Open coil traction system

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Sliding mechanics have become a popular method for space closure, with the development of preadjusted edgewise appliances. Furthermore, various space closing auxiliaries have been developed and extensively evaluated for their clinical efficiency. Their effectiveness is enhanced with optimum force magnitude and low load deflection rate/force decay. With the advent of nickel-titanium (Ni-Ti) springs in orthodontics, load deflection rates have been markedly reduced. To use Ni-Ti springs, clinicians have to depend upon prefabricated closed coil springs. The open coil traction system, or open coil retraction spring, is developed utilizing Ni-Ti open coil springs for orthodontic space closure. This article describes the fabrication and clinical application of the open coil traction system, which has a number of advantages. It sustains a low load deflection rate with optimum force magnitude, and its design is adjustable for a desired length and force level. It is fail-safe for both activation and deactivation (ie, it cannot be overactivated, and the decompression limit of the open coil is controlled by the operator). The open coil traction system can be offset from the mucosa to help reduce soft tissue impingement. ORTHODONTICS (CHIC) 2012;13:e153–e161.

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With the development of preadjusted edgewise appliances and low friction brackets, sliding mechanics have become a popular method for space closure. Various retraction force techniques have been developed with sliding mechanics such as elastic modules, ligature lacebacks, elastomeric chains, and closed coil springs. Most have been extensively evaluated for their efficiency.4-14 Their efficiency was enhanced with optimum force magnitude and low load deflection rate/force decay. Load deflection rate/force decay has been markedly reduced with development of nickel-titanium (Ni-Ti). To use Ni-Ti, the clinician has to depend upon prefabricated closed coil springs, which are commercially available in a fixed length with prefabricated hooks. Preparing and incorporating the engaging hook into closed coil spring from a spool is a complicated task. With mini-implant anchorage, special attachment hooks are necessary for preformed closed coil springs. Clinicians have to depend upon different grades (light, medium, heavy) or different lengths (7 to 12 mm) of closed coil springs for varying the force level at different situations.

This article describes a procedure for the construction and clinical application of the open coil traction system (or open coil retraction spring). The open coil traction system serves an efficient auxiliary for space closure in sliding mechanics with preadjusted edgewise appliances and is constructed using an Ni-Ti open coil spring.
FABRICATION AND CLINICAL APPLICATION

The open coil traction system is constructed using an Ni-Ti open coil spring. The length of the open coil to be constructed depends upon the span between anterior (crimped hook on archwire) and posterior (molar hook or mini-implant head) hooks and the amount of extraction space. Thereby, the design and fabrication of the open coil traction system is described with the distance between the anterior and posterior hooks to be 25 mm and premolar extraction space of about 8 mm.

- Take 18 mm of 0.030-inch Ni-Ti open coil spring and anneal its terminal ends (about two-two coils at both ends) (Fig 1).
- Take two 3.5-cm pieces of 0.014-inch stainless steel wire guide wires, and prepare a double helix at one end in each guide wire to form a helical stop. Keep the plane of the helical stop perpendicular to long axis of guide wire and its diameter approximately equal to that of the Ni-Ti open coil lumen (Fig 1).
- Insert both guide wires (straight parts) through the open coil spring from both sides (lumen opening), and pass them through the entire lumen coaxially toward each other (ie, in opposite directions) (Fig 2) and through the helical stop of the opposing guide wires (Fig 3). Completely stretch the penetrated guide wires of both sides and compress the open coil spring in between the two helical stops.
- Prepare a first round engaging hook in one of the guide wires. By doing so, the open coil gets compressed from 18 to 14 mm. This will be the anterior side of the open coil traction system for engaging the anterior attachment on archwire (Fig 4a). (Annealing the terminal parts of the open coil causes early compression in only those parts, abutting well with the helical stop. As such, poking of the free ends of the Ni-Ti open coil wire is avoided.)
- Prepare a second round engaging hook in another guide wire at other end of spring. This will be posterior side of the open coil traction system for engaging the posterior attachment (molar hook or mini-implant head). The recommended total length between the two hooks of the open coil traction system at rest position is about 17 mm (Fig 4b). Although the initial length of the open coil was 18 mm, its final configuration in the open coil traction system became 14 mm.
- Confirm the extent of open coil traction system activation by stretching the hooks apart (Fig 5a).
- In one modification of the open coil traction system, an intermediate helical stop may be prepared if controlled and limited space closure or retraction is desired (Fig 5b). In cases in which closing force is not desirable after a certain amount of space closure, this intermediate helical stop is helpful since it does not allow further decompression of the open coil spring.
- In modus operandi of the open coil traction system, when applied for premolar extraction case, its total length at rest position (17 mm, distance between two round engaging hooks) is about 8 mm shorter than the span between anterior and posterior points of attachments (crimped hook on archwire anteriorly and molar hook or mini-implant head posteriorly, which is about 25 mm) (Fig 6a). During space closure, the open coil in open coil traction system decompresses with approaching toward its rest position (Figs 6b and 6c).

In case of mini-implant anchorage, prepare posterior engaging round hook adequate in size, so that it easily engages over the mini-implant head. If the ligature hole is existing in the mini-implant head, posterior engaging round hook is not necessary, as posterior guide wire can be directly inserted through it and cinched/bent back (Fig 7).
Fig 1 Components in the construction of the open coil traction system.

Fig 2 Straight parts of both guide wires are inserted through both sides of lumen opening of the open coil spring and passed through entire lumen toward each other (in opposite directions).

Fig 3 After insertion through the lumen of open coil, the straight parts of the guide wires also pass inside the helical stop of the opposing guide wires.

Fig 4a First (anterior) engaging round hook prepared in one guide wire.

Fig 4b The open coil traction system in its rest position. Although the initial length of open coil was 18 mm, in final configuration, it is compressed to 14 mm. The total recommended length of the open coil traction system at rest (distance between two engaging hooks) is about 17 mm.

Fig 5a The extent of the open coil traction system activation is checked by stretching both engaging hooks apart.

Fig 5b In one modification of the open coil traction system, an intermediate helical stop is prepared in the middle of the guide wire.
Open coil traction system

Fig 6 Schematic diagrams depicting the modus operandi of the open coil traction system, when applied for a first premolar extraction case. (a) At rest, the open coil traction system is 8 mm shorter than the total span between the molar hook and anterior archwire hooks. (b) With activation, the open coil gets sandwiched between two helical stops. (c) With deactivation of the open coil traction system, space closure is achieved.

Fig 7 Instead of a posterior engaging round hook, a posterior guide wire was directly inserted through a ligature hole available in the mini-implant head and cinched/bent back.
CASE REPORT

Diagnosis and treatment plan
A 20-year-old woman presented with the chief complaints of bimaxillary protrusion, convex profile, and protrusive lips (Fig 8). She was diagnosed as mild skeletal Class II and dental Class I malocclusion with bialveolar protrusion and mild horizontal growth pattern. Treatment plan called for first premolar extractions to resolve proclination considering as group B anchorage case. Use of transpalatal bar was decided for controlling anchorage and open coil traction system as a space-closing auxiliary.
The 0.018-inch preadjusted edgewise brackets were bonded. After 2 1/2 months, alignment and leveling were completed in both arches and the four first premolars were extracted (Fig 9). Space closure was started with conventional sliding mechanics and considered as case of group B anchorage. Coordinated arch forms and precurved 0.016 × 0.022-inch stainless steel continuous archwires in both arches were used to prevent the bite from deepening during retraction as per conventional sliding mechanics with preadjusted edgewise brackets. A partly prefabricated custom-made open coil traction system was used for en masse retraction. They were stretched and engaged posteriorly over first molar hooks and anteriorly to the hook on archwire (Fig 10). Forces delivered by the open coil traction system were calibrated and optimized with tension gauge to deliver 250 to 300 g. At the end of 1 year, space closure was completed (Fig 11) without adverse effects and bimaxillary proclination was resolved. Retraction springs did not show any signs and symptoms of soft tissue irritation and distortion. Maxillary wraparound and mandibular Hawley retainers were delivered.
Fig 12  Posttreatment photographic and cephalometric record, as well as pre- and posttreatment cephalometric superimposition.
Treatment results
After 15 months of total active treatment, the treatment goals had been achieved. The maxillary and mandibular anterior teeth were retracted and uprighted, approaching their normal position over the basal bone, and the patient showed a good Class I dental relationship. Space closure was completed without adverse effects. With retraction of the upper and lower lips, the facial profile was improved (Fig 12).

DISCUSSION
The modus of force generation with the case was decompression of the compressed open coil spring. This decompression force was used here to generate the definitive traction system.

Springs with larger lumen size and smaller wire diameter are indicated for orthodontic use because of their more constant force production. The lumen size of the open coil spring (0.030-inch) used in the open coil traction system is definitely larger than that of today's commercially available closed coil springs. Boschart et al compared the load-deflection rates of 10-mm lengths for variety of open and closed coil springs. The advent of Japanese Ni-Ti archwires led to the introduction of the Ni-Ti coil spring. Miura et al studied the differences between the Japanese Ni-Ti open and closed coil springs and stainless steel springs. The closed coil springs made of stainless steel showed a linear relationship between the load and deflection. The Ni-Ti springs, however, demonstrated a superelastic effect, with a constant load for a large range of deflection. Miura et al also indicated that open coil springs deliver a relatively more constant load value in superelastic region than the closed coil spring. Thus, a more desirable continuous force can be obtained from the open coil spring than the closed coil spring. Superelastic activity is evident when the open coil spring is compressed from 75% to 15%. Miura et al showed the clinical applicability of the open coil spring with wire a diameter of 0.012-inch, lumen of 0.030-inch, and 150 g of superelastic activity when the spring was compressed between the maxillary central incisor and canine. When the pitch of the coil spring is changed from fine to coarse, the load value of superelastic activity can remain the same and the range of superelastic activity increases.

In the case shown here, the open coil traction system provided an efficient method for the extraction space closure and offered a number of advantages:

- The use of Ni-Ti open coil maintains a low load deflection rate, while the design is adjustable for the desired length and force level. At varied distance between the anterior and posterior attachments, the same spring can be adjusted to control the force levels by varying guide wire length while preparing the second engagement hook. (For excessive span between the posterior molar hook and the anterior archwire hook, the desired magnitude of force may be delivered without overcompression of the open coil traction system just by increasing one guide wire length.)
- It is fail-safe for both activation and deactivation—it cannot be overactivated, and the decompression limit of the open coil is controlled by the operator.
- A possibility to offset the open coil traction system from the mucosa reduces its soft tissue impingement.
- The size of posterior engaging hook may be customized according to the size and shape of posterior attachment. In case of miniscrew anchorage, engaging hook is fabricated enough in size so that it engages miniscrew head easily. Sometimes, posterior hooks in the open coil traction system may not be required if a hole is present in the mini-implant head.
By marking guide wires at specific intervals, the force exerted by the spring may be calibrated.

It is more economical than the closed coil spring, and partial prefabrication in stock reduces chair time and requires only minor adjustments of guide wire length and hook preparation.

With this innovation, the clinician does not have to depend on only conventional approaches. The open coil traction system serves an alternative and has the advantage of a low load deflection rate and a long range of action.

REFERENCES