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Case Report

Clinical Tips from a Case of Non-Extraction Orthodontic Treatment Using the Modified Quad-Helix for Narrow Dental Arches

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Abstract

Orthodontic treatment for severe narrowing of both the maxillary and mandibular dental arches often involves tooth extraction and interproximal reduction. To avoid these procedures, we performed skeletal expansion using dedicated expansion appliances. Although the Quad-Helix (QH) has long been used effectively for maxillary expansion, achieving substantial orthopedic effects with this appliance has generally been considered difficult. In this study, we developed a modified QH (TYO-QH) to maximize parallel expansion of the maxillary dental arch and correct asymmetry. For mandibular expansion, we used the Bio-Template, a screw-based appliance. This combined approach enabled semi-rapid asymmetric expansion and was associated with improvements not only in masticatory function but also in tongue function, swallowing function, nasal breathing, and postural habits. These findings suggest that the TYO-QH is effective for expansion of the maxillary complex and may broaden the possibilities of orthodontic treatment.

Keywords: *Modified Quad-Helix; Maxillary Skeletal Expansion; Non-Extraction Orthodontic Treatment; Asymmetrical Cases; Semi-Rapid Maxillary Expansion*

Introduction

Narrow dental arches in both the maxilla and mandible can lead to impaired occlusion, which may in turn affect mastication, breathing, speech, and posture. In addition, such conditions may be associated with adverse oral health outcomes, including future tooth loss. Orthodontic treatment for severe narrowing of the upper and lower dental arches often involves tooth extraction; however, because expansion is also frequently required, treatment can become more complex.

Appliances used primarily for expansion of the maxillary complex include screw-based expanders and rapid expansion techniques that use temporary anchorage devices (TADs). In our practice, we use the Quad-Helix (hereinafter referred to as the MOS-QH), which consists of bilateral anchor bands and four helical loops. By activating the wire, the amount and direction of expansion, as well as rotation of the anchor teeth and tooth angulation, can be controlled. Because the appliance does not include an expansion screw, no active adjustment by the patient is required. However, because of the structural design of the MOS-QH, the anchor teeth tend to move mesially during expansion [1].

Moreover, expansion tends to be greater in the posterior region than in the anterior region, making parallel expansion of the entire dental arch difficult to achieve. In this study, we used a modified Quad-Helix (hereinafter referred to as the TYO-QH) to achieve parallel expansion of the maxillary dentition and correct bilateral asymmetry, with the aim of orthopedic improvement. We also report the outcomes of combining this approach with Bio-Template-guided parallel expansion of the mandible and discuss its clinical implications.

Structure and mechanics of TYO-QH

The TYO-QH features an omega-shaped loop added to the midline bridge section of the MOS-QH. The rest of the structure is essentially the same. The direction of activation is adjusted by expanding this omega loop. The appliance is activated toward the target expansion as early as possible at placement (Figure 1):

- Retention band: Primarily placed on the first molar, but selection depends on the situation.
- Wire: Primarily uses cobalt-chromium alloys such as Elgiroi with a diameter of 0.9 mm.

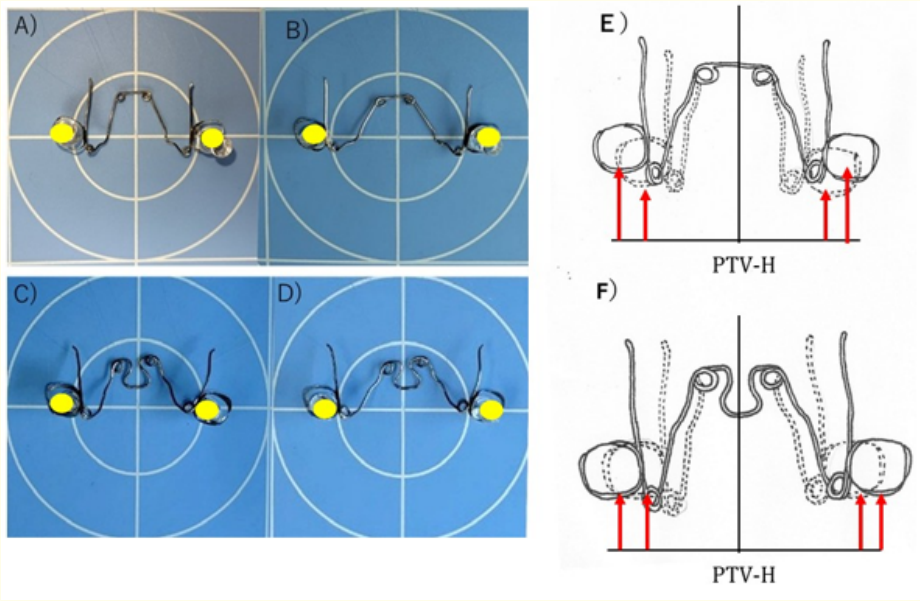

Figure 1: *A) MOS-QH (Before Expansion). B) MOS-QH (After Expansion). C) TYO-QH (Before Expansion). D) TYO-QH (After Expansion). E, F) Schematic Diagrams Before and After Expansion: Dashed lines: Before Expansion; Solid lines: After Expansion. E) MOS-QH: Molar movement occurs anteriorly due to expansion. F) TYO-QH: Lateral expansion can be achieved with minimal molar displacement by expanding the anterior omega loop. PTV-H: Represents the midpoint of the left and right PTVs on the horizontal plane in the theoretical cephalometric X-ray.*

Case Presentation

Initial observation

1. Brief patient profile:

- Age and sex: 23, Male.
- Chief complaint:
- Desire for orthodontic treatment without tooth extraction.
- Difficulty breathing through the nose.

2. Facial and intraoral examination (Figure 2):

- Left mandibular displacement.
- Maxillary and mandibular asymmetry
- Narrow maxillary and mandibular dentition

3. Lateral cephalometric X-ray trace and VTO:

- Angle CL II, Skeletal CL I, Doricho facial type FA 81.6°/85.9°, FD 80.7°/88.6°, MP 37.4°/26.6°, LFH 55.9°/48.6° Conv. 4.2 mm/4.5 mm, U6 to PTV 16.6 mm/19.2 mm.
- L1 to Apo 5.1 mm, 33.3° (Figure 3).

Figure 2: *Before treatment.*

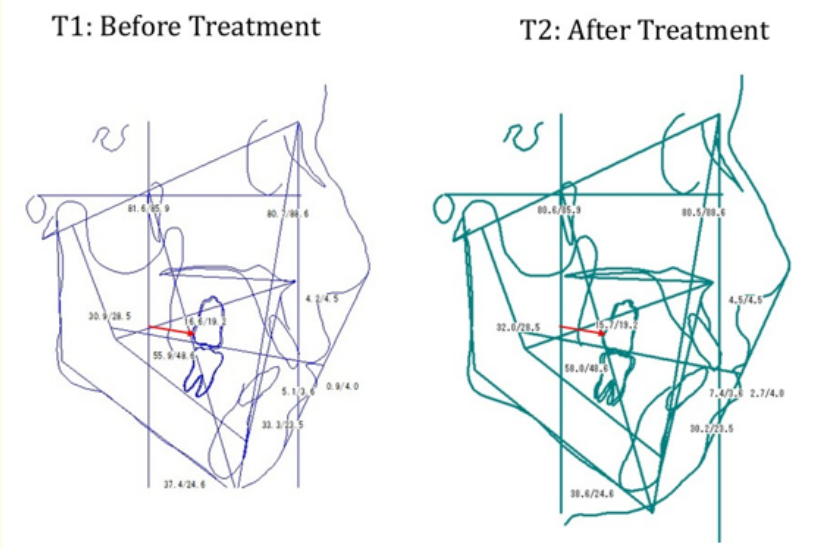

Figure 3: *Pre- and post-treatment comparison based on lateral cephalometric analysis. The red arrow indicates the linear horizontal distance from the distal surface of the first molar to the Pterygoid Vertical (PTV) plane. After treatment, the first molar had moved 0.9mm posteriorly compared to before treatment.*

Diagnosis

Asymmetric underdevelopment of the maxilla and mandible.

Treatment planning

1. Expansion of the mandibular arch using the biotemplate.
2. Addressing the particularly narrow premolar and canine regions. Expansion of the maxillary complex using TYO-QH.
3. Multi-bracket system.
4. Functional problems such as low tongue posture should be corrected.

After treatment

1. Facial findings: The frontal view was nearly symmetrical, with improvement in anterior facial appearance (Figure 4).
2. Intraoral findings: The molar relationship was Angle class I.
3. TMJ: No significant changes were observed.
4. Lateral cephalometric X-ray trace: The facial axis was open at 80.6°, but within 1 standard deviation (SD). The distance from U6 to PTV decreased from 16.6 mm to 15.7 mm, and the first pair of molars shifted slightly distally. A slight posterior displacement was observed in the first molar (Figure 3).
5. Effect of TYO-QH (Figure 5)

Figure 5 shows the superimposition of models before and after lateral expansion using TYO-QH. The area corresponding to the incisal foramen, where changes due to treatment are considered minimal, was used as the reference point for superimposition.

Purple indicates the pre-expansion state, and brown indicates the post-expansion state. An expansion of 9.1 mm was achieved between the mesio-lingual cusps of the left and right first molars, and 8.8 mm between the mesio-lingual cusps of the left and right first premolars.

There was minimal tipping of the molar region before and after expansion. Additionally, improvement in bilateral asymmetry was observed.

6. A comparison of pre- and post-treatment PA views also revealed improvements in the midface, including maxillary lateral expansion, correction of asymmetry around the foramen piriforme and posterior nares, and lowering of the nasal floor (Figure 6).

Figure 4: *After treatment.*

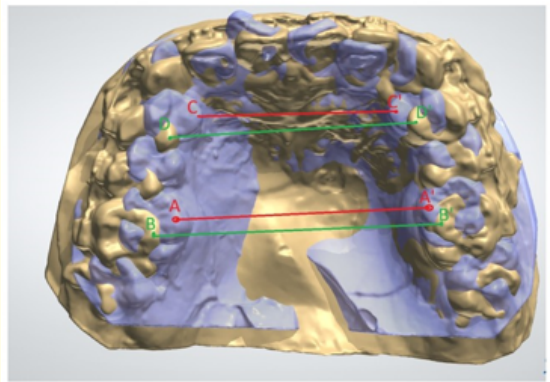

Figure 5: *Overlay of models before and after lateral expansion using TYO-QH. Purple: Before expansion; Brown: After expansion; Reference point for overlay: Incisal papilla. A-A': Before expansion: Interproximal distance between the lingual cusps of the left and right first molars: 37.2 mm. B-B': After expansion: Interproximal distance between lingual cusps of left and right first molars: 46.3 mm. C-C': Before expansion: Intercuspal distance between the mesiolingual cusps of the left and right first premolars: 28.1 mm. D-D': After expansion: Intercuspal distance between the mesiolingual cusps of the left and right first premolars: 36.9 mm.*

Consideration

With the MOS-QH, expansion of the midpalatal suture and improvement of the maxillary complex can be achieved; however, tipping, and mesial movement of the anchor teeth may also occur (Figure 1) [1].

Because the treatment goal in this case was to avoid tooth extraction, any reduction in arch length resulting from mesial movement of the anchor teeth was undesirable.

Use of the TYO-QH resulted in 9.1 mm of expansion between the mesiolingual cusps of the first molars, which served as the anchor teeth, with minimal tipping and no mesial movement. In addition, 8.8 mm of expansion was achieved between the lingual cusps of the right and left first premolars, again with minimal tipping (Figure 5). Comparison of posteroanterior cephalometric images obtained before and after treatment showed lateral expansion of the maxilla, lowering of the nasal floor, and improvement in asymmetry around the piriform foramen and posterior nares, indicating favorable midfacial improvement (Figure 6). The patient also reported subjective improvement in nasal breathing, olfaction, masticatory function, and posture, which may have been associated with expansion of the maxillary complex.

To generate continuous orthopedic force, it may be preferable to activate the TYO-QH to the target expansion at insertion rather than increase activation incrementally during treatment. In this 23-year-old adult patient with sufficient bone mass, an activation force of approximately 1,000g was considered acceptable [2].

The addition of an Omega Loop to the MOS-QH may have increased appliance flexibility by increasing the effective wire length, thereby reducing stiffness and allowing gentler force delivery. In addition, Co-Cr (Elgiloy) has a lower load-deflection rate than stainless steel, which may help prevent excessive orthopedic force while facilitating tooth movement.

After placement of the TYO-QH, the force decreases as the dental arch expands; however, the Omega Loop may help reduce this attenuation. This may allow sustained orthopedic force to be transmitted to the premolar region, thereby promoting more parallel expansion and contributing to semi-rapid expansion [2-4]. Although the QH is an effective appliance for orthodontic expansion, caution is warranted because of potential adverse effects such as root resorption and alveolar bone damage. The appropriate activation threshold for the TYO-QH may vary depending on age and individual case characteristics, and further quantitative investigation is required.

Previous reports suggest that the midpalatal suture may remain incompletely closed until approximately 30 years of age [5]. Although further investigation is needed, this finding suggests that TYO-QH may be applicable in adult patients up to the early 30s.

In addition, because changes in alveolar process morphology were also observed, further study is needed to characterize these three-dimensional changes in greater detail.

Conclusion

The TYO-QH is highly effective for expansion of the maxillary complex and is expected to contribute to expanding the possibilities of orthodontic treatment.

The orthodontic appliance used in this study was developed by the author. The design and functional characteristics of the appliance are protected by Japanese intellectual property rights (Japanese Patent No. 1775385).

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