CASE REPORT

Treatment of a severe arch-length deficiency with anteroposterior and transverse expansion: Long-term stability

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This article describes the nonextraction treatment of a girl in the late mixed dentition with a severe arch-length deficiency. Rapid maxillary expansion and molar distalization were combined with a lip bumper in the mandible, followed by fixed appliances. Although the literature has reported a high rate of relapse with this method of treatment, excellent stability was achieved at 5 years 3 months posttreatment. The merits of extraction vs nonextraction treatment and stability are discussed. (Am J Orthod Dentofacial Orthop 2010;137:401-11)

Arch-length deficiency is a common problem in orthodontics. Clinical signs of tooth-size–arch-length discrepancy are crowding, impaction, and incisor proclination. The controversy persists over whether to increase the size of the arch by expansion or decrease the size of the teeth by interproximal enamel reduction or extraction to resolve the discrepancy. Tooth extraction, an efficient way to resolve crowding, can have detrimental effects on facial esthetics if done haphazardly.1 Furthermore, tooth extraction is not a better guarantee for stability than anteroposterior or transverse arch expansion in the permanent dentition.2 This case report describes the nonextraction treatment of a girl with a severe arch-length deficiency. The possible issues that led to the long-term stability will be discussed.

DIAGNOSIS AND ETIOLOGY

The patient was a girl, age 11 years, whose chief complaint was an unpleasant smile. Her medical history was noncontributory, and her dental history included routine dental evaluations. She had no restorations, and her oral hygiene was good. The probable cause of her malocclusion was a combination of genetic and developmental factors.

The patient had a straight profile with a tendency to lip retrusion. The nasolabial angle was slightly increased, but the chin extension was adequate. From a frontal view, the face was triangular and symmetrical. The lower lip height (distance from the superior border of the lower lip to the bottom of the chin) was increased relative to the upper lip height. She had competent lips with a thin vermilion. She had normal maxillary incisor vertical display on smiling, but a poor smile arc with the upper incisal curve not running along the lower lip. Transversally, the smile was narrow dentally, displaying the mandibular teeth (Fig 1).

Intraorally, she was in the late mixed dentition stage of development with a persistent mandibular right second deciduous molar. She had an Angle Class I molar relationship on the left side and an edge-to-edge molar relationship on the right side. She had a transverse maxillary deficiency with a transpalatal first molar width of 30 mm. The maxillary arch form was narrow and V-shaped with a high palatal vault. There was no posterior crossbite, but the maxillary posterior teeth were buccally inclined, whereas the mandibular posterior teeth were lingually inclined (dental compensation). The arch-length deficiency was 13 mm in the maxillary arch with no space for the canines to erupt. The mandibular arch was ovoid, and the right canine was also unerupted. The mandibular arch-length deficiency was 7 mm but could be reduced to 4.5 mm if leeway space was gained from the retained deciduous molar with arch-length maintenance. There was a maxillary midline diastema of 1 mm, and both dental midlines were aligned and coincident with the facial midline. The maxillary right lateral incisor was in crossbite. Overjet was normal, and overbite was 50% (Figs 1 and 2).

The panoramic radiograph showed a full complement of teeth, including developing third molars. The second molars were not erupted and positioned high in the maxilla. The unerupted maxillary canines were

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The author reports no commercial, proprietary, or financial interest in the products or companies described in this article.
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Submitted, June 2007; revised and accepted, August 2007.
0889-5406/$36.00
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doi:10.1016/j.ajodo.2007.08.040
oblique. The roots of the mandibular right second deciduous molar showed 30% resorption, and the succedaneous premolar had 50% root development (Fig 3).

Cephalometric analysis showed a skeletal Class I anteroposterior relationship evidenced by an ANB angle of 4°; the Wits appraisal of –4 mm indicated skeletal Class III compensated by severe hyperdivergence (FMA, 34°; SN-MPA, 50°). The maxillary and mandibular incisors were upright, and the soft-tissue analysis confirmed lip retrusion with an increased value of the Holdaway line to the tip of the nose (Fig 4, Table I).

TREATMENT OBJECTIVES

The main objectives in treating this malocclusion were to reposition the impacted canines and address the arch-length deficiency. The upright incisors would need to be proclined to improve lip support. Transverse maxillary deficiency would also need to be addressed to enhance smile esthetics and width. Finally, ideal overbite and overjet and an optimal posterior intercuspation would need to be achieved.

TREATMENT ALTERNATIVES

Three treatment options were considered.

1. Extraction of 4 first premolars to allow canine eruption and resolve the severe arch-length deficiency. The main advantage of this treatment option would be a shorter treatment time with no need for patient cooperation. Nevertheless, 4 premolar extractions would not address the upright incisors and the lip retrusion, and might even worsen the profile. Furthermore, by not addressing the initial transverse maxillary deficiency, smile esthetics would not be improved.

2. Extraction of the maxillary first premolars and arch maintenance in the mandible followed by incisor...
proclination. Class III elastics or a maxillary protraction facial mask (dental forces) would be needed to finish in a Class II molar relationship. This treatment option would address the arch-length deficiency with less adverse effect on the profile than 4 premolar extraction. However, profile and smile esthetics would not be optimized.

3. Nonextraction treatment with rapid maxillary expansion (RME) followed by maxillary molar distalization with headgear and lip bumper in the mandible, and proclination of the incisors. The arch-length deficiency would be resolved by transverse and anteroposterior arch expansion, and both profile and smile esthetics would be enhanced. However, this treatment plan relies heavily on patient compliance. Furthermore, long-term stability is questionable, and some type of long-term or permanent retention might need to be considered.

The nonextraction treatment option was adopted because the patient’s chief concern was facial esthetics. Cooperation and stability issues were discussed with the patient and her parents.

**TREATMENT PROGRESS**

A tissue-borne appliance with bands attached to the first premolars and first molars was used for RME. The appliance was activated once a day for 24 days; approximately 6 mm of arch widening was obtained at the level...
of the first molars. The screw was then locked with a dou-
bble ligature tie, and the expander served as a stabilizer for
the next 10 months (Fig 5, A). After stabilization, a man-
dibular lip bumper was placed with bands attached to the
first molars. The persistent deciduous molar was ex-
tracted 1 month later to favor distal drifting of the first
premolar into the leeway space and allow spontaneous
eruption of the right canine in proper alignment (Fig 5,
B). The lip bumper was discontinued 20 months later af-
fter full eruption of the right second premolar.

Table I. Cephalometric summary

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Norm</th>
<th>Pretreatment (11 y)</th>
<th>Retention (15 y 10 mo)</th>
<th>Posttreatment (21 y 1 mo)</th>
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</thead>
<tbody>
<tr>
<td>Skeletal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SNA (°)</td>
<td>82</td>
<td>76</td>
<td>78</td>
<td>77</td>
</tr>
<tr>
<td>SNB (°)</td>
<td>80</td>
<td>72</td>
<td>74</td>
<td>73</td>
</tr>
<tr>
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<td>4</td>
</tr>
<tr>
<td>FH-NA (maxillary depth) (°)</td>
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<td>92</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td>FH-NP (facial angle) (°)</td>
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<td>88</td>
<td>89</td>
<td>90</td>
</tr>
<tr>
<td>Wits (mm)</td>
<td>1</td>
<td>–4</td>
<td>–1</td>
<td>1</td>
</tr>
<tr>
<td>SN-MPA (°)</td>
<td>32</td>
<td>50</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>FMA (°)</td>
<td>25</td>
<td>34</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Dental</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UI-SN (°)</td>
<td>103</td>
<td>86</td>
<td>98</td>
<td>98</td>
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<td>UI-NA (°)</td>
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<td>20</td>
<td>21</td>
</tr>
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<td>UI-NA (mm)</td>
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<td>1</td>
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<td>5</td>
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<td>LI-NB (°)</td>
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<td>32</td>
<td>30</td>
</tr>
<tr>
<td>LI-NB (mm)</td>
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<td>8</td>
<td>8</td>
</tr>
<tr>
<td>LI-MP (°)</td>
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<td>88</td>
</tr>
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<td>LI-Apo (mm)</td>
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<td>UI-LI (°)</td>
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<td>153</td>
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<td>126</td>
</tr>
<tr>
<td>Soft tissue</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Holdaway line (mm)</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Tip of nose</td>
<td>9</td>
<td>12</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Subnasale</td>
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<tr>
<td>Lower lip</td>
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<td>1</td>
<td>–1</td>
<td>–1</td>
</tr>
<tr>
<td>Supramentale</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Pogonion</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

Fig 5. Progress intraoral photographs.
Cervical traction headgear was placed after expander removal. The outer bow of the headgear was bent upward to direct the forces (250 g per side) through the center of resistance of the maxillary first molars, generating a translatory distal movement of these teeth. The headgear’s inner bow was expanded to prevent the first molars from getting into crossbite while being distalized into a wider portion of the arch. One month later, the maxillary arch was bonded with edgewise brackets (0.022 × 0.028 in). Compressed coil springs were used to open the needed space for the unerupted canines while proclining the anterior teeth. The headgear was used for 11 months and discontinued when the maxillary canines started erupting, while a Class III molar relationship was achieved (Fig 5, C and D).

The mandibular arch was banded and bonded 15 months after the maxillary arch, when the maxillary canines were erupted completely. A normal progression of archwires was used to level, align, and coordinate the arches. Class II and vertical elastics were also needed to achieve proper anteroposterior occlusal interdigitation. The impacted mandibular third molars were

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**Table II.** Arch-width measurements (mm)

<table>
<thead>
<tr>
<th>Arch</th>
<th>Maxillary</th>
<th>Mandibular</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
</tr>
<tr>
<td>3-3</td>
<td>–</td>
<td>23</td>
</tr>
<tr>
<td>4-4</td>
<td>20</td>
<td>25</td>
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<tr>
<td>5-5</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>6-6</td>
<td>30</td>
<td>35</td>
</tr>
</tbody>
</table>

T1, Pretreatment; T2, posttreatment; T3, 5 years 3 months posttreatment; 3, canine; 4, first premolar; 5, second premolar; 6, first molar.

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Fig 6. Posttreatment facial and intraoral photographs (age, 15 years 10 months).
removed during active treatment at 14 years of age. Her cooperation was excellent, and the appliances were removed at age 15 years 10 months—3 years 10 months after the start of fixed appliance treatment.

Retention consisted of a maxillary Hawley appliance worn full time for 24 months, followed by 3 months of nighttime wear. The mandibular retainer consisted of a 0.0215-in twisted wire bonded onto the lingual sides of the incisors and canines. The fixed mandibular retainer could be kept permanently to enhance the long-term stability of the results.

**TREATMENT RESULTS**

Favorable facial changes were observed with better lip support and an improved nasolabial angle. The lips appeared thicker with a wider vermilion. A normal lip line and smile arc were observed on smiling without mandibular tooth display. There were no black triangles, and the smile width had improved dramatically (Fig 6). Intraorally, the severe arch-length deficiency was eliminated in both arches with proclination of the anterior
teeth, molar distalization, and transverse expansion. The transpalatal first molar width was increased by 5 mm to a normal arch width of 35 mm (Table II). The impacted canines were repositioned and aligned. Bilateral Class I canine and molar relationships were established with optimal overbite and overjet and a well-interdigitated buccal occlusion. The right second molars were not touching at retention but settled into occlusion after treatment. There was excellent tooth alignment, and both arch forms were ovoid and coordinated (Figs 6 and 7).

The posttreatment panoramic radiograph showed good overall root parallelism. The supporting tissues appeared healthy, and no apical blunting was noticed despite the lengthy treatment time. The maxillary third molar buds were still in high positions, and the roots were not developed (Fig 8). The posttreatment cephalometric radiograph and the superimposed tracings showed even downward and forward facial growth with no changes in the skeletal measurements as expected with no orthopedic treatment. There was good vertical control, and the pretreatment high mandibular plane angle was reduced by 1° for FMA and 2° for SN-MPA, despite the use of mechanics (RME, cervical traction headgear, and lip bumper) that have a tendency to open the bite. This decrease in FMA could be attributed to ramus growth and mandibular border remodeling that was concomitant with an increase in the posterior facial height-anterior facial height ratio. Both the maxillary and mandibular molars were moved distally at the end of treatment. The maxillary and mandibular incisors were proclined to normal relationships. Soft-tissue analysis showed a clear advancement of the upper and lower lips, along with growth of the chin and nose. This improved the relationships to the Holdaway line of chin, lips, and nose (Figs 9 and 10, Table I).

Posttreatment records taken 5 years 3 months after fixed appliance removal showed more favorable facial changes with improved lip fullness and smile aesthetics. Upon smiling, there was optimal transverse tooth display to the second premolars on each side without black spaces. The lip line looked normal, displaying the entire clinical crown, and the smile arc was optimal with the incisal edges of the maxillary teeth running along the lower lip curvature (Fig 11). Intraorally, long-term stability was excellent after 3 years without maxillary retention (Figs 11 and 12, Table II). The maxillary third molars appeared impacted on the panoramic radiograph, and extraction was recommended (Fig 13). The superimposed cephalometric tracings at posttreatment (age 15 years 10 months) and 5 years 3 months posttreatment (age 21 years 1 month) showed some facial growth (Fig 14). This confirmed a continuation of mandibular and maxillary growth into what is conventionally termed “early adulthood.”

In addition to late
mandibular growth, the maxillary and mandibular dente-
tion moved forward and downward, whereas the nose
moved more downward than forward. The distance
from the Holdaway line to the tip of the nose was re-
duced from 9 to 5 mm, confirming the increased lip
fullness between posttreatment and 5 years 3 months
posttreatment (Fig 14, Table I).

DISCUSSION

The indication for extraction in orthodontics has his-
torically been controversial. Angle and his followers
believed that they could grow bone with their appli-
cances, obviating the need for extractions in all patients.
They were first challenged by Case, who advocated
tooth extraction for protrusion. But, Tweed, in his
search for stability, swung the pendulum in the opposite
direction in 1940, when he aligned 100 consecutively
retreated patients with 4 first-premolar extractions at
the Angle Society meeting in Chicago. Today, there is
subjective dissatisfaction with facial esthetics achieved
by a strictly limited extraction approach. Also, there is
realization that the removal of teeth does not guarantee
stability; therefore, many clinicians have favored re-
turning to nonextraction treatment. Most clinicians
are now treating without extractions and are using
RME and lip bumpers to increase arch size. There is
still considerable controversy about whether better
long-term stability is achieved by extraction or nonex-
traction treatment. Various studies have shown that
anteroposterior and lateral increases in the mandibular
arch form usually fail, with the dental arch form

Fig 11. Posttreatment facial and intraoral photographs at 5 years 3 months (age 21 years 1 month)—
3 years without maxillary retention.
typically returning to its pretreatment size and shape.8,9,15 Conversely, there was excellent long-term stability in patients treated by Cetlin, even though the mandibular intercanine width was developed in every patient.16 With increasing demands for nonextraction treatment, are we compromising long-term stability to satisfy the well-documented public preference for fuller and more protrusive facial profiles than our customary cephalometric standards?17-19

RME has traditionally been used to correct crossbites. For this patient, the procedure was used, even though there was no crossbite, to broaden the smile and gain arch perimeter to avoid extractions.20 She had a transverse maxillary deficiency (first molar transpalatal width, 30 mm) camouflaged by laterally flared maxillary posterior teeth. Maxillary arches less than 31 mm wide need expansion.21 The presence or absence of a clinical posterior dental crossbite does not indicate the absence of a transverse skeletal discrepancy.22 RME has been shown to increase the perimeter of the maxillary arch and can provide space to correct moderate (3-4 mm) crowding.21-23 An average increase in arch perimeter of 4.7 mm for an average molar expansion of 6.5 mm has been reported.24,25 To address the pretreatment maxillary arch-length deficiency of 13 mm, 4 mm were gained from RME, 5 mm from incisor proclination (2.5 mm labially), and the remaining 4 mm from molar distalization (2 mm per side). Among the various methods used for maxillary molar distalization are headgears and noncompliant interarch appliances. The latter have a reciprocal effect except for those connected to palatal implants. The headgear appliance with its extraoral anchorage has proven to be a valuable nonextraction approach in distal movement.26 Despite its need for patient compliance, it was selected for its control over the transverse dimension.

The spontaneous transverse expansion of the mandibular arch after RME usually does not supply adequate space for mandibular crowding.27 Alternative nonextraction treatments to solve the 7 mm arch-length deficiency in the mandibular arch are a lingual arch or
A lip bumper. Arch maintenance with a passive lingual arch has shown encouraging long-term stability.\(^28\) However, it could not provide more than 2.5 mm of space, which is the amount of leeway space from the retained right second deciduous molar.\(^{29}\) A lip bumper was more appropriate because it allowed an increase in arch dimensions in addition to the space gain from the leeway.\(^{30}\) By holding the cheeks and the lip away from the buccal surfaces of the teeth, tongue pressure can act unopposed to increase transverse arch dimensions and procline the incisors in addition to distal movement of molars. The lip bumper was effective in resolving the 7 mm of arch-length deficiency in the mandibular arch by maintaining 2.5 mm of leeway space and gaining 3 mm from incisor proclination (1.5 mm labially) and an additional 2 mm from molar distalization (1 mm per side). As a result, spontaneous tooth alignment was achieved before full fixed appliances.

Many guidelines have been suggested to enhance stability, including placing the teeth upright over basal bone or in their pretreatment position, obtaining proper occlusal relationship and function, maintaining pretreatment arch form and intercanine width, avoiding overexpansion, taking into account muscle balance and harmony, and prolonged or permanent retention.\(^{7,31-33}\) Today, we have enough evidence that RME is a reliable procedure with long-term stability\(^{34,35}\); even studies reporting significant relapse have shown substantial net gains.\(^{36-38}\) The long-term stability of lip bumpers remains untested. This patient had lingually inclined mandibular buccal segments compensating for a constricted maxillary arch. One might expect mandibular expansion concurrent with maxillary expansion to be more stable because posterior teeth have been uprighted over basal bone (decompensation). Further research on posterior tooth stability is needed because data regarding teeth uprighted over basal bone are mostly on incisors. A study of RME combined with lip bumper expansion therapy in the late mixed dentition followed by fixed appliances found good long-term stability; the sample had mean arch-length deficiencies of 1.24 mm in the maxilla and 1.32 mm in the mandible.\(^{59}\) This case report showed excellent long-term stability despite a severe arch-length deficiency.

Although the fixed retainer from canine to canine was maintained, the occlusion and the transverse dimension in the posterior part of the mandibular arch remained stable; there was no change in arch-width measurements from appliance removal to 5 years posttreatment (Table II). There are no clear-cut stability studies showing when fixed mandibular retainers can be removed; maintaining them permanently is not unreasonable to avoid relapse. With the possibility of gaining some leeway space, arch-length deficiency in the mandibular arch was 4.5 mm. Therefore, the stability challenge for this patient was in the maxillary arch, which should have dictated an extraction approach with its 13 mm of arch-length deficiency. However, the patient’s facial esthetics were enhanced with non-extraction treatment, and the posttreatment records 3 years out of maxillary retention showed excellent alignment, and occlusal and arch-width stability (Fig 11, Table II).

This case report challenges various studies in which this enlargement method of treatment was found to have the poorest stability results compared with serial extraction, arch maintenance, and extractions in the permanent dentition.\(^{40}\) The lengthy treatment time with the lip bumper (20 months) and in fixed appliances (3 years 10 months) probably allowed enough time for muscle adaptation. Optimal tooth interdigitation, prolonged retention, and individual adaptation were also responsible for the long-term stability of the results.
REFERENCES