across the labial surfaces of the typodont teeth, from maxillary left first molar to maxillary right canine, so that a straight piece of wire could be inserted in the bracket slots. The right premolars were not bracketed, simulating the clinical technique with an interbracket distance of 25-40mm to the tipped right first molar.

Six different types of commercially available Neo Sentalloy*** archwires used in .022" edgewise brackets were tested: .018" × .025" and .0215" × .028" archwires, each in force levels of 100gm-cm (F100), 200gm-cm (F200), and 300gm-cm (F300). Each wire was heated in warm water to 50°C, which would allow it to cool to an approximate mouth temperature of around 37°C by the time it was tested on the typodont.

The wire was placed with its center corresponding to the midline of the typodont. It was inserted into the torque gauge so that one end

*Registered trademark of RMO Inc., P.O. Box 17085, Denver, CO 80217.

**AMETEK, P.O. Box 1764, Paoli, PA 19301.

***Trademark of GAC International, Inc., 185 Oval Drive, Central Islip, NY 11722.

Dr. Lai is an Associate Clinical Professor and Director of the Cleft Palate Group, Department of Orthodontics, College of Dentistry, Division of Biological Sciences, Medicine and Surgery, New York University, 345 E. 24th St., New York, NY 10010. He is also in the private practice of orthodontics in New York City. Dr. Chu was a postgraduate resident in the Department of Orthodontics, New York University, when this research was conducted, and is currently practicing orthodontics in Brooklyn, NY. Dr. Vijayaraghavan is a lecturer and researcher in the Dental Materials Department, College of Dentistry, New York University.

Dr. Lai

Dr. Chu

Dr. Vijayaraghavan

was engaged in the molar tube of the simulated tipped molar, while the other lay outside where the patient's cheek would have been (Fig. 2). The wire was then twisted along its axis 180° clockwise or counterclockwise, depending on the desired direction of crown movement, and engaged in the brackets from the canine of the same quadrant to the contralateral molar (Fig. 3). The brackets were then tied in with elastomeric ligatures.

Before each reading, the torque gauge was recalibrated to zero to ensure accuracy, uniformity, and reproducibility of measurements. Each of the six types of wires was tested at 25mm, 30mm, 35mm, and 40mm interbracket spans. There were a total of four trials for each subgroup: three with the wire twisted clockwise and one with the wire twisted counterclockwise. The force was read from the torque gauge to the nearest .01oz-in, then converted to gm-cm.

Fig. 1 Torque-measuring apparatus: torque gauge, typodont, acrylic base.

Fig. 2 Wire inserted into clamp of torque gauge, simulating molar tube.

Results

There was no significant difference ($p > .05$) in mean torque values for interbracket spans between 25mm and 40mm for any given wire type (Table 1). However, there were several significant differences among groups, as analyzed by the Scheffe test.

In general, for every 1mm increase in interbracket distance, there was a .3gm-cm decrease in force. When the wire size increased from .018" × .025" to .0215" × .028", the torsional force increased by 30-35%. For either wire size, the torsional force increased 15gm-cm as the force of the wire increased from F100 to F300.

These results indicate that for convenience of selecting and stocking wires, three different

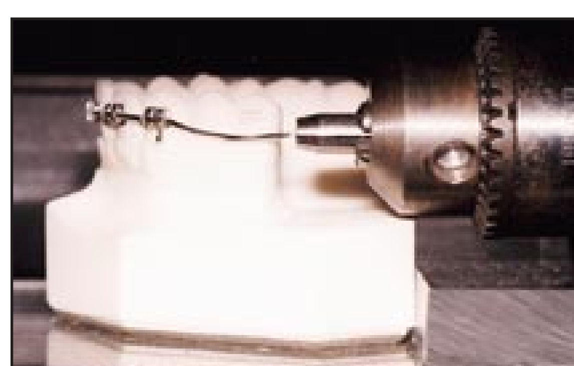

Fig. 3 Wire twisted 180° and tied into brackets.

TABLE 1
MEAN (S.D.) TORQUE FORCE (GM-CM)

Wire	Interbracket Distance 25mm	30mm	35mm	40mm	Overall	
.018" × .0215"						
F100	39.9 (6.6)	40.3 (6.6)	39.2 (7.5)	37.6 (8.3)	39.3 (6.6)	a,b*
F200	50.6 (8.8)	48.1 (8.1)	45.8 (10.7)	43.7 (10.8)	47.1 (9.1)	a
F300	56.3 (11.0)	54.7 (10.5)	53.5 (10.3)	51.2 (9.7)	53.9 (9.5)	b
.0215" × .028"						
F100	58.6 (8.5)	57.8 (5.9)	53.5 (10.2)	48.3 (5.1)	54.5 (8.1)	a
F200	64.7 (15.8)	63.3 (14.7)	58.6 (12.7)	53.7 (12.1)	60.1 (13.2)	b
F300	75.8 (12.6)	78.1 (6.4)	78.1 (9.1)	74.2 (9.8)	76.7 (8.9)	a,b

*Common letters indicate significant differences ($p < .05$) between groups.

types would be adequate for most clinical situations: .018" × .025" (F100), .0215" × .028" (F100), and .0215" × .028" (F300).

Clinical Application

After analysis of the laboratory study, this technique was employed clinically in 68 patients, ranging in age from 12 to 40, in Dr. Lai's private practice and the Orthodontic Department of New York University. The buccally or lingually tipped molars included 43 mandibular first molars, 25 mandibular second molars, 29 maxillary first molars, and 17 maxillary second molars, for a total of 116. Three representative cases are shown here.

Case 1

A 10-year-old female presented with a Class I malocclusion, crowded upper and lower arches, and a lingually tipped mandibular right

Fig. 4 Case 1. A. Insertion of superelastic nickel titanium torquing wire into mandibular right first molar tube. B. Wire twisted counterclockwise to generate buccal crown torque.

first molar, which was also in crossbite.

Both arches were bonded and banded; .014" Australian archwires were used for two months, followed by .018" Australian wires.

Two years into treatment, an .0215" × .028" Neo Sentalloy wire (F200) with 180° buccal crown torque was inserted in the mandibular right first molar tube (Fig. 4). The adjacent premolars and canine were bypassed because the wire was twisted and thus could not be fully engaged in the slots. (We learned that the archwire should be tied with ligature wires through the vertical slots of the adjacent brackets to prevent extrusion of the tipped molar and possible disengagement of the wire.)

The torquing wire was removed after three months (Fig. 5), and .017" × .025" stainless steel finishing archwires were placed.

Case 2

A 14½-year-old female presented with a Class I malocclusion and lower anterior spacing. A previous orthodontist had tried unsuccessfully to upright the lingually impacted mandibular right second molar before removal of fixed appliances (Fig. 6).

Both arches were bonded with brackets and molar tubes, and .016" nickel titanium archwires were placed. After two months of initial leveling, an .018" × .025" Neo Sentalloy wire (F200) with 180° buccal crown torque was engaged in the mandibular right second molar tube. The wire was removed after two months due to pericoronitis of the molar, but was replaced three months later.

After two more months of molar torquing, an .020" stainless steel archwire was inserted for space closure. One year into treatment, molar torquing was resumed with an .025" × .028" Neo Sentalloy wire (F300) for one month (Fig. 7). Finishing arches were .017" × .025" stainless steel.

Fig. 5 Case 1. Molar uprighting after three months (photo taken nine months later).

Fig. 6 Case 2. Mandibular right second molar tipped lingually and partially impacted, with only buccal surface exposed and in contact with opposing molar.

Fig. 7 Case 2. Second molar uprighted after several applications of superelastic nickel titanium torquing wire, totaling five months.

Case 3

An 11 1/2-year-old female presented with a Class II malocclusion, a deep overbite, a 10mm overjet, and a buccally tipped maxillary right first molar, which was also in crossbite.

The maxillary first premolars were extracted, and both arches were banded and bonded. Archwires progressed from .016" Australian (five months) to .018" Australian (two months), followed by .019" × .025" nickel titanium, all with accentuated curves of Spee. Space closure was carried out over another year with .018" Australian wires.

Eighteen months into treatment, an .0215" × .028" Neo Sentalloy wire (F200) with 180° lingual crown torque was applied to the maxillary right first molar (Fig. 8). After three months, space closure was continued with an .020" stainless steel wire with accentuated curve of Spee. Lingual crown torque was then resumed on the molar, using an .0215" × .028" Neo Sentalloy wire (F300) for one more month (Fig. 9).

Fig. 8 Case 3. Superelastic nickel titanium wire with 180° torsion applied to maxillary right first molar in buccal crossbite.

Fig. 9 Case 3. Correction of crossbite after two torquing applications, totaling four months.

Discussion

The forces measured in the laboratory and the results produced in clinical trials demonstrate that the 180° torsional force generated by Neo Sentalloy wires is suitable for correction of the following common problems:

- Buccal crossbite or buccal tipping of maxillary molars due to either ectopic eruption or orthodontic palatal expansion.
- Lingual tipping of mandibular molars due to transverse constricting mechanics.
- Severe lingual tipping of mandibular molars due to ectopic eruption and/or malocclusion. These cases are the most difficult to treat, since the molar may be tipped so severely that the buccal surfaces occlude with the opposing occlusal surfaces (Case 2).

In clinical use, the actual amount of torque is almost always greater than 180° because of the molar tipping. We have not used bite plates or other bite-opening appliances, but have noted no adverse effects when the technique was employed for short intervals of two to three months. Side effects such as occlusal canting, root resorption, root perforation through the lingual or buccal plate, extrusion, intrusion of the molar and adjacent teeth, and periodontal bone loss could occur if the wire were left in place for longer periods of time.

To avoid side effects, it is important to recall patients promptly whenever they miss appointments. One can also place a strong base archwire, such as .020" stainless steel, under the torquing wire from the adjacent premolar to the contralateral molar to prevent occlusal canting.

ACKNOWLEDGMENTS: The in vitro studies were conducted by Dr. May P. Chu in the Dental Materials laboratory at New York University College of Dentistry. The biostatistics were calculated by Dr. T.V. Vijayaraghavan in the Dental Materials laboratory at New York University College of Dentistry. The authors would like to thank Edward Marill, Tom Macari, Charles Schultz, and Chris Turner of GAC International, Inc., for providing the materials and instructions for this research project.

REFERENCES

1. Johnson, E. and Lee, R.S.: Relative stiffness of orthodontic wires, J. Clin. Orthod. 23:353-363, 1989.
2. Kapila, S. and Sachdeva, R.: Mechanical properties and clinical application of orthodontic wires, Am. J. Orthod. 96:100-109, 1989.
3. Miura, F.; Mogi, M.; and Ohura, Y.: Japanese NiTi alloy wire: Use of the direct electric resistance heat treatment method, Eur. J. Orthod. 10:187-191, 1988.
4. Khier, S.E.; Brantley, W.A.; and Fournelle, R.A.: Bending properties of superelastic and nonsuperelastic nickel-titanium orthodontic wires, Am. J. Orthod. 99:310-318, 1991.
5. Andreasen, G.F. and Morrow, R.E.: Laboratory and clinical analyses of Nitinol wire, Am. J. Orthod. 73:142-151, 1978.
6. Andreasen, G.F. and Hilleman, T.B.: An evaluation of 55 Cobalt substituted Nitinol wire for use in orthodontics, J. Am. Dent. Assoc. 82:1373-1375, 1971.
7. Drake, S.R.; Wayne, D.M.; Powers, J.M.; and Asgar, K.: Mechanical properties of orthodontic wires in tension, bending, and torsion, Am. J. Orthod. 82:206-210, 1982.
8. Harris, E.F.; Newman, S.M.; and Nicholson, J.A.: Nitinol arch wire in a simulated oral environment: Changes in mechanical properties, Am. J. Orthod. 93:508-513, 1988.
9. Miura, F.; Mogi, M.; and Okamoto, Y.: New application of superelastic NiTi rectangular wire, J. Clin. Orthod. 24:544-548, 1990.
10. Miura, F.; Mogi, M.; Ohura, Y.; and Hamanaka, H.: The superelastic property of the Japanese NiTi alloy wire for use in orthodontics, Am. J. Orthod. 90:1-10, 1986.
11. Miura, F.; Mogi, M.; Ohura, Y.; and Karibe, M.: The superelastic Japanese NiTi alloy wire for use in orthodontics, Part III: Studies on the Japanese NiTi alloy coil springs, Am. J. Orthod. 94:89-96, 1988.
12. Viazis, A.: Bioefficient therapy, J. Clin. Orthod. 29:552-568, 1995.
13. Rauch, E.D.: Torque and its application to orthodontics, Am. J. Orthod. 45:817-830, 1959.