Long-term adaptations to changes in the transverse dimension in children and adolescents: An overview

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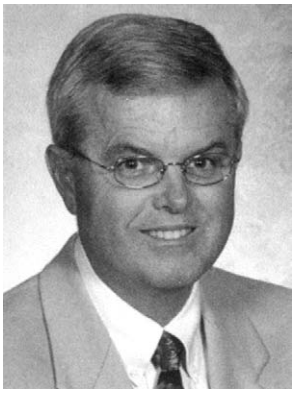

Can the transverse dimensions of the dental arches be widened in a stable fashion over the long term? This question continues to challenge clinicians and researchers.[1] Most orthodontists cite the correction of crossbite as the primary reason for altering the transverse dimension with rapid maxillary expansion (RME). A less obvious but more common orthodontic problem, whose etiology in part is related to imbalances in the transverse dimension, is a discrepancy between tooth size and arch size. The most frequently observed type of malocclusion in routine orthodontic practice is dental crowding, an underlying imbalance between aggregate tooth size and available arch perimeter. This relationship also might be expressed clinically as protrusion and flaring of the teeth relative to the underlying basal bone. Proposed solutions include extraction, interproximal reduction, and orthodontic and orthopedic expansion of the dental arches.[2]

We have known for nearly 150 years that the maxilla can be expanded.[3] Although Haas made RME routine in many orthodontic practices in the 1960s,[4] it is surprising how few long-term studies of RME are sound methodologically—at least by today's standards. Most of the sound investigations have been published only during the last decade. Several recent studies by our group at the Univesity of Michigan are relevant,[5-10] and all but 1[11] have been published or are in press in refereed orthodontic journals. The control groups for the studies described here were derived from the University of Michigan Growth Study[12,13] and the University of Groningen (The Netherlands) Growth Study.[14] In all investigations involving the analysis of dental casts, arch width, arch depth, arch perimeter, and molar angulation were assessed in all examined subjects at all observation times.

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Treatment in adolescents

One of the treatment protocols at the University of Michigan involves RME combined with comprehensive edgewise orthodontics. The treatment effects produced by this protocol were evaluated in patients who began treatment in the late mixed or early permanent dentition.[5] A Haas-type expander with acrylic coverage on the palate was used. The treated group included 112 patients, and their records were compared with those of 41 untreated controls. Serial dental casts were available at pretreatment (T1), after expansion and fixed appliance therapy (T2), and at long-term observation (T3). The mean durations of the T1-T2 and T2-T3 periods for the treatment group were 3 years 2 months ± 5 months, and 6 years 1 month ±1 year 2 months, respectively, with the last observation interval at 20 years of age.

Treatment with RME followed by fixed appliances produced significantly favorable long-term changes in almost all maxillary and mandibular arch measurements. In comparison with the controls, the treated subjects' net gains at T3 (20 years of age or older) were 6.0 mm in maxillary arch perimeter and 4.5 mm in mandibular arch perimeter. The duration of retention with a fixed mandibular appliance in the posttreatment period did not appear to affect the long-term outcomes of the treatment protocol significantly.[5]

A companion lateral cephalometric study of the long-term cephalometric effects of a subgroup of patients treated with the same protocol showed that RME therapy used to treat Class I and Class II patients did

not have a significant long-term effect on either the vertical or the anteroposterior skeletal dimensions of the face when compared with a matched group of patients treated with fixed appliances alone or with untreated controls.[6] For example, there was no opening of the mandibular plane angle and no forward or backward movement of Point A over the long term. Furthermore, a companion posteroanterior cephalometric study on the same patient sample demonstrated the long-term stability of the skeletal correction in the transverse dimension.[7]

Treatment in children

Another treatment protocol that we have used extensively for the last 25 years is orthopedic expansion of the maxilla with a bonded acrylic splint expander in the early mixed dentition, with or without prior mandibular dental "decompensation" with a removable Schwarz expander.[2] In about two-thirds of the patients studied, brackets also were placed on the maxillary anterior teeth to achieve incisor alignment in about 4 to 6 months. After the RME appliance was removed, the expansion typically was stabilized by having the patient wear a maintenance plate on a full- or part-time basis. Phase 2 consisted of full edgewise appliances to optimize the occlusion.

We have completed 2 prospective clinical studies of the long-term effects of the expansion protocol. The first study examined the treatment effects of the acrylic splint RME appliance used alone in the early mixed dentition (ie, no prior mandibular expansion).[8] The dental casts of 51 consecutively treated patients were compared with those of 41 untreated controls at 3 intervals: T1, T2, and T3. The mean ages for the treatment group were 8 years 10 months at T1, 13 years 10 months at T2, and 19 years 9 months at T3.

Treatment with an acrylic splint expander followed by fixed appliances produced significantly favorable long-term changes in almost all maxillary and mandibular arch measurements. The amount of change in maxillary and mandibular intermolar and intercanine widths fully corrected the initial discrepancies. Approximately 4 mm of long-term relative increase in maxillary arch perimeter and 2.5 mm additional maintenance of mandibular arch perimeter were observed in patients when compared with untreated subjects. (These patients were judged not to need active expansion of the mandibular dental arch at the beginning of treatment.) These results suggest that this protocol is effective and stable for the treatment of constricted maxillary arches, although it can relieve modest deficiencies in arch perimeter.

In about 40% of patients undergoing early orthopedic expansion, we expanded the mandibular arch orthodontically before RME to alleviate anterior crowding or lingually inclined mandibular posterior teeth (RME-Schwarz group). The lower Schwarz appliance was activated once a week to create a modest increase in arch length anteriorly and to upright the mandibular posterior dentition before RME.[2]

In our final study in this series (so far),[9] we considered 2 groups of patients, 1 treated with RME alone and 1 with the Schwarz/RME sequence. Both groups were matched longitudinally to untreated controls. The dental casts of 27 RME-only patients were compared with those of 23 RME-Schwarz patients and 16 untreated controls with constricted maxillary arches at 4 intervals: pretreatment, after expansion and before fixed appliance therapy, after fixed appliance therapy, and at long-term observation. The mean ages for the treated groups were approximately 9, 12, 14, and 20 years at the 4 intervals.

Treatment with an acrylic splint RME alone and combined with a mandibular Schwarz appliance followed by fixed appliances produced significant long-term increases in maxillary arch widths over controls. The use of the mandibular Schwarz expander before RME led to significantly more favorable results compared with the RME-only protocol. Significantly greater increases in the transverse width of the mandibular arch and arch perimeter occurred as did uprighting of the mandibular posterior teeth buccally, thus allowing for an amount of maxillary expansion that was clinically effective to correct moderate tooth-size/arch-size discrepancies. During the overall observation interval, the significant increases in maxillary and mandibular arch perimeters in the RME-Schwarz group were 3.8 and 3.7 mm, respectively, when compared with the matched control group. The RME-only protocol produced modest long-term increases in maxillary arch perimeter (2.6 mm); the average long-term increase in mandibular arch perimeter (2.0 mm) in the RME-only group was not statistically significant.

Spontaneous Class II correction

In addition to resolving tooth-size/arch-size discrepancies, another phenomenon has been serendipitous: the so-called "spontaneous correction"[2] of mild Class II (and paradoxically, Class III) malocclusions in patients with maxillary constriction, perhaps as a manifestation of "maxillary deficiency syndrome."[10] A most interesting (and somewhat surprising) observation after our initial efforts to expand Class II patients in the early mixed dentition was the spontaneous correction of Class II malocclusion in some patients during the retention period. Such patients had either an end-to-end or a full cusp Class II molar relationship at the start of

treatment. Generally, they did not have severe skeletal imbalances, but typically were characterized clinically as having either mild to moderate mandibular skeletal retrusion or an orthognathic facial profile.

These patients were overexpanded (with a tendency toward a buccal crossbite) relative to the mandibular arch, with only the lingual cusps of the maxillary posterior teeth contacting the buccal cusps of the mandibular posterior teeth. After removal of the expander, a maxillary maintenance plate was used for stabilization. Six to 12 months later, the tendency toward a buccal crossbite often disappeared, and some patients had a solid Class I occlusal relationship. The shift in molar relationship in these patients occurred before the transition from the mandibular second deciduous molars to the second premolars, the point at which improvement in Angle classification sometimes occurs in untreated subjects because of the forward movement of the permanent mandibular first molars into the leeway space.

To examine this relationship, a large sample of patients and control subjects was required.[11] We assembled the cephalometric records of 574 patients treated in our private practice who had undergone acrylic splint RME therapy during the early mixed dentition and whose cephalometric films were available at T1 and T2. For comparison, we used subjects from the University of Michigan Growth Study (n = 136) whose longitudinal cephalometric films were available at the same times. Both groups were divided about equally into 3 subgroups based on pretreatment molar relationship as viewed in the initial cephalogram.

A subject in the *Class I* group had the mesial contact point of the maxillary first molar that was 2 mm or more distal to the same contact point on the mandibular molar relative to the occlusal plane. The group with *slight Class II tendency* had the maxillary mesial contact point 1.5 to 0.5 mm posterior to the mandibular mesial contact point, and the *Class II tendency* group had an end-to-end or mesial relationship of the mesial contact point of the maxillary molar relative to the mesial contact point of the mandibular molar. For all groups, the average ages were about 8.5 years at T1 and 12.5 years at T2.

We assumed that the molar relationship of the untreated Class I group would remain unchanged, and that was the case (0.0 mm). In the treated Class I group, the average positive change in molar relationship was 0.5 mm. The average changes in molar relationship were 0.6 mm in the untreated group with slight Class II tendency and 1.0 mm in the treated group. If the hypothesis about the spontaneous Class II correction was to be supported, the greatest positive change would be observed in the Class II tendency group. Interestingly, this was the case for both the controls (0.7 mm) and the patient group (1.8 mm). In the latter untreated group, the molar relationships of 48% of the subjects remained unchanged, 41% improved, and 11% worsened. In the treated Class II tendency group, 35% remained unchanged, 63% improved, and only 2% became worse. These results are preliminary at best. We plan to add additional untreated subjects from the Denver Growth Study before our analysis is complete.

Final remarks

RME has been shown to be far more effective as an adjunct to routine orthodontics than simply as an appliance used to correct unilateral and bilateral posterior crossbites. Our long-term research has indicated that patients with mild to moderate crowding can be managed effectively with RME, especially those whose mandibular posterior teeth initially are tipped lingually. More severe crowding, however, must be managed by removal of permanent teeth. When the outcomes of 520 consecutively treated patients from our practice who underwent RME in the early mixed dentition were analyzed, 52 patients ultimately had permanent teeth removed.[15] The teeth typically removed were maxillary first premolars or 4 premolars, leading to a 10% extraction rate in this prospective treatment sample. The need for extraction was based primarily on profile considerations that were evident at the beginning of phase 2.

Thus, when applied in the appropriate patient, RME alone or combined with a removable mandibular Schwarz appliance has been shown to provide clinically significant increases in available arch width compared with matched untreated controls; this protocol might also lead to a spontaneous improvement in molar relationships in some patients during the transition to the permanent dentition.

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