THE HYBRID ORTHODONTIC TREATMENT SYSTEM (HOTS)

This paper describes the Hybrid Orthodontic Treatment System (HOTS), an innovative method used in first premolar extraction cases. It comprises the following three components: (1) a miniscrew, (2) dual-dimension wires, and (3) multiloop edgewise archwires. HOTS consists of four clearly defined treatment steps: (1) setup, (2) leveling, (3) separate but simultaneous anterior and canine teeth retraction, and (4) final adjustment. HOTS achieves a predictable treatment outcome with a shorter treatment time. World J Orthod 2010;11:168–179.

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For the treatment of first premolar extraction cases with edgewise mechanics, the traditional methods of retracting the six anterior teeth are initial retraction of the two canines followed by the retraction of the four incisors (two-stage retraction)\(^1\)\(^–\)\(^4\) or moving all six anterior teeth lingually (en masse retraction)\(^5\),\(^6\). Each method has its advantages and disadvantages. The former has an advantage when retracting the canines; they can travel along the alveolar trough, which is between the labial and lingual cortical bone in the narrow canine area. This method requires a longer treatment time because each separate retraction can take as long as 6 months to complete. In the latter method, it is advantageous that the full retraction can be started earlier than in the former method, but the direction of the canine retraction might not be as favorable because the canines are retracted straight backward, which interferes with the lingual cortical bone. Consequently, this may lead to prolonged treatment times. What is needed then is an efficient treatment system that achieves predictable treatment outcomes with a shorter treatment time without being dependent upon patient compliance.

Three advances in the field of orthodontics have led to the creation of a new treatment system for first premolar extraction cases: (1) the miniscrew\(^7\)\(^–\)\(^9\); (2) the dual-dimension wire (DDW), which has an anterior rectangular portion and a round posterior portion\(^10\); and (3) the multiloop edgewise archwire (MEAW), which is a 0.016 × 0.022-inch stainless steel rectangular wire with multiple L-loops.\(^1\)(\(^1\)\(^1\))\(^1\)(\(^1\)\(^2\)). Because this new system combines these three devices with a new treatment concept, it is named the Hybrid Orthodontic Treatment System (HOTS). This paper describes HOTS and illustrates its use with a case report.
HOTS

The essential feature of this system is the insertion of miniscrews into the buccal sides of the maxillary alveolar bone usually between the maxillary second premolars and the first molars, allowing the maxillary canines to be retracted along the canine curvature with the round portion of the DDW, simultaneously retracting the four incisors with the rectangular portion controlling their torque (Fig 1). Simultaneous movements are achieved with the utilization of multiple elastomeric modules or closed coil springs that run from the inserted miniscrew on the left and right sides of the maxillary arch, respectively. This method of anterior retraction clearly differs from the previously mentioned traditional methods. In the finishing stage, after the closure of the extraction space, MEAW is used to further fine-tune the overjet, overbite, and posterior occlusal relationship. Thus, HOTS combines the simplicity of the sliding mechanics with the versatility of the MEAW treatment method, improving treatment efficiency and quality without being dependent upon the patient compliance, which is one of the major unpredictable factors in orthodontic treatment.

HOTS SETUP

HOTS can use either standard or preadjusted edgewise bracket systems. In this paper, all descriptions are made presupposing a 0.018-inch slot size. Users of the 0.022-inch slot size should adjust the size of the wires accordingly. Double buccal tubes are used for both the maxillary and mandibular first molars to control the anterior overbite by using intrusion arch mechanics.13,14 Because headgear is not used in this system, the auxiliary tube at the maxillary first molar is used to accommodate auxiliary archwires. The double tube is also used, especially in the mandibular arch, to accommodate the distal end hook (DEH), which was developed to allow an alternative to miniscrews (Fig 2). In HOTS, miniscrews are usually placed only in the maxilla and first molar bilaterally. In our experience, miniscrews placed in the mandible are likely to have a greater tendency to fail. This observation is in accordance with the results obtained by Sung et al.15 In addition, it is more difficult to place miniscrews in the proper position due to the narrow attached gingival area. Besides, the broad mesial surface areas of the roots of the mandibular molars leads to less anchorage loss than that of the maxillary first molars, providing they are protracted in an upright position, something that is possible with the DEH. Insertion of miniscrews in the mandible is considered only if maximum anchorage is required.

DISTAL END HOOK

The DEH is 5 to 7 mm in height and inserted from the posterior to the anterior through the mandibular first molar auxiliary tube (Fig 2a). As this hook is currently not marketed, the clinician has to create one by bending 0.017 × 0.025-inch stainless steel wire. To reduce deformations, prior to use, the hook needs to be heat treated to increase its stiffness. The DEH is a removable auxiliary device, which can be utilized only when its use is indicated. As the point of force application is near...
the center of resistance, the mesial tipping tendency of these teeth will be prevented, as well as increasing anchorage. When protraction of the mandibular posterior teeth is intended, though, the DEH enables bodily mesial movement of these teeth, although the protracting speed is significantly reduced (Figs 2b and 2c).

One possible adverse effect of this force system is the occurrence of buccal flare out of the distal part of the mandibular first molars and the consequent buccal displacement of the adjacent second molars. There are two ways to avoid this unfavorable effect. One is to counterrotate the first molar by incorporating a strong distal offset. The other is to make the second molars occlude tightly to accomplish stabilization. Of course, stiff continuous archwires, including DDWs, should be used rather than thin archwires, soft archwires, or MEAW because all of these wires allow relatively free and uncontrollable individual tooth movement.

Fig 2 (a) Insertion of DEH at the mandibular left first molar, (b) DEH in place with a coil spring to an anterior hook, and (c) position of the molar after space closure. Note how the tooth has become upright by comparing it with the lamina dura showing the previous position.

Fig 3 Wires used in HOTS with 0.018 × 0.025-inch bracket slots.
ARCHWIRES USED IN HOTS

For 0.018 × 0.025-inch slot edgewise bracket systems, the following sequence of five archwires are usually used (Fig 3): 0.012-inch Ni-Ti round archwire, 0.014-inch or 0.016-inch round Ni-Ti archwire, 0.016 × 0.022-inch rectangular Ni-Ti archwire, DDW (anterior 0.017 × 0.025-inch rectangular and posterior 0.016-inch round archwire for the 0.018-inch slot size), and MEAW (0.016 × 0.022-inch stainless steel archwire with multiple L-loops). The MEAW is used effectively in the final stage of the treatment to solve any residual problems, such as slightly more or less than optimal overjet or overbite, with poor occlusion of the posterior teeth, even after all the spaces have been closed. MEAW also works very efficiently in flattening the dumped dentition often seen after closing the extraction space (see the Case Report section of this article, Fig 9e).

STEPS IN THE HOTS TREATMENT

The HOTS treatment consists of four clearly divided steps (Fig 4), and the predicted total treatment time ranges from approximately 18 to 22 months, averaging around 20 months.

Stage I (1 to 2 months)

Insertion of the miniscrews in the maxilla and bond-up of both arches followed by the insertion of an initial leveling arch of 0.012-inch Ni-Ti wire. The first premolars to be extracted are also temporarily bonded with the bracket height 1 mm more gingival than the adjacent teeth to loosen and extrude these teeth to make extractions easier. The extractions of the first premolars are intentionally delayed until after the initial leveling so that canine retraction can utilize the enhanced tissue reaction at the extraction site (Fig 4a).
Stage II (5 to 6 months)

This stage consists of leveling the maxillary and mandibular arches and can be subdivided into the following three sub-stages:

Stage II-1. Leveling with 0.014- or 0.016-inch Ni-Ti archwire and extraction of the first premolars followed by the immediate start of canine retraction (Fig 4b).

Stage II-2. Further leveling and canine retraction with 0.016-inch Ni-Ti archwire (Fig 4c). Normally, the maxillary canine is pulled to the miniscrew, and the mandibular canine is pulled to the DEH.

Stage II-3. Further leveling with 0.016 x 0.022-inch Ni-Ti archwire (Fig 4d). To achieve the full leveling of the posterior teeth, a larger Ni-Ti archwire (for example, 0.017 x 0.025-inch) can be used. Canine retraction at this stage is optional. They can be further retracted in Stage III along the round portion of the DDW.

Stage III (6 months)

Simultaneous retraction of the canines and the additional four incisors by multiple traction modules, such as elastomeric modules and coil springs on the DDW (Fig 4e).

Stage IV (6 months)

Final overjet and overbite correction and settling of posterior teeth with MEAW (Fig 4f). In the limited number of cases that do not require any further correction, this final stage can be omitted.

DUAL-DIMENSION WIRE

The DDW comprises an anterior rectangular portion (0.017 x 0.025-inch) and a posterior round portion (0.016-inch), which fits the 0.018 x 0.025-inch slot edgewise bracket system. For the 0.022-inch slot bracket system, a somewhat thicker wire size (0.019 x 0.025-inch) should be used. If a clinician prefers to use this combination, an additional 13 to 15 degrees of torque may be necessary for better control of the incisors to compensate for the increased play. When DDW was introduced in the early 1980s by Wool, miniscrews were not yet commonly available, and the DDW was used with intra- and/or intermaxillary elastics; however, the control of posterior teeth was insufficient with this combination since the posterior portion of this wire was round, which allowed too much play in the rectangular slot. In contrast, using DDW to retract the anterior teeth from the MISs (rather than from the anchor teeth) allows more efficient retraction of the anterior teeth, causing much less friction in the posterior region. Thus, the potential of the DDW can be fully expressed only in combination with miniscrews.

CONSIDERATIONS ON THE FORCE APPLICATION

During the retraction of the maxillary anterior teeth, there are three types of sagittal movements: lingual crown tipping, bodily movement, and lingual root tipping. Sia measured the initial displacement of the maxillary central incisor in vivo when a retraction force parallel to the occlusal plane was applied at different levels of vertical hooks soldered bilaterally between the lateral incisor and the canine onto the 0.016 x 0.022-inch Blue Elgiloy wire (Rocky Mountain Morita). These results imply that when the hook is placed approximately 7 mm above the bracket slot and MISs are inserted at the same level in the posterior region, it becomes possible to retract the anterior teeth almost bodily. Theoretically, if the height of the hook is below this level, the anterior teeth will be retracted with accompanying lingual crown tipping, and if it is above this level, they will be retracted with lingual root tipping. In a later in vivo study, Sia et al. found that the center of resistance was located at 0.78 of the root length from the root apex. For an average sized maxillary incisor (23.8 mm) in Japanese populations, it is equivalent to a point 8 mm above the average slot height.
DEVELOPMENT OF A NEW VARIABLE HEIGHT CRIMPABLE VERTICAL HOOK

The Sia et al study inspired the development of a new type of crimpable vertical hook that has three labial disks placed at the heights of 4, 6, and 8 mm (Fig 5). This crimpable hook was designed to allow retraction of the four maxillary incisors in three different modes when retracted from the heights of 4, 6, and 8 mm: tipping movement, controlled tipping movement, and bodily movement, respectively. The lower level disks can also be used to allow the direction of the force to be more horizontal when the residual space has to be closed by protracting the posterior teeth. Figure 1 illustrates Stage III of HOTS, which is the simultaneous space closing stage using the DDW and the newly developed crimpable vertical hook, which was named the Discopender468.

AMOUNT OF FORCE USED WITH HOTS

The amount of force used with HOTS may be about half that of the conventional en masse retraction method used, due to the significantly decreased amount of friction generated by the 0.016-inch round wire sliding through the 0.018 × 0.025-inch slot. The amount of friction will be almost negligible if a self-ligation type bracket is used in the posterior region. In HOTS, the appropriate amount of force necessary for the canine retraction, sliding on the 0.016-inch round wire, will be around 100 cN. For the retraction of the four incisors, a total of 300 cN (150 cN on each side) of force will be applied, exerting 75 cN of force on each tooth. This will be approximately half of the amount used with conventional en masse retraction. An adequate amount of play between the round portion of the DDW and the rectangular slot, and the significantly lower level of force used in this system, will eliminate the unfavorable side effect of intrusion of the maxillary posterior teeth and a resultant rotational change of the entire dentition, which is frequently observed with the conventional en masse retraction system in combination with inserted miniscrews.

DEVELOPMENT OF A NEW CLOSED COIL SPRING

To bring the abovementioned light force concept into practice, an adjustable single-eyelet Ni-Ti closed coil spring, which is preset to exert exactly 100 cN of force when activated to the lengths of 1 cm, was developed. With this unique coil spring, what a clinician has to do in the retraction phase (Stages II and III) is to maintain the designated length of the spring, not to measure the amount of force which is more cumbersome, to apply the exact preset amount of force at each adjustment. This coil spring, therefore, was named the smart coil spring (SCS) (Fig 6).
DISCUSSION

Traditionally, in the treatment of first premolar extraction cases, two major anterior retraction methods have been used: the two-stage retraction method and the en masse retraction method. Although the first approach seems to exert better biomechanical control over the canine movement, its major shortcoming is the extended time required for the retraction of the six anterior teeth because the retraction of the four incisors starts only after the completion of the retraction of the canines. The narrow corner area where the canine is located is supported by hard labial and lingual cortical bone of the alveolar ridge (Fig 7). Retraction of the canines separately along the corner curve (as with the two-stage retraction method) will provide more favorable outcomes because it is possible to avoid having the roots of these teeth interfere with the cortical bone, compared to when one is retracted straight backward with thick rectangular wire (as in the en masse retraction method) (Fig 8a, left).

With HOTS, the canines are retracted along the corner curve of the canine area, sliding on the round portion of the DDW, while the four incisors are retracted simultaneously using the rectangular anterior portion. The canines can travel along the alveolar trough smoothly without having their roots interfere with the cortical bone because they can wiggle around the round wire while they are traveling (Fig 8a, right).

In Stage II, while the canines are traveling along the less stiff 0.016-inch Ni-Ti round wire, the distal tipping of the canine and consequent deepening of the anterior bite may occur because the line...
of action of the retraction force passes below the center of resistance. Development of longer canine hooks may be the simplest and the best solution for this problem. Nevertheless, this tendency will not be of importance because the canines travel only a short distance in this stage. They are retracted only to resolve the crowding in the anterior region. The major retraction of the canines occurs during Stage III, together with the incisors, sliding on the much stiffer round portion of the DDW. Although the canines may also demonstrate a distal tipping tendency in this stage, the 8-mm-long vertical hooks placed bilaterally between the lateral incisors and canines will prevent deepening of the anterior bite. The anterior segment of the archwire will be raised upward by the cantilever effect derived from the bending movement produced at the junction of the vertical hooks and the archwire. Anterior bite deepening, a consequence of distally sliding canines, will not occur with the mechanics at work in Stage III. This opinion has been well-supported by the recent 3D finite element method study.22

Thus, HOTS simultaneously achieves the full merits of the round wire sliding mechanics for the canine retraction and the full torque control of the anterior teeth. Furthermore, with the en masse retraction method, the canines tend to move inward as they are retracted backward, requiring further correction of the arch form after the completion of the retraction (Fig 8b). Since HOTS allows the canines to move along the canine curvature, further correction of the arch form should not be required. This lack of necessity for arch form correction with HOTS will further reduce treatment time.

**CASE REPORT**

The treatment procedure of a 23-year-old woman with a Class II steep mandibular plane is described in Figs 9 to 12. The active treatment time was a mere 20 months. Treatment with four first premolar extractions followed by HOTS was applied to improve her facial profile, as well as to resolve her severe crowding. HOTS was used to fully utilize the extraction space without affecting the mandibular plane, which was already steep at the onset of treatment. In this patient, the use of Class II elastics would have aggravated the condition with a clockwise rotation of the mandible as a consequence of the extrusion of the mandibular molars. HOTS overcomes the problems associated with Class II elastics by completing the mechanics within a single arch.
Fig 9  A 23-year-old woman was diagnosed as having a Class II steep mandibular plane angle with severe crowding.

(a) Pretreatment intraoral photographs.

(b) Three months into treatment (Stage I). Maxillary arch: Canines were retracted on 0.014-inch Ni-Ti archwire with a retraction module from the inserted miniscrews. Mandibular arch: The same mechanics as with the maxillary arch. However, the canines were retracted from the DEHs, not from the miniscrews.

(c) Four months into treatment (Stage II). Further leveling with 0.016-inch Ni-Ti archwire. Retraction of maxillary and mandibular canines was continued.

(d) Eight months into treatment (Stage III). Maxillary arch: DDW with variable height vertical hooks (Discopender468) was placed for the simultaneous retraction of the six anterior teeth. Mandibular arch: 0.016 × 0.022-inch Ni-Ti archwire was placed since the extraction space had already closed.

(e) Seventeen months into treatment (Stage IV). Maxillary arch: 0.017 × 0.022-inch titanium-molybdenum alloy (TMA) wire was placed as a final wire. Mandibular arch: MEAW (0.016 × 0.022-inch stainless steel wire) was placed with the activation adjusted into a reversed curve form to flatten the mandibular dentition. Reversed triangular elastics were used bilaterally to raise the deepest part of the mandibular dentition.
Intraoral view after 20 months of active treatment. Good occlusion was achieved. Note that the maxillary incisors were not excessively upright, indicating that bodily retraction of the incisors has been successfully achieved.

One year after the end of the active treatment period, stable treatment results were demonstrated.

Fig 10  (a) Pre- and (b) post-treatment facial photographs show significant changes in facial appearance.
CONCLUSION

Although further investigation and refinement are required, with the features and merits of HOTS, the treatment time may be reduced by up to 6 months compared with the conventional edgewise extraction treatment system without being dependent on patient compliance.

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