A new torquing method for anterior tooth inclination control: a clinical report with a 7-year follow-up

Hyung-Kyu Noh, Ho-Jin Kim and Hyo-Sang Park
Department of Orthodontics, School of Dentistry, Kyungpook National University, Daegu, Republic of Korea

Appropriate orthodontic mechanotherapy, particularly in relation to incisor inclination control is a key consideration for successful treatment and the delivery of optimal aesthetics. A novel, easy, safe and effective torquing technique, termed Park’s cervical torque tie, has been devised. A female patient sought orthodontic treatment and presented with a Class II division 2 malocclusion with crowding but a favourable facial profile. The treatment plan involved the distal movement of the maxillary posterior teeth, decrowding and incisor inclination correction. Palatal root movement was applied to the retroclined upper incisors by a novel cervical torque tie. The treatment was successfully completed after the distalisation of the dentition and palatal root movement of the upper incisors. However, following post-treatment cone-beam computed tomography, less bone coverage was evident on the palatal surface of the upper incisors. After a seven year follow-up, the treatment results were well maintained, and cortical bone regeneration was confirmed.

Introduction
Retroclined upper incisors are a characteristic feature of a Class II division 2 malocclusion. The lingually tipped incisors not only impair smile aesthetics, but also interfere with normal masticatory function. For affected patients, the establishment of appropriate incisor inclination is a main therapeutic goal. Depending on the clinical situation, the treatment approach may vary. A consonant smile arc and an appropriate incisal display are components of an aesthetically pleasing smile. Therefore, when the upper incisor’s vertical position is normal, a pure moment, also known as a force couple, is needed to correct the steep incisal inclination without vertical tooth displacement.

Edgewise mechanics deliver the moment of a couple by twisting an archwire and its placement into a bracket slot. The 3rd order effect can be achieved either directly by bending the wire or indirectly by engaging the wire into brackets bonded with an adjusted slot inclination. However, regardless of the twisting type, several biomechanical drawbacks, for example, reciprocal movements, the round-tripping possibility, initial high orthodontic force level and abrupt degradation of effective moments, have been reported.

Park et al. have suggested microimplant-aided lever arm mechanics to manage a Class II division 2 malocclusion. A microimplant provides skeletal anchorage and a long lever arm cramped to the main archwire generates the required palatal root movement via a light continuous force. These mechanics addressed previous biomechanical shortcomings; however, the lever arm sometimes caused severe soft tissue irritation and oral hygiene issues, which restricted the application range. Therefore, the
A new simple and effective torquing method for the maxillary incisors: Park’s cervical torque tie

Figure 1 illustrates the force diagram of Park’s cervical torque tie. An elastic thread is tied to hooks which are crimped bilaterally between the lateral incisor and the canine. In addition, the thread can be tied from the archwire distal to the canine bracket, from one side to another, to increase the torque effects on the lateral incisors. Practically, a 0.017 × 0.025-inch SS wire is suggested for a 0.022-inch slot bracket to provide sufficient play for inclination control.
In this technique, there is no need to twist the wire for torque application and inclination control, as the force from the thread tie generates the necessary moment. The thread pushes the incisor's cervical area toward the palate. Simultaneously, the force of the thread, pulling the hook, is transmitted through the main archwire to the incisor's bracket position and pushes the crown labially. These two forces of the same magnitude $F$ and acting in the opposite direction, at different locations with distance $D$, constitute a force couple of magnitude $M = F \times D$ in the root palatal direction. The greatest moment is delivered to the central incisors, and a lesser moment may be applied to the lateral incisors.

The advantages of Park’s cervical torque tie are most evident when quantitatively analysed (Figure 1C, D). In the conventional wire twisting technique, the moment arm length cannot exceed the wire dimension. For example, the moment arm’s upper limit is 0.025 inches (approximately 0.64 mm) for a 0.019 × 0.025-inch stainless steel (SS) wire. In this case, the achievable effective moment is less than 1.28 N mm, even if a large orthodontic force of 2 N is applied. However, using Park’s torque tie technique, the moment arm can be adjusted in the range of 3 to 5 mm and even with a small orthodontic force of 1 N, a large moment of 3 to 5 N mm is available.

With changes in tooth inclination, the moment acts until the bracket slot wall is in tight contact with the edge of the wire. The tendency for crown labial flaring can be prevented by placing a bend at the distal of the terminal molar or by applying a distal force to the hook from an anchorage unit which can be a group of molars or a microimplant. When exerting palatal root movement to four incisors, the elastic thread can be tied to the main archwire at the

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**Figure 2.** (A, B) The cervical torque tie’s intraoral view. The composite resins on the cervical area prevent the gingival damage which can be caused by the gingivally displaced thread. (C, D) Diagrams showing the couple force direction. The grey tooth indicates the initial position, and the orange tooth represents the latter position. Depending on whether the thread is on the cervical or incisal area, palatal or labial root moment can be obtained.
distal of the canine instead of to the hooks. Gingival damage, which may be caused by gingivally displaced threads, can be prevented by a composite resin dam placed at the clinical crown’s cervical area (Figure 2A, B). To reduce the incidence of cervical erosion or caries, resin varnish may be applied onto the tooth surfaces, \(^{19,20}\) and to reduce food and plaque entrapment, an elastic thread with a hard and smooth surface texture is recommended. The direction of the force moment can be reversed simply by placing the thread on the incisal portion rather than the cervical area, resulting in palatal crown movement (Figure 2C, D).

Case report

Clinical assessment

A 21-year-old female patient visited Kyungpook National University Dental Hospital’s Orthodontics Department, Daegu, Republic of Korea, with the chief complaint of ‘I want to straighten my front teeth’. The facial profile was straight. Smile appearance was aesthetically pleasing with a consonant smile arc and acceptable incisal display. Intra-oral, moderate-to-severe crowding (11 mm in the upper arch, 6 mm in the lower arch), 2.5 mm depth in the curve of Spee, and U-shaped arch forms were observed. Class II canine and molar relationships were present on the right side, a Class II canine and Class I molar relationships on the left side, and 4 mm of overbite were noted (Figure 3).

Impacted upper third molars were identified on the panoramic radiograph. On the lateral cephalogram, the maxilla and mandible’s anteroposterior (AP) and vertical relationships were confirmed to be normal. The upper and lower incisors were retroclined (Table I).
Diagnosis and treatment objective
The patient was diagnosed with a Class II division 2 malocclusion with acceptable smile aesthetics. The treatment objectives were: (1) to obtain Class I canine and molar relationships; (2) to correct the anterior crowding and U-shaped arch form; (3) to improve the inclination of the upper and lower incisors; (4) to maintain the straight profile; and (5) to preserve the consonant smile arc and display of the upper incisors when smiling.

Treatment plan
Given the amount of crowding, premolar extractions were considered, however, the patient did not want teeth removed but distalisation of the posterior teeth was accepted. The treatment plan involved (1) the extraction of the upper third molars and distal movement of the upper posterior teeth to correct the occlusal relationships and obtain space to align the upper anterior teeth; (2) the placement of microimplants to control the anteroposterior position of the upper and lower molars; (3) Park’s cervical torque tie application to improve the inclination of the upper incisors; and (4) the use of a bonded anterior bite block to create space for lower incisor bonding.

Treatment progress
After extracting the upper third molars, 0.022-inch slot self-ligating brackets with an MBT prescription (Empower, AO, Sheboygan, WI, USA) were bonded to the upper posterior teeth and the lower arches and 0.016-inch Nickel-Titanium (NiTi) wires were inserted. To reduce the overbite, anterior bite blocks were also bonded to the palatal surface of the upper central incisors. Microimplants (diameter 1.3 mm, length 7 mm, SH1312-07, Absoanchor, Dentos, Daegu, Korea) were placed in the buccal alveolar bone between the upper second premolars and first molars, and between the lower first and second molars on both sides. A light distal force was applied to the first premolars from the microimplants using elastic threads (Super Thread, T-45, RMO, Denver, USA) (Figure 4A).

After three months of treatment, 0.016 × 0.022-inch SS sectional wires were placed in the upper arch. Distalisation of the upper molars was actively carried out. An elastic thread was also tied between the upper first premolars across the palate to prevent mesiobuccal rotation of the buccal segments (Figure 4B).

After four months of treatment, a 0.016 × 0.022-inch beta-titanium (TMA) wire was engaged in the lower arch. A light distal force was maintained to hold the lower molar’s AP position. After nine months of treatment, alignment of the lower dentition was completed. During the treatment course, the distalling force was applied as needed.

After 10 months of treatment, bilateral spaces were successfully created distal to the maxillary canines. Aesthetic brackets (0.022-inch slot, MBT prescription, Brillant, Forestadent, GmbH) were bonded onto the canines, and for alignment, 0.014-inch NiTi sectional wires were inserted (Figure 4C). The wire size was sequentially increased. After 12 months of treatment, 0.016 × 0.022-inch SS sectional wires were again placed and the molar-distalising and width-preserving forces, were continued.

After 16 months of treatment, upper incisor brackets were bonded. A 0.016-inch NiTi wire was inserted and a distal force via an elastic thread (Square Thread, ST-045, Dentos Co, Daegu, Korea) was applied to the canines from the microimplants. Another thread was tied to the archwire distal to the left canine bracket, to the same position on the right side, and the middle portion of the thread was placed on the cervical portion of the incisors to apply a lingual root force moment (Figure 4D). After 18 months of treatment, a 0.017 × 0.025-inch SS wire with short.

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Table I. Cephalometric measurements

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<tr>
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<th>Posttreatment</th>
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<tr>
<td>SNA (degree)</td>
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<tr>
<td>SNB (degree)</td>
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<tr>
<td>ANB (degree)</td>
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<td>Wits appraisal (mm)</td>
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<td>FMA (degree)</td>
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<tr>
<td>U1 to FH (degree)</td>
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<tr>
<td>(degree)</td>
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<tr>
<td>Upper lip to E-line</td>
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<td>(mm)</td>
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<tr>
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</tr>
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<td>(mm)</td>
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Figure 4. Treatment progress. (A) Initiation of treatment. (B) Three-month intraoral photograph. (C) 10-month intraoral photograph. (D) 16-month intraoral photograph. (E) 18-month intraoral photograph.
hooks was engaged. However, the canine relationship on the right was still Class II. A distal force was therefore applied to the hook from the microimplant on the right, and a light holding force was applied to the left canine from the microimplants in addition to a cervical torque tie between the hooks (Figure 4E).

After 29 months of treatment, Class I canine and molar relationships were achieved with improved incisal inclination (Figure 5). However, a crossbite was identified on the right second molars. An overlay expansion archwire and cross-elastics were used to expand maxillary arch width.

After 36 months, the treatment was completed. A lingual bonded retainer was provided on the lower anterior teeth, and removable circumferential retainers were delivered to the upper and lower arches. An anterior bite plate was incorporated into the upper retainer.

**Treatment result**

The facial profile remained straight, and the smile arc and incisal display were maintained. A normal overjet and shallow overbite were obtained with Class I canine and molar relationships. The upper and lower incisor inclination improved (Figure 6). Pre- and post-treatment cephalometric superimpositions revealed the maxillary molar distalisation and palatal root movement of the central incisors (Figure 7). The lower incisors were proclined and the lower molars were extruded, resulting in a mandibular clockwise rotation.

Pre- and post-treatment CBCT superimposition showed asymmetric molar distalisation (Figure 8).

The right second molar was distalised by 4.81 mm while the left was moved 2.78 mm, reflecting the initial asymmetric occlusal relationship. Mild root resorption was evident on the post-treatment CBCT images (Figure 9). In the post-treatment CBCT images, there appeared to be less bone coverage over the palatal surface of the maxillary left lateral incisor, right central incisor, and right lateral incisor (Figure 9). As the patient did not complain of any symptoms, careful monitoring was prescribed.

After seven years of follow-up, the overall treatment outcome was well maintained. During this period, there were neither signs of relapse nor clinical discomfort (Figure 10). CBCT scans, taken seven years later, revealed the increased cortical bone coverage on the upper incisor’s palatal surface (Figure 9).

**Discussion**

Retroclined upper incisors are a characteristic problem of a Class II division 2 malocclusion or an improperly managed premolar extraction case. As this condition is aesthetically and functionally of concern, restoring proper axial inclination of the upper incisors has been a desired objective of orthodontic treatment.1–3 If intrusion of the upper incisors is required in the management of their retroclination, or if an excessive gummy smile, or a deep curve of Spee is present, inclination control and intrusion can be simultaneously attempted by applying an intrusive force using a microimplant or intrusion arch.6,7 Otherwise, as presented in the described case, the moment of a force couple would be appropriate
to achieve palatal root movement.\textsuperscript{6,7} The key is the application of the appropriate force couple to the incisors. Conventional techniques, such as archwire bending, a torquing arch or preadjusted brackets, deliver the moment by the archwire twisting in the bracket slot. Considering the small dimension of a 0.018 or 0.022-inch slot, a strong orthodontic force is necessary to obtain a clinically effective moment of 5 to 20 N mm.\textsuperscript{6,21–23} Due to the SS wire’s high torsional stiffness and limited range, the produced moment tends to be initially high but diminishes during the course of its action, which is not desirable for the efficiency and accuracy of tooth movement.\textsuperscript{8,22,24} In addition, reciprocal movement of adjacent teeth is unavoidable, and thereby the possibility of round-tripping which is a predisposition for orthodontically-induced external root resorption.\textsuperscript{6,8,25} The appliance configuration presented in this clinical report, is a modified version of previously-suggested lever arm mechanics, which resolved the biomechanical drawbacks of a long lever arm attached to the main archwire.\textsuperscript{7} A long lever arm sometimes caused soft tissue irritation and poor oral hygiene\textsuperscript{9} and so was shortened. The apparent absence of a palatal root moment was supplemented by Park’s cervical torque tie. The moment applied by the torque tie is determined by the thread force ($F$) multiplied by the height ($D$) of the thread with respect to the main archwire. A sufficient moment can be obtained even with a small orthodontic force by virtue of a moment arm of 3 to 5 mm. After 11 months of continuous application of the cervical torque tie, the treatment was completed, proving its moment-delivering ability.
The biomechanics, depicted in Figure 1, is essentially the same as that of a piggyback arch in the Begg technique. However, the torque tie thread method has many advantages over a piggyback wire. Clinically, the cervical torque tie can be easily implemented without complex wire bending. The magnitude of the moment can be adjusted simply by changing the force and/or the position of the thread. Since this method may aesthetically and hygienically be superior to a wire auxiliary, it can be applied without concern during the space closing phase of premolar extraction cases.

An additional unique feature of the mechanics was that a 0.017 × 0.025-inch SS wire may be chosen as the main archwire, despite the need for third-order control. In conventional torque control mechanics, a full size 0.021 × 0.025-inch TMA wire is usually preferred for providing torque and, unlike a SS wire, the force level and its degrading pattern remains in a biologically acceptable range. However, even with the use of a TMA wire, the risk of reciprocal and jiggling movement on adjacent teeth may still occur and best avoided by minimising twist in the wire. Imprecision is a factor that diminishes a bracket’s torque expression in conventional mechanics. However, there should be a play between the wire and bracket slot in the presented torque tie method. The thread force produces a lingual root moment, and the movement of the teeth continues until the bracket slot contacts the edge of the wire. If more inclination control is required, wire twist can be incorporated, not to produce a torque moment but rather, to provide play for the movement. In this case, a 0.017 × 0.025-inch SS wire was inserted...
into the -0.022-inch slot MBT prescription bracket without twisting the wire. Although the bracket torque prescription was 17°, there was play of 15.5°; therefore, the actual effective torque was only 1.5°. Park’s cervical torque tie successfully produced lingual root movements. As the palatal root movement from a light cervical torque tie force exerted a gradual and long-range light moment on the upper incisors, there was minimal root resorption despite the considerable amount of palatal root movement.

As the occlusal relationship was initially asymmetric, more distalisation was required on the right than on the left side, as depicted in Figure 8. A large amount of molar distal movement can bring about a molar crossbite owing to the shape difference of the basal bone between the maxilla and the mandible. In the middle of the treatment, a crossbite developed involving the second molars, and the corrected overjet of the second molars was minimal at the end. The crossbite, which could not be completely resolved, may have been a clinical sign indicating that the right upper molars almost reached their distal limit.

A treatment goal was to maintain a straight profile. Therefore, the antero-posterior position of the incisor crowns had to be maintained. This was confirmed via pre- and post-treatment cephalometric superimposition. Severe crowding and severely retroclined upper incisors require significant palatal or distal root movement of the maxillary incisors and canines. This considerable amount of palatal or distal root movement resulted in unexpected outcomes, one of which was less bone coverage on the palatal surface of the upper incisors.

The total treatment period was relatively long. The main reason is believed to be the long period to resolve the severe crowding of the maxillary dentition. A lack of 11 mm of space usually requires premolar extraction. At the patient’s request, non-extraction treatment was decided and, as a result, a large amount of distal movement of the posterior teeth was required. Hence, it took 29 months to unravel the crowding and improve the occlusal relationships. After 18 months of treatment, a 0.017 × 0.025-inch SS wire was inserted into the maxillary arch, and a cervical torque tie was placed. The 11-month time required to improve the inclination was similar to the time required for usual root torque control. This treatment technique was introduced for the first time; therefore, there is no related study comparing the treatment period with other methods. Further studies on this topic are indicated.
The potential side effects of the presented technique might be the possibility of gingival damage, plaque retention, and an increased chance of cervical erosion or caries. The gingival damage from a displaced thread can be prevented by adding a resin dam on the cervical area (Figure 2) after resin varnish application to reduce cervical erosion. Plaque retention can be minimised by an elastic thread with a hard and smooth surface texture. More importantly, close attention should be paid to avoid the possible side effects of the technique during treatment.

It was confirmed that the presumed bony dehiscence at the palatal surface of the upper incisors was recovered by thick palatal cortical bone over the seven post-treatment years. Controversy exists regarding the regeneration of a bony dehiscence.\textsuperscript{11–13,15–17} Recently, a reported clinical case has shown dehiscence remodelling over anterior palatal alveolar bone.\textsuperscript{18} In that study, the thick and healthy palatal gingiva was assumed to be a contributing factor by protecting the periodontal ligament containing the necessary cells for bone regeneration. A similar effect might be applicable to the present case, or newly-formed bone of less density was not apparent on the radiograph. With time, the bone matured and increased in density enough to be seen at the 7-year follow-up CT. Further histological and statistical studies are indicated.

Figure 10. Seven-year follow-up extra- and intraoral photographs.
Summary
A new, easy to apply and safe torquing method using elastic thread was introduced. The palatal root movement could be successfully delivered by a light continuous force while minimising biomechanical side effects. Presumed palatal bony dehiscence, caused by significant palatal root movement of the upper incisors beyond the alveolar bone housing was restored by deposited cortical lining during the seven years of follow-up. Further research on the investing bone and its remodelling is indicated.

Corresponding to
Hyo-Sang Park, DDS, PhD, Professor and Chair, Department of Orthodontics, School of Dentistry, Kyungpook National University, Daegu, Korea
Email: parkhs@knu.ac.kr

Conflict of interest
The authors declare that there is no conflict of interest.

References