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# Treatment of a severe transverse dental arch discrepancy assisted by 3-dimensional planning

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This report describes the treatment of a 16-year-old girl with a severe transverse dental arch discrepancy resulting from a mildly constricted maxillary arch and an overexpanded mandibular arch. The patient had a Class I skeletal relationship, a high mandibular plane angle, a Class III molar relationship, bilateral posterior crossbites, and deviated midlines. A 3-dimensional digital setup was used to assist treatment planning. The digital setup allowed us to evaluate multiple treatment options before deciding on the most suitable one for the patient. The final treatment protocol consisted of extraction of upper second premolars and lower first molars due to enamel hypoplasia. Starting with the leveling and alignment stage of treatment, the maxillary archwires were expanded and the mandibular wires were constricted to correct the transverse discrepancy. An auxiliary expansion arch was used to achieve overcorrection. The active treatment period was 24 months. Proper overbite and overjet, facial balance, and good occlusion were achieved. (Am J Orthod Dentofacial Orthop 2013;143:105-15)

A posterior crossbite typically results from a constricted maxillary arch width. Maxillary expansion is a valid way to solve this problem.[1-5] However, in a few patients, the problem lies in the mandible: ie, excessive mandibular width. Mandibular width is more difficult to alter, regardless of expansion or constriction. Surgical measures can be adopted at added risks and costs.

## DIAGNOSIS AND ETIOLOGY

The patient was a 16-year-old Chinese girl. Her chief complaints were "crowded teeth and difficulty eating." After having been declined by other clinics her parents brought her to our department. Her medical and dental histories were unremarkable. The extraoral examination showed that she had a slightly convex profile. Her lips were competent at rest but had moderate hypermentalis activity (Fig 1). There were no temporomandibular joint symptoms, and mandibular movements were normal. The clinical examination along with the photographs showed that the maxillary dental midline coincided with the facial midline, and the mandibular midline was shifted to the right side by 2 mm. Enamel hypoplasia was noted on all first molars, especially the mandibular ones. Generalized mild gingivitis associated with fair oral hygiene was noted, but probing depths were within the normal limits.

The dental casts showed Class III molar and canine relationships, and most of the posterior teeth were in crossbite with unstable occlusal contacts (Fig 2). The maxillary arch was symmetrical and tapered in shape with 11 mm of crowding in the anterior region. The patient had a 1-mm overjet and a 1-mm open bite. The left lateral incisors were in crossbite as well. The mandibular arch was symmetrical and had a rounded form with 5 mm of crowding. Maxillary arch intercanine and intermolar widths were within normal limits, but the same measurements in the mandibular arch were much greater than the norms (Table 1).

The panoramic radiograph showed no missing teeth, except for the maxillary third molars. Thin condyles were noticed on the panoramic radiograph. Although the patient had no temporomandibular joint symptoms, an additional examination was undertaken to ensure that there was no abnormal condylar resorption. Based on the findings from the cone-beam computed tomography examinations (3DX; Morita, Kyoto, Japan), we made a diagnosis of condylar hypoplasia (Fig 3).

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**Fig 1.** Pretreatment facial and intraoral photographs at age 16 years.

The cephalometric analysis showed a Class I skeletal relationship. The mandibular plane was high with a steep occlusal plane (MP-SN angle, 49.7°; SN-OP angle, 28.9°). The lower facial height ratio was slightly increased. Dentally, the maxillary and mandibular incisors were moderately protrusive relative to the alveolar base (Table II). The patient was diagnosed with a Class III malocclusion and a Class I skeletal pattern with a high mandibular plane angle.

The lateral cervical vertebrae on the cephalometric radiograph showed that the patient had passed her growth peak, although some growth was expected during the treatment. The etiology of this malocclusion was unclear. A possible explanation was that the severe crowding in the maxillary arch along with the buccally displaced and inclined premolars and first molars in the mandibular arch caused the severe transverse discrepancy.

## TREATMENT OBJECTIVES

The treatment objectives were to correct the Class III malocclusion, correct the transverse discrepancy, alleviate the crowding, achieve proper dental inclination, correct the anterior open bite, and correct the midline deviation. The high mandibular plane should be at least maintained or even improved by attempting to produce counterclockwise rotation of the mandible to improve the profile.

## TREATMENT ALTERNATIVES

The optimal treatment plan included orthognathic surgery. In this option, the narrow maxillary arch could be expanded to fit the wide mandibular arch, or the mandibular arch could be constricted to coordinate with the maxillary arch. Either option would involve more risk and cost. In addition, the patient would have to wait until age 18 for the surgery.

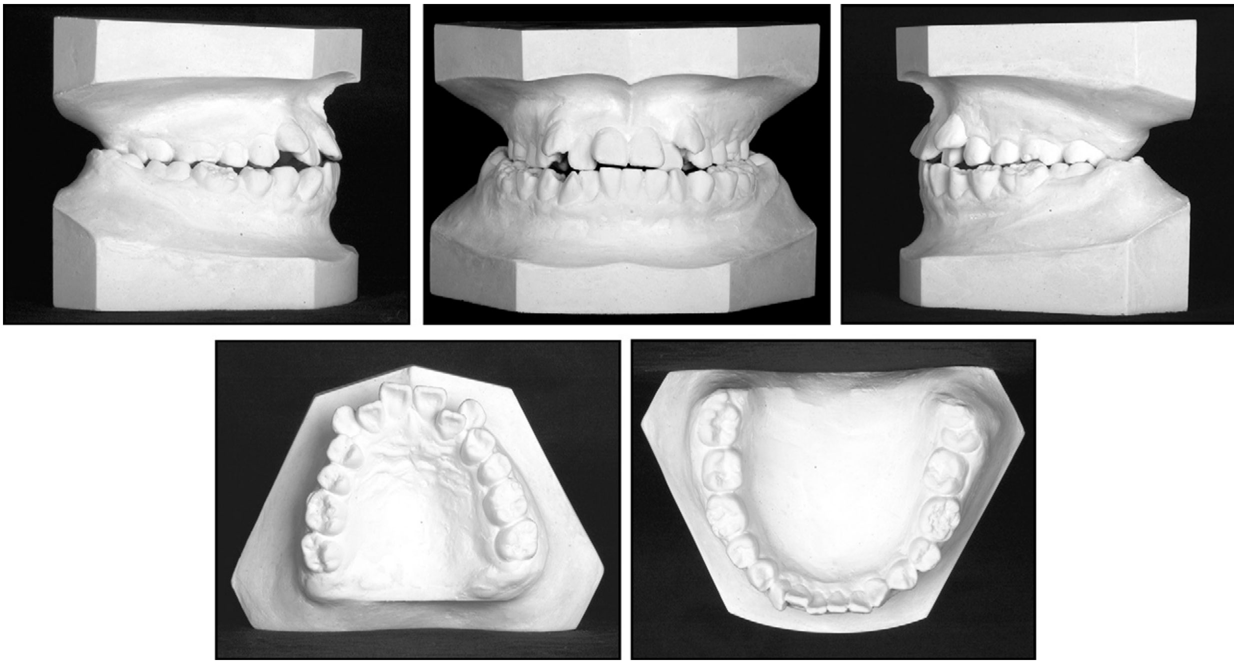

**Fig 2.** Pretreatment dental casts.

**Table I.** Dental arch dimensions and digital setup results (in millimeters)

| | *Maxilla* | | | | | *Mandible* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *3-3* | *4-4* | *5-5* | *6-6* | *7-7* | *3-3* | *4-4* | *5-5* | *6-6* | *7-7* | *8-8* |
| Pretreatment | 34.1 | 36.3 | 42.8 | 49.0 | 54.7 | 23.2 | 34.6 | 46.1 | 56.7 | 55.6 | 60.6 |
| Nonextraction | 35.4 | 42.8 | 49.9 | 55.0 | 60.7 | 25.3 | 36.4 | 44.1 | 52.6 | 55.8 | 58.8 |
| U5L4 | 34.1 | 41.9 | | 48.6 | 54.6 | 25.5 | | 35.0 | 43.4 | 50.1 | 55.0 |
| U5U6 | 34.3 | 41.6 | | 48.8 | 54.9 | 25.6 | 34.8 | 41.6 | | 50.4 | 55.6 |
| Posttreatment | 34.5 | 41.8 | | 48.6 | 55.0 | 25.4 | 34.7 | 41.6 | | 50.8 | 56.2 |

*3*, Canine; *4*, first premolar; *5*, second premolar; *6*, first molar; *7*, second molar; *8*, third molar; *U*, maxillary; *L*, mandibular.

However, both the patient and her parents rejected surgery as an option.

The second alternative was orthodontic treatment only. Due to the significant transverse discrepancy, a digital setup was used to assist in the treatment planning. The digital setup allowed us to evaluate multiple treatment options before deciding on the most suitable one for the patient. Measurements were made on the digital models (Fig 4). The maxillary intercanine and intermolar dimensions were close to normal, whereas the mandibular counterparts were far beyond the norms (Table I).[6-8] In this condition, if a nonsurgical, nonextraction treatment plan were adopted, although torque correction of the mandibular first molars would provide constriction of 4.1 mm (from 56.7 to 52.6 mm) of the intermolar width, the required maxillary dentoalveolar expansion would have been substantial (from 49.0 to 55.0 mm), possibly unstable, and probably periodontally unacceptable (Fig 5).[9] Because of the severe crowding in the maxillary anterior area and the maxillary incisor angulations, an extraction protocol was chosen.

According to the setup results, if the maxillary second premolars and the mandibular first premolars were extracted, the mandibular intermolar width would have to be decreased by 13.3 mm (from 56.7 to 43.4 mm). We deemed this to be clinically difficult to achieve through tooth movement alone (Fig 6). If the maxillary second premolars and the mandibular first molars were extracted, more space would be available to solve the transverse problem in the mandibular arch. The mandibular second and third molars would be protracted mesially to replace the first molars. The intermolar dimension in the mandibular arch would be decreased by 6.3 mm

**Fig 3.** Pretreatment radiographs and cone-beam computed tomography image of the left temporomandibular joint.

**Table II.** Cephalometric measurements

| *Measurement* | *Mean* | *SD* | *Initial* | *Final* |
|---|---|---|---|---|
| SNA (°) | 82.8 | 4.0 | 75.8 | 77.1 |
| SNB (°) | 80.1 | 3.9 | 73.1 | 74.2 |
| ANB (°) | 2.7 | 2.0 | 2.7 | 2.9 |
| A-NFH (mm) | 0.0 | 3.7 | −7.7 | −5.8 |
| Pg-NFH (mm) | −5.7 | 3.8 | −20.9 | −20.1 |
| Wits (mm) | −1.1 | 2.9 | −6.7 | −2.8 |
| MP/SN (°) | 32.5 | 5.2 | 49.7 | 49.4 |
| MP/FH (°) | 31.1 | 5.6 | 43.4 | 43.2 |
| MP/PP (°) | 27.6 | 4.6 | 40.7 | 37.4 |
| SN/OP (°) | 16.1 | 5.0 | 28.9 | 20.6 |
| FH/OP (°) | 12.4 | 4.4 | 22.6 | 14.5 |
| U1-AP (mm) | 7.2 | 2.2 | 10.6 | 7.5 |
| L1-AP (mm) | 4.9 | 2.1 | 8.0 | 4.8 |
| U1/PP (°) | 115.8 | 5.7 | 121.3 | 111.4 |
| L1/MP (°) | 93.9 | 6.2 | 88.4 | 85.6 |
| U1/L1 (°) | 124.2 | 8.2 | 110.0 | 125.4 |
| Upper lip–E-line (mm) | −2.5 | 1.5 | −1.2 | −2.9 |
| Lower lip–E-line (mm) | 1.4 | 1.9 | 3.4 | 0.6 |

(from 56.7 to 50.4 mm), 4.1 mm of which could be obtained from altering the buccolingual inclination. Moreover, this would help to correct the steep occlusal plane (Fig 7).

The patient and her parents accepted the extraction plan. The treatment goals were to improve the dental alignment and coordinate the arch widths, correct the deviation of the mandibular dental midline, and establish bilateral Class I canine relationships and complete Class II molar relationships.

## TREATMENT PROGRESS

The patient received oral hygiene instructions before the placement of the fixed appliances. Preadjusted fixed appliances (0.022 × 0.028-in, MBT system; 3M Unitek, Monrovia, Calif) were placed. Archwire reformation was done from the initial alignment with the 0.016-in nickel-titanium wires including expansion of upper wires and constriction of lower wires. The amount was about 5 mm in the molar areas. Then compressed coil springs were placed on reshaped 0.018-in stainless steel wires to open space for the crowded maxillary left lateral incisor and the mandibular right lateral incisor. When enough space was obtained, segmented 0.012-in auxiliary nickel-titanium wire was used for alignment of the lateral incisors.

After the alignment, there was little space left in the maxillary arch, and the incisor relationship became

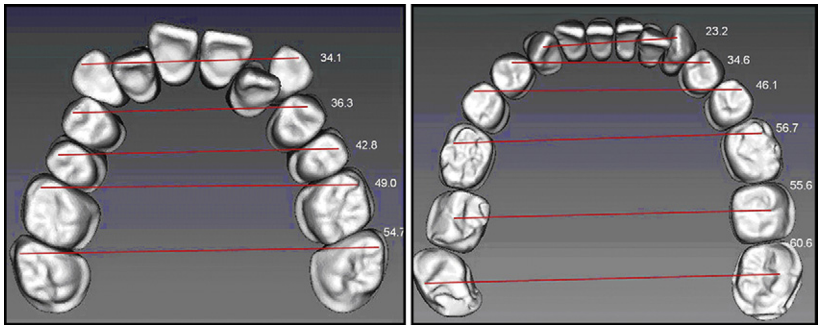


**Fig 4.** Measurements of transverse arch dimensions: intercanine width, distance between the cusp tips of the right and left canines; interpremolar width, distance between the buccal cusp tips of the right and left premolars; maxillary intermolar width, distance between the mesiobuccal cusp tips of the maxillary molars; mandibular intermolar width, distance between the buccal grooves on the molars.

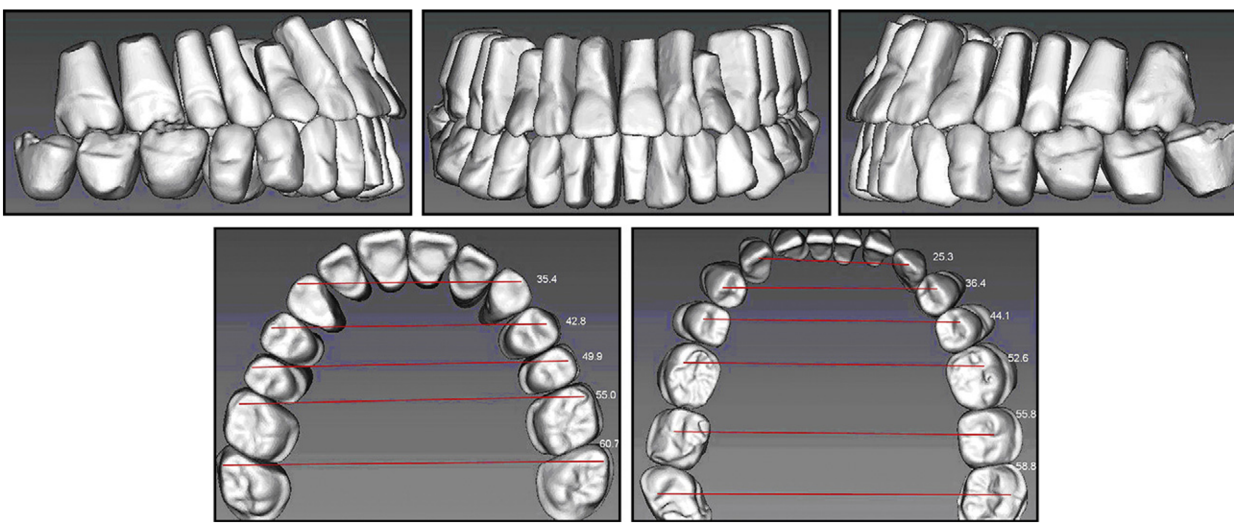


**Fig 5.** Digital setup results for nonextraction treatment.

edge-to-edge. A minimal overjet was established in the posterior region. Then the maxillary archwire progressed to 0.019 × 0.025-in stainless steel wire and a 0.045-in stainless steel auxiliary expansion arch extending from the buccal tubes on the maxillary first molars to further increase the posterior overjet.[10] Class III elastics were used from the mandibular lateral incisors and canines to the maxillary first molars to increase the anterior overjet. After creation of proper overbite and overjet, intra-arch elastics were used to close the extraction space. Then 0.018-in and 0.018 × 0.025-in stainless steel wires were placed sequentially in the mandible. Class II elastics and intra-arch elastics were used to adjust the molar relationship and close the remaining extraction space (Fig 8). The auxiliary expansion arch was used for 5 months, and overcorrection of the posterior crossbite was achieved.

After 18 months of treatment, the severe transverse arch-width discrepancy was resolved, proper overbite and overjet were established, and the extraction spaces were closed. The finishing and detailing took an additional 6 months. The appliances were removed after 24 months of active treatment. Maxillary and mandibular Hawley retainers were used for retention.

## TREATMENT RESULTS

A well-aligned dentition and a harmonious facial balance were obtained. The facial profile was improved by retracting the mandibular anterior teeth and protracting the mandibular molars. Muscle strain of the mentalis and lower lip disappeared (Fig 9). A stable Class I canine and Class II molar relationship with good interdigitation and ideal overjet and overbite

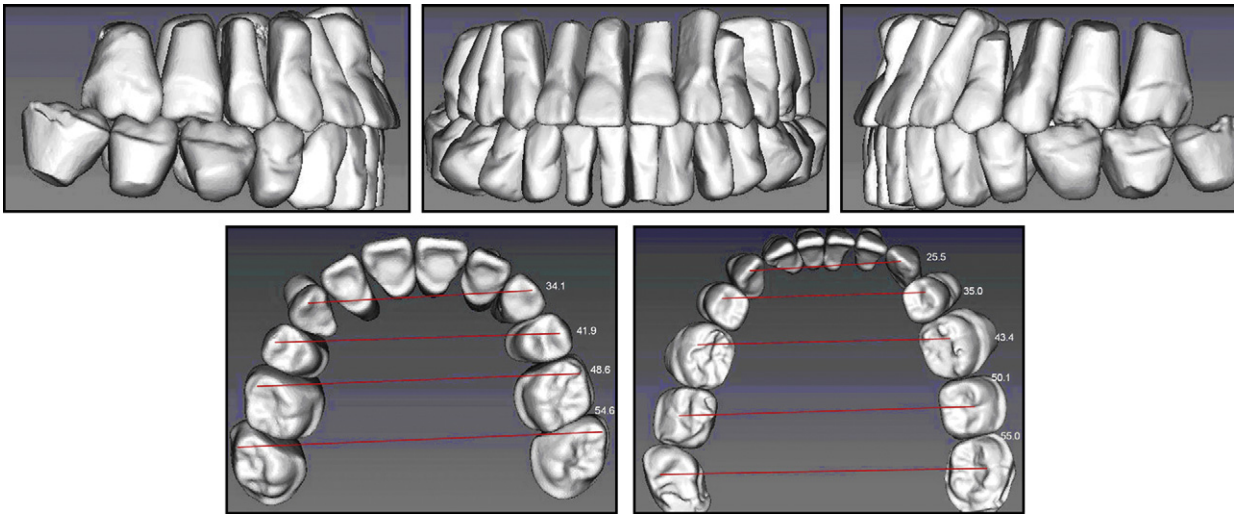


**Fig 6.** Digital setup results for extraction of the maxillary second premolars and the mandibular first premolars.

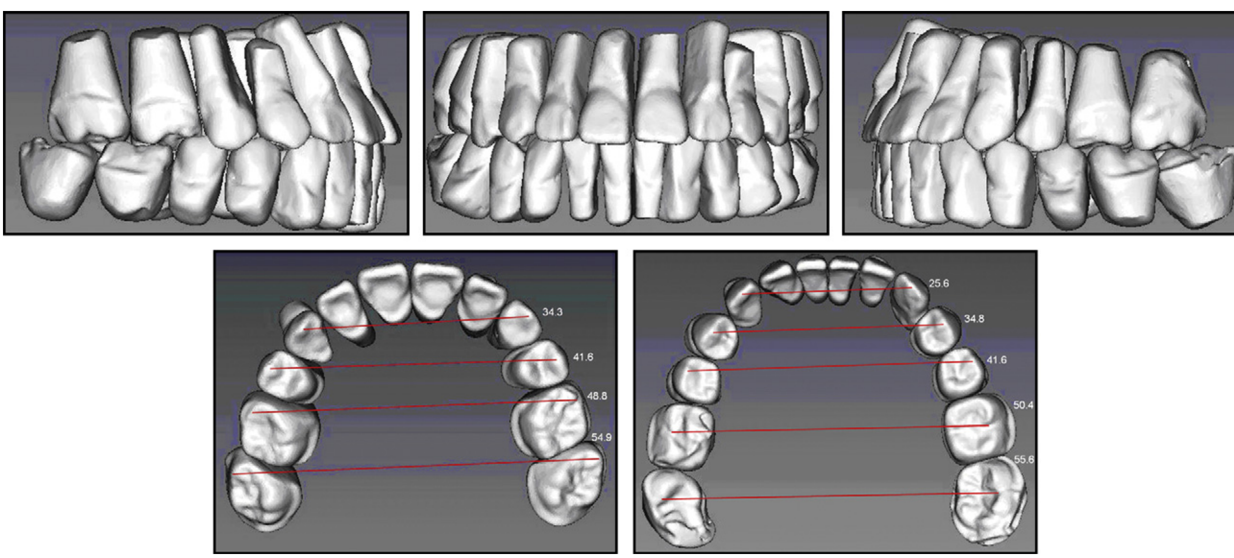


**Fig 7.** Digital setup results for extraction of the maxillary second premolars and the mandibular first molars.

were achieved despite the occlusion in the right molar area. This was due to the more severe attrition of the mesiobuccal cusp of the maxillary right first molar and the tooth-size discrepancy between the maxillary first molar and the mandibular second molar. Interproximal reduction was considered but eventually refused by the patient because she was already satisfied with the result and wanted to finish treatment. The dental midlines were coincident (Fig 9). The final result was remarkably similar to the digital setup prediction (Figs 7 and 10, Table 1).

The panoramic film showed no significant root resorption or alveolar bone loss (Fig 11). Cephalometric superimposition showed that the incisors were retracted, the profile was improved, the steep occlusal plane returned to normal, and the mandibular plane was maintained (Fig 11). The model superimpositions showed significant changes in the mandibular arch widths. The mandibular second molars were mesially displaced by about 5.5 mm (half of the extraction space) (Fig 12). Before treatment, the patient had an unstable occlusion resulting from a severe transverse

**Fig 8.** Intraoral photographs 12 months into treatment: a 0.045-in stainless steel auxiliary expansion archwire was used to further increase the posterior overjet. Class II elastics from the mandibular second molars to the maxillary hooks and intramandibular elastics were used to further close the remaining space and adjust the molar relationship.

**Fig 9.** Posttreatment facial and intraoral photographs at age 18 years.

discrepancy. After treatment, a well-intercuspated occlusion was obtained, and the patient was able to occlude comfortably.

Records taken 25 months after treatment indicate that the correction of the posterior crossbite remained stable, and the profile was improved (Fig 13).

## DISCUSSION

Theoretically, treatments of posterior crossbite differ markedly, depending on the underlying cause. Skeletal crossbites, usually resulting from a narrow maxilla but occasionally from an excessively wide mandible,

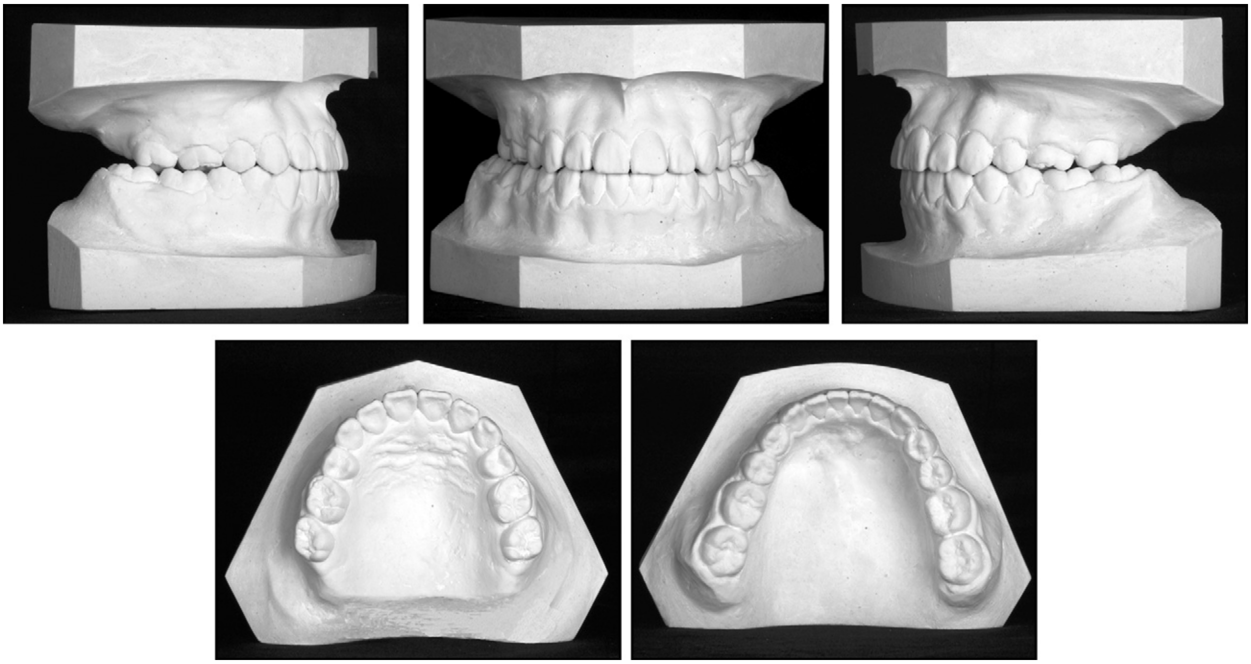

**Fig 10.** Posttreatment dental casts with lingual occlusion views.

generally are treated by heavy forces to open the midpalatal suture. Dental crossbites are treated by moving the teeth with lighter forces.[11] The preferred appliance for correction of maxillary dental constriction is an adjustable lingual arch that requires little patient cooperation. Both the W-arch and the quad-helix are reliable and easy to use. If teeth in both arches contribute to the problem, cross-elastics between banded or bonded attachments in both arches can reposition both the maxillary and the mandibular teeth. The vector of the elastic pull moves the teeth vertically and buccolingually; this will extrude the posterior teeth, reduce the overbite, and rotate the mandible downward and backward. Therefore, cross-elastics should be used with caution in patients with increased lower face height or limited overbite.

It is uncommon that posterior crossbite in this patient resulted from a normal maxilla and an excessively wide mandible. Steep mandibular and occlusal planes and an anterior open bite increase complexity of treatment. In such a complicated situation, a diagnostic setup is useful to assist treatment planning. Treatment planning is a key element for successful outcome. The diagnostic setup was introduced by Kesling[12] in 1956. Individual teeth on the models could be manually sectioned and repositioned to desired locations with wax. The treatment results could be visualized in advance.

Digital diagnostic setups were developed to obtain treatment predictions in a more efficient way. Three-dimensional setups could help clinicians during diagnosis and treatment planning to determine various treatment options, monitor changes over time, predict and display final treatment results, and measure treatment outcomes accurately.[13,14] However, one thing must be kept in mind: tooth movement has no limits on computers. No matter which alternative is applied, good alignment and occlusion can be achieved on the computer screen, but the same result might not be realistic for the patient. Tooth movement has biologic limitations. Too much expansion or contraction might lead to an unstable result or even a disastrous consequence. So, the digital setup results must be analyzed based on biologic principles and clinical experience. The most appropriate option should be both theoretically sound and clinically realistic.

In this patient, the crossbite was due to an excessively wide mandibular arch. Generally, the mandibular transverse dimension is difficult to modify, because of the thick cortical bone. If nonextraction therapy were used, maxillary expansion would have been required, leading to clockwise rotation of the mandible and an increased anterior open bite. Extractions, on the other hand, provided the space to align the dentition and adjust the transverse

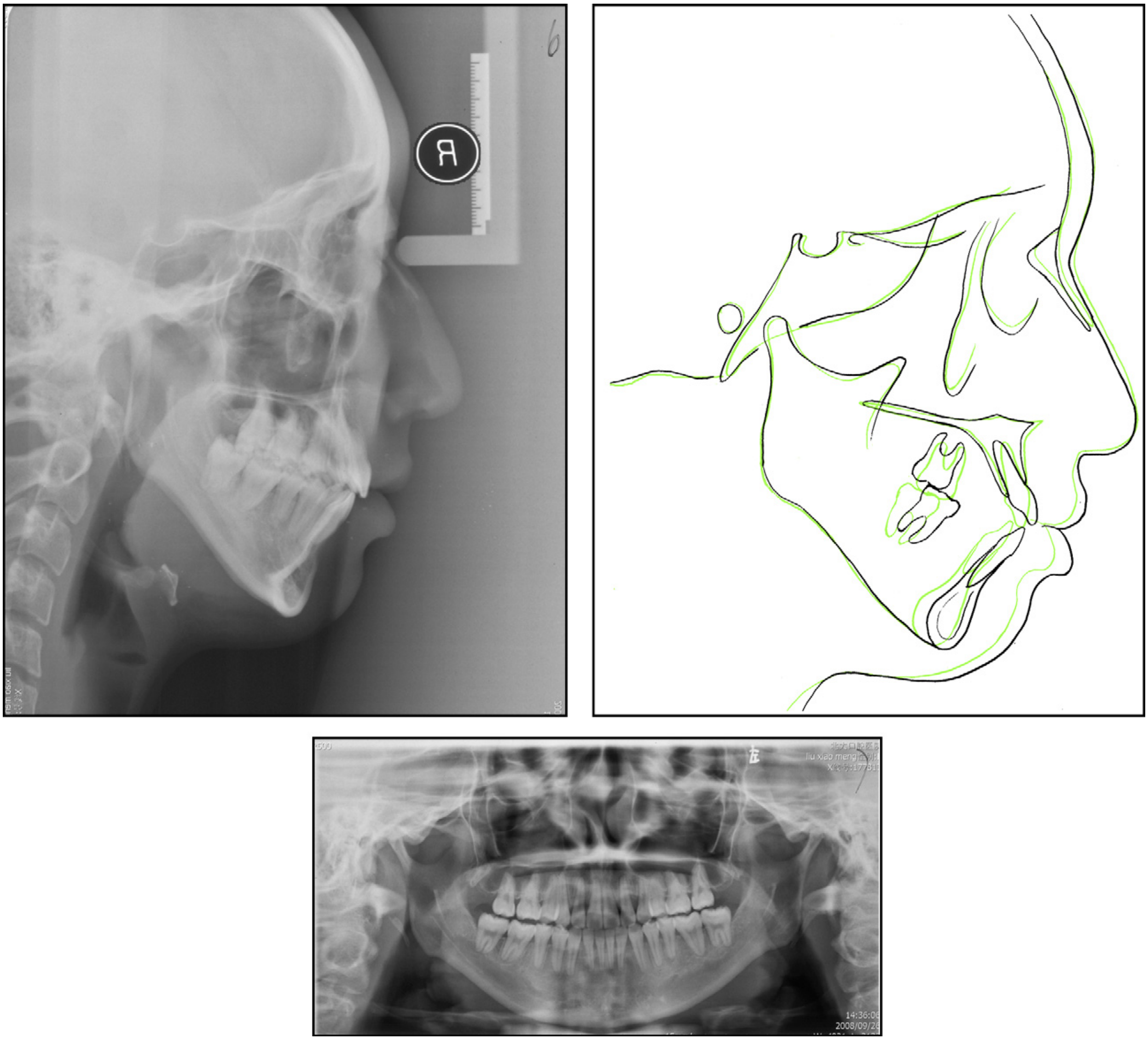

**Fig 11.** Posttreatment radiographs and superimposed cephalometric tracings.

dimension. Extraction of the maxillary second and mandibular first premolars is a typical pattern for treating a Class III malocclusion, but it was not adopted because the setup results indicated that it was impossible for the mandibular first molars to be constricted by 13.3 mm without penetrating the lingual bony plate. Extraction of the maxillary second premolars and the mandibular first molars was finally chosen, because this would lead to a treatment result that could be achieved. The constriction of 6.3 mm could be obtained from buccolingual inclination change (4.1 mm) and mesial movement of the second molar. In addition, extraction of the compromised mandibular first molars would minimize the need for future restorations.[15] More space would be available in the mandibular arch for comprehensive adjustment.

The final result shows that normal maxillary arch width was maintained, and the abnormal mandibular arch width returned to a normal value. The mandibular dentition was retracted and constricted. Reforming the shape of the archwires from the beginning of treatment proved to be effective in correcting the transverse discrepancy. Light but continuous force released from the reformed archwires might be beneficial to alveolar remodeling. Good lingual occlusion indicated that the posterior crossbites were corrected not through lingual tipping of the mandibular second

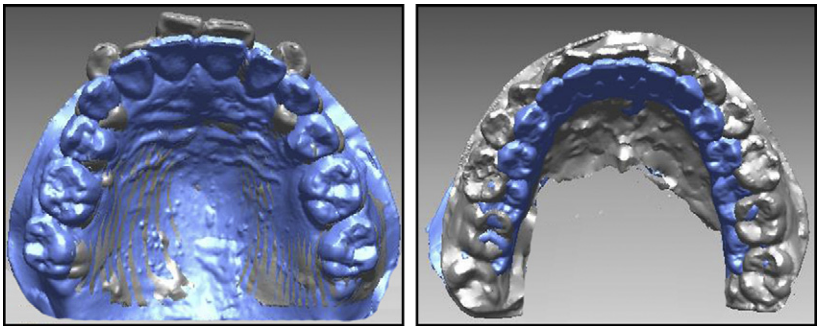

**Fig 12.** Superimposed dental casts.

**Fig 13.** Facial and intraoral photographs 25 months after treatment.

molars, but through bodily movement in an anteroposterior and buccolingual direction, resulting in a stable occlusion (Fig 9). The 0.045-in stainless steel auxiliary expansion archwire was used only to maintain the maxillary arch width and achieve overcorrection.

## CONCLUSIONS

A Class III patient with a severe transverse discrepancy, a high mandibular plane angle, an open bite, and an unstable occlusion was successfully treated with simple and sound appliances and mechanics.

The treatment was successful because of a proper diagnosis and treatment plan. A novel and innovative technique is an important part of diagnosis in complex cases.

## REFERENCES


1. Haas AJ. Palatal expansion: just the beginning of dentofacial orthopedics. Am J Orthod 1970;57:219-55.
2. Haberson VA, Myers DR. Midpalatal suture opening during functional posterior crossbite correction. Am J Orthod 1978; 74:310-3.
3. Thilander B, Wahlund S, Lennartsson B. The effect of early interceptive treatment in children with posterior crossbite. Eur J Orthod 1984;6:25-34.
4. Erdinc A, Ugur T, Erbay E. A comparison of different treatment techniques for posterior crossbite in the mixed dentition. Am J Orthod Dentofacial Orthop 1999;116:287-300.
5. McNamara JA. Early intervention in the transverse dimension: is it worth the effort? Am J Orthod Dentofacial Orthop 2002;121:572-4.
6. Knott VB. Longitudinal study of dental arch widths at four stages of dentition. Angle Orthod 1972;42:387-94.
7. Lee RT. Arch width and form: a review. Am J Orthod Dentofacial Orthop 1999;115:305-13.
8. Tancan U, Badel M, Serdar U. Dental and alveolar arch widths in normal occlusion, Class II division 1 and Class II division 2. Angle Orthod 2005;75:941-7.
9. Betts NJ, Vanarsdall RL, Barber HD. Diagnosis and treatment of transverse maxillary deficiency. Int J Adult Orthod Orthog Surg 1995;10:75-96.
10. McLaughlin RP. Systemized orthodontic treatment mechanics. St Louis: Mosby; 2000. p. 82.
11. Proffit WR. Contemporary orthodontics. 3rd ed. St Louis: Mosby; 2000. p. 435-9.
12. Kesling HD. The diagnostic setup with consideration of the third dimension. Am J Orthod 1956;42:740-8.
13. Macchi A, Carrafiello G, Cacciafesta V. Three-dimensional digital modeling and setup. Am J Orthod Dentofacial Orthop 2006;129: 605-10.
14. Motohashi N, Kuroda T. A 3D computer-aided design system applied to diagnosis and treatment planning in orthodontics and orthognathic surgery. Eur J Orthod 1999;21:263-74.
15. Årtun J, Mirabella AD. Treatment of arch length deficiency in an adult male: the extraction of compromised molars rather than healthy premolars. Angle Orthod 1994;64:327-32.