# Early Treatment of Hyperdivergent Open-Bite Malocclusions

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This article establishes the morphologic attributes that characterize hyperdivergent open-bite (Hyp-OB) subjects, reviews associated etiologic factors, compares the various treatment modalities, and provides a rationale and a possible approach for early treatment. Treatment of Hyp-OB patients must address three-dimensional dentoalveolar and skeletal problems in both jaws. For early treatment to be successful, it must effectively deal with the etiology of the problem and the resulting mandibular skeletal dysmorphology. Of the various treatment approaches, including high-pull headgear, extractions, and bite blocks, the vertical chin cup holds the greatest potential for mandibular skeletal modification. Although early treatment can be theoretically justified based on psychosocial benefits and growth potential, more clinical and experimental research is required to optimize the treatment approach and define the long-term consequences. (Semin Orthod 2002;8:130-140.) *Copyright 2002, Elsevier Science (USA). All rights reserved.*

$T$reatment is ultimately dependent on an appropriate diagnosis, which in turn requires an unambiguous description of the problem. Before the advent of cephalometrics, orthodontists necessarily focused on dental relationships and defined open-bite malocclusion based on the vertical relationships of the maxillary and mandibular teeth. By the early 1960s, it became evident that distinctions needed to be made between open-bite malocclusions that included a skeletal component and those that did not.

Simple open-bite malocclusions that do not include skeletal components present less of a challenge for orthodontists; such open-bites often correct spontaneously.[1,2] Because spontaneous correction occurs in up to 80% of mixed-dentition open-bite cases, it has been suggested that interceptive treatments are of little or no value.[3] Successful treatment approaches are also available for persistent cases that do not self-correct.[4,5]

In contrast, open-bite malocclusions that include skeletal components have proven to be extremely challenging for orthodontists. Most investigators have simply referred to them as skeletal open bites[6,7]; Schudy[8] characterized them as hyperdivergent, which reflects the skeletal phenotype.

## Morphologic Characteristics

The typical hyperdivergent open-bite (Hyp-OB) patient presents with three-dimensional skeletal and dentoalveolar problems pertaining to both the maxilla and mandible. Variation in expression of traits among subjects should be expected. Within-subject differences clearly show that most of the dysmorphology occurs in the mandible.

Table 1 summarizes the problem list for the maxilla. The most consistent findings across

**Table 1.** Maxillary Morphologic Characteristics of Untreated Open Bites

| Author | Heights | | Length | SNA | PPA | Dentoalveolar Heights | | Width |
|---|---|---|---|---|---|---|---|---|
| | Ant | Post | | | | Incisor | Molar | |
| Subtelny and Sakuda[6] | 0 | 0 | 0 | ? | 0 | ↑ | ↑ | ? |
| Bell[105] | ? | ? | ? | ? | ? | ↑ | ? | ↓ |
| Isaacson et al[106] | 0 | ? | ? | ↓ | ? | ↑ | ↑ | ↓ |
| Nahoum et al[107] | ↓ | ? | ↓ | ? | ↓ | 0 | 0 | ? |
| Schendel et al[108] | 0 | ? | ? | ↓ | ? | ↑ | ? | ? |
| Lundström and Woodside[109] | ↓ | 0 | ? | ? | ? | ? | ? | ? |
| Fields et al[110] | 0 | 0 | ? | 0 | ? | ↑ | ↑ | ? |
| Nanda[95,96] | ↓ | 0 | ? | ? | ↓ | ? | ? | ? |
| Haralabakis et al[111] | 0 | 0 | ↓ | ? | ? | ↑ | ↑ | 0 |
| Trouten et al[112] | 0 | ↑ | ? | ? | ↓ | ? | ? | ? |
| Lopez-Gavito et al[113] | ↓ | 0 | ? | ↓ | ↓ | ↑ | ↑ | ? |
| Janson et al[114] | ? | 0 | ? | ? | ? | ↑ | ↑ | ? |

Abbreviations: ↑, increase; ↓, decrease; 0, no difference; ?, not reported.

studies pertain to anterior and posterior dentoalveolar heights, which tend to be excessive. When evaluated, the palatal plane angles have been reported to be flatter because of decreased anterior upper facial heights; posterior upper facial heights do not appear to be affected. There is also a tendency for maxillas to be shorter and slightly recessive. When transverse dimensions have been evaluated, the maxilla is often reported to be narrow with an increased incidence of posterior cross-bites.

The most consistent mandibular characteristics are increased lower anterior facial heights, steeper mandibular planes, and larger gonial angles (Table 2). These traits combine to produce increased lower to upper and lower to total anterior facial height ratios. Most studies also report decreased posterior facial heights caused by smaller ramus heights. It has also been shown that the glenoid fossa is positioned more superior relative to sella turcica. Mandibular dentoalveolar heights are also generally reported to be excessive in Hyp-OB patients.

## Etiology of Hyp-OB Malocclusion

It is well established that abnormal muscles and habits are associated with Hyp-OB malocclusion.[6] Finger, thumb, and tongue habits are perhaps the best known physical factors that produce open-bite malocclusions by lowering the mandible and preventing normal eruption.[9] Individuals with prolonged nonnutritive-sucking habits have been repeatedly shown to have a

**Table 2.** Mandibular Morphologic Characteristics of Untreated Open Bites

| Author | Heights | | Corpus | Gonial | | | Dentalveolar Heights | |
|---|---|---|---|---|---|---|---|---|
| | Ant | Post | Lt | Angle | MPA | Retrogn | Incisor | Molar |
| Schudy[8] | ↑ | ↓ | ? | ? | ↑ | ↑ | ? | ↑ |
| Subtelny and Sakuda[6] | ↑ | ↓ | 0 | ↑ | ↑ | ↑ | 0 | 0 |
| Bell[105] | ↑ | ↓ | ? | ↑ | ↑ | ↑ | ↑ | ? |
| Isaacson et al[106] | ↑ | ↓ | ? | ? | ↑ | ↑ | ? | ↑ |
| Nahoum et al[107] | ↑ | ↓ | ↓ | ↑ | ↑ | ? | 0 | ↓ |
| Schendel et al[108] | ↑ | ↓ | ? | ? | ↑ | ↑ | ? | ↑ |
| Lundström and Woodside[109] | ↑ | ? | ? | ↑ | ↑ | ↑ | ? | ? |
| Cangialosi[115] | ↑ | ↓ | ? | ↑ | ↑ | ? | ? | ? |
| Fields et al[110] | ↑ | ↓ | 0 | ↑ | ↑ | 0 | ↑ | ↑ |
| Nanda[95,96] | ↑ | 0 | ? | ↑ | ? | ? | ? | ? |
| Haralabakis et al[111] | ? | ↓ | ↓* | ↑ | ? | ? | ↑ | 0 |
| Trouten et al[112] | ? | ? | ? | ↑ | ↑ | ? | ? | ? |
| Lopez-Gavito et al[113] | ↑ | ↑ | ? | ? | ↑ | ↑ | 0 | 0 |
| Janson et al[114] | ? | ? | ? | ? | ? | ? | ↑ | ↑ |

Abbreviations: ↑, increase; ↓, decrease; 0, no difference; ?, not reported.
*Females only.

decrease overbite,[10-14] increased overjet,[10,11,13] decreased palatal width,[11,15] and increased lip incompetence.[12]

There is considerable evidence showing smaller, less active, muscles and weaker bite forces among hyperdivergent subjects. Masseter and medial pterygoid muscle volumes and cross-sectional areas have been positively correlated with posterior face and ramal heights and negatively correlated with the mandibular plane and gonial angles.[16-21] Kiliaridis and Kalebo[22] showed that women with thin masseter muscles had proportionately longer faces. Bakke et al[23] found that muscle thickness at the most voluminous, superficial portion of the masseter was significantly correlated with bite force, anterior face height, and mandibular inclination. Moreover, the amplitudes of masseter and temporalis electromyographic (EMG) activity at rest, during swallowing, chewing, and maximal biting have also been negatively related with mandibular hyperdivergence in children 9 to 11 years of age.[24] Bakke and Michler[25] showed that EMG activity during maximal voluntary contraction was negatively correlated with anterior face height, mandibular inclination, vertical jaw relation, and gonial angle.

The smaller, less active muscles that characterize Hyp-OB subjects produce lower than normal bite forces.[26] In adults, stronger molar and incisor bite forces are highly correlated with smaller gonial angles, lower mandibular plane angles (MPA), and larger posterior face heights.[27,28]

The relationship between weaker bite forces and hyperdivergence is not as strong for children as adults. Proffit and Fields[29] originally showed no significant differences in occlusal forces between long-face and normal children 6 to 11 years of age. By using more refined analytical techniques, Garcia-Morales et al[30] recently found that children (age 9.3 ± 3.6 years) with greater skeletal hyperdivergence had poorer mechanical advantage and lower maximum bite forces.

Although the association is well established, it remains controversial whether lower occlusal forces in long-face individuals produce hyperdivergence[26] or whether weaker occlusal forces are a biomechanical result of the long vertical facial proportions.[31] This controversy is at least partially resolved by studies showing typical Hyp-OB

features among individuals with genetically determined neuromuscular diseases that weaken masticatory muscles. Patients with myotonic dystrophy have 2 to 3 times less EMG activity of the temporalis and masseter muscles during maximum clenching, lower maximum bite forces, anterior open bite malocclusions, and hyperdivergent growth patterns.[32,33] Similarly, individuals with spinal muscular atrophy have open-bite malocclusions, increased vertical skeletal dimensions, steep mandibular plane angles, and hyperdivergent facial patterns.[34] They also have weaker, less efficient, masticatory muscles that fatigue more quickly than those of matched controls.[35]

Numerous experimental animal studies and human clinical studies have also shown relationships between the Hyp-OB phenotype and chronic upper, middle, and lower airway obstructions. Rhesus monkeys forced to become mouth breathers showed greater than expected increases in anterior face height associated with mandibular lowering, decreases in arch width, and changes in tongue position and shape.[36] In fact, both light and heavy nasal obstruction produces downward and backward mandibular rotation, increased gonial angulation, and anterior open bite in primates[37] and rodents.[38]

The relationship between airway obstruction and skeletal hyperdivergence is well established in humans.[39,40] Compared with their nose-breathing counterparts, chronically allergic mouth-breathing children 6 to 12 years of age have narrower maxillas; greater incidence of posterior cross-bites; longer anterior facial heights; steeper palatal, occlusal, and mandibular planes; larger gonial angles; and more retrognathic mandibles.[41] Mouth breathers with hypertrophied adenoids have narrow maxillas, lower tongue positions, proclined incisors, and increased lower anterior facial heights.[42] Normalization of incisor inclination, maxillary arch width, depth of the bony nasopharynx, and mandibular plane inclination has been reported for children after adenoidectomies to correct severe nasopharyngeal obstruction.[43,44] Children with enlarged tonsils also have more retrognathic mandibles, larger lower anterior facial heights, and larger MPAs.[45] The controversy concerning airway relates more to our ability to accurately diagnose airway problems for individuals rather

**Table 3.** Outcomes of Various Treatments Modalities for Hyperdivergent Open-Bite Malocclusion

| Effect Site | HPHG | HPGH + Splint | Extract | HPHG + Extract | Passive PBB | Active PBB | VCC |
|---|---|---|---|---|---|---|---|
| Condylar growth/amt | − | − | 0 | 0 | 0 | 0 | + |
| Condylar growth/dir | 0 | 0 | 0 | 0 | − | 0 | + |
| Mandibular AP Position | 0 | 0 | 0 | 0 | + | + | + |
| Posterior Face Height | − | − | 0 | 0 | + | 0 | + |
| Anterior Face Height | 0 | 0 | 0 | 0 | + | + | 0 |
| Skeletal AP Relations | + | + | 0 | 0 | + | + | + |
| U6 Position | + + | + + | − | + + | + | + | + |
| L6 Position | − | 0 | − | ~ | + | + | + |
| Overbite | 0 | 0 | + | + + | + + + | + | + |
| Overjet | + | + | + | + + | + | + | + |

Abbreviations: 0, no difference; −, not significant; +, significant; + +, very significant; + + +, extremely significant.

than in the relationship between obstruction and skeletal hyperdivergence.

The common denominator among Hyp-OB subjects with habits, weak muscles, and airway obstructions appears to be a lowered mandibular posture. An individual's response to airway obstruction is immediate and predictable; the activity of the neck and masticatory muscles, head posture, and mandibular posture change quickly.[46,47] Habits and weak elevator muscles might also produce changes in mandibular posture that, during growth, necessitate developmental adaptations leading to the Hyp-OB dysmorphology.

## Treatment Modalities

Based on the forgoing, treatment of Hyp-OB patients must address three-dimensional problems pertaining to the dentoalveolar and skeletal structures of both jaws. Although hyperdivergent Class III open-bite cases are perhaps the most difficult to treat nonsurgically, they occur less frequently. In contrast, the Class II is the most common type of hyperdivergent patient. A severe hyperdivergent Class II patient requires reductions in dentoalveolar height throughout the maxilla and mandible (Table 3); reductions in gonial angulation; increased palatal plane angulation; maxillary expansion; and true mandibular autorotation to increase posterior mandibular height, redirect condylar growth, decrease anterior lower facial height, and reposition the chin forward (Fig 1).

### High-Pull Headgear

High-pull headgear (HPHG) has traditionally been the appliance of choice for treating Hyp-OB patients because it has been shown to effectively hold maxillary sutural growth and vertical dentoalveolar development.[48-53] Although animal studies have reported absolute distal and superior displacement of metallic implants in the maxilla,[54,55] human studies do not support increased autorotation.[49,56] In fact, Baumrind and coworkers[51,57] found that high-pull patients displayed relative increases in the MPA and reduced condylar growth.

Acrylic splints with HPHG create one large anchor unit that prevents unfavorable tipping of the upper molars.[54,55,58-61] Caldwell and collaborators[62] showed that this approach produced a superior and distal displacement of the maxilla, reductions of the Sella-Nasion-A (SNA) angle, clockwise rotation of the palatal plane, and relative intrusion of the upper molars. Importantly, they also reported increased lower molar eruption, decreased mandibular growth, and increased Sella-Nasion-B (SNB) angulation.

### Extractions

Extraction therapy for hyperdivergent patients is predicated on the belief that molars moved mesially out of the occlusal wedge increase mandibular autorotation, decrease anterior facial height, and reduce open-bite malocclusions. However, Yamaguchi and Nanda[63] reported no differences in molar position or the A point-Nasion-B (ANB) angulation between extraction and nonextraction patients treated with high-pull face bows. Staggers[64] showed no significant differences between Class I nonextraction and extraction cases in changes of anterior facial height, upper to lower face height ratios, MPAs, posterior to anterior facial height ratios, or the distances of the molars to the palatal and man-
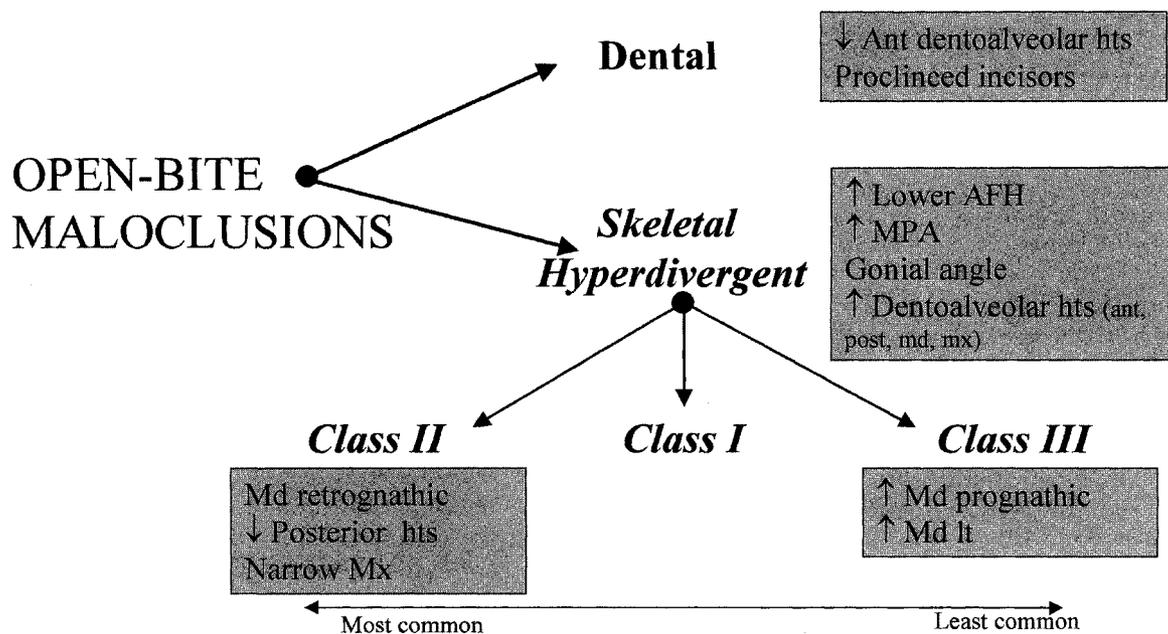
**Figure 1.** Problem lists for open-bite malocclusions. (AFH = anterior facial height; ant = anterior; post = posterior; md = mandible; mx = maxilla)

dibular planes. After extractions, Class II patients show decreases in the ANB angle, supraeruption of the lower molars, and increases in the MPA.[65] Pearson[66] evaluating cases with moderately steep MPAs treated with extractions and occipital headgears also reported significant supraeruption of the lower molars. Clearly, forward mandibular rotation and loss or even maintenance of vertical facial and dentoalveolar heights does not occur in the extraction patients.

Combined HPHG and extraction treatment produces results similar to extractions only. The primary differences pertain to the molars; the vertical movements of the upper molar are better controlled, but the lower molar shows even greater compensatory supraeruption.[65,66] The positive effects of combined HPHG and extraction treatment are confined to the maxillary dentoalveolar regions. If the goal is to improve the orientation, position, and shape of the mandible, then other treatment approaches may be required.

**Posterior Bite Blocks**

Posterior bite blocks (PBB) have been shown to effectively modify vertical skeletal patterns in an-

imal models[67-73] and humans.[74-81] However, PBBs hinge the mandible open beyond its resting position by varying amounts, which tends to increase the gonial angle.[69,72,79] McNamara[79] concluded that the maxillary complex was most affected by PBB, although changes have been reported to occur throughout the craniofacial complex.[67]

Animal studies evaluating repelling magnets embedded in bite-block appliances show superior-anterior maxillary displacement and molar intrusion. However, they also show greater potential for root resorption, deviated mandibular jaw posture that could produce skeletal asymmetries, and lateral open bites.[70,73,75,76] Kalra and Burstone,[76] evaluating fixed magnetic bite blocks, reported increased mandibular length, decreased facial convexity, intrusion of the lower and upper molars, improved overjet and molar relationships, and small decreases in the mandibular plane angle and y axis. After treatment, posterior tooth eruption closed the posterior open bite, and the transverse jaw deviations self-corrected. More pronounced treatment effects have been reported for magnetic than spring-loaded bite blocks.[80]

Iscan and associates[74] compared the effects of

a spring-loaded bite block (SLBB) worn for 6 months to a passive bite block and a vertical chin cup worn for 8 months. Both groups showed similar amounts of forward maxillary displacement, increases in mandibular length, posterior molar intrusion, mandibular autorotation, increased overbite, and reductions of anterior facial height. The SLBB group showed greater reductions in the ANB angle and lower molar intrusion, whereas the passive bite block and vertical chin cup group showed greater improvement in lower facial height and overbite. The SLBB also showed gonial angle increases, an undesirable effect.

Dellinger's[77] active vertical corrector, with repelling magnets embedded in bite blocks and acrylic shields to prevent lateral jaw deviations, is used in conjunction with a vertical chin cup. Intrusion of the posterior teeth, mandibular autorotation, and reductions in anterior height have been shown after 4 to 7 months of treatment. Dellinger[78] has also reported good long-term stability for five treated cases. Barbre and Sinclair,[81] evaluating the effects of the active vertical corrector without the vertical chin cup, showed increased overbite, decreased lower anterior facial height, and reductions in mandibular plane angulation associated with upper and lower molar intrusion.

### Vertical Chin Cup

Pearson[82-84] has used the vertical chin cup in the mixed and permanent dentition to reduce the mandibular plane angle and limit increases in anterior facial height. A case treated with a vertical-pull chin cup in conjunction with a Kloehn cervical headgear showed significant dental and skeletal alterations; upper molar eruption and descent of the maxilla were inhibited while mandibular growth was redirected toward a more horizontal direction.[85] Treatment success was attributed to the increase in posterior facial height. Chin cups have also been used during active rapid palatal expansion (RPE) therapy to minimize the vertical displacement of the maxilla and control the opening of the mandibular plane angle.[86] Importantly, the vertical chin cup is the only appliance shown to effectively alter mandibular shape by increasing posterior heights, redirecting condylar growth, and decreasing gonial angulation.

## Timing of Treatment

Early treatment can be best justified based on psychosocial benefits and growth potential for correction. Because facial appearance is the most important determinant of physical appearance[87] and the oral region contributes most to overall facial appearance,[88] abnormalities in the oral region negatively affect interpersonal relations,[89] how individuals are perceived by others,[90,91] and self-perception.[92] Early treatment might also obviate the costs and risks associated with relatively complex two-jaw surgical procedures typically performed to correct Hyp-OB malocclusions.

In terms of growth potential, early treatment of Hyp-OB is predicated on the knowledge that (1) it can be diagnosed early, (2) the phenotype does not self-correct, (3) potential for mandibular rotation and associated remodeling is greatest during childhood, (4) certain characteristics may require long periods of growth to fully correct, and (5) treatments are available that can correct complex three-dimensional configuration of problems.

### The Problem Is Apparent Early and Does Not Self-Improve

Longitudinal studies agree that the Hyp-OB phenotype develops early and, on average, does not worsen with age. Longitudinal comparisons show a strong tendency to maintain long, average, and short facial type; most individuals (77%) present with the same facial type at 5 and 25.5 years of age.[93] Although there are growth differences between open- and deep-bite subjects in anterior face height,[94] the overall pattern of development is established early, even before the eruption of the first permanent molars, and maintained during growth. The mandibular plane and gonial angles of both open- and deep-bite groups decrease with age, which tend to decrease the absolute magnitude of skeletal imbalance for open-bite subjects.[95] Untreated vertical growers show less increase of Sella-Nasion-Pogonion (S-N-Pg), less decrease in the MPA, and less decrease in the gonial angle than horizontal growers.[96] If treatment mechanics of long-face individuals require orthopedic modification, it has been suggested that treatment should be initiated before the adolescent spurt.

Based on various measures of vertical development, Garcia-Morales and Buschang[97] recently showed that untreated subjects classified as hyperdivergent at 6 years of age maintain their dysmorphology relative to average or hypodivergent subjects through 15 years of age (Fig 2). Correlations between the individuals' 6- and 15 year-old phenotypes ranged between 0.5 to 0.75. Approximately 64% of the 6-year-old subjects classified as having a high MPA were also classified with high MPAs at 15 years; 28% had average MPAs and 8% had low MPAs (Fig 3A). Changes that occurred were related to the 15-year-old phenotype (correlations range 0.5-0.7) but not to the 6-year-old phenotype. In other words, knowing what a young child looks like helps predict his/her adult status but not his/her growth changes. Although most 6-year-old subjects with high MPAs improved, 24% became more hyperdivergent (Fig 3B). Together, these data suggest that the apparent stability displayed between group averages should not be expected for individual patients. These data emphasize that early interceptive treatment of Hyp-OB patients cannot be justified because we cannot currently predict whose malocclusions will worsen.

**Childhood as a Period of Greater Potential**

Overall growth potential and the capacity of certain characteristics to change are greater during childhood than adolescence. It is also possible that younger children would be more cooperative and more willing to undergoing complex long-lasting treatment regimens than adolescents.

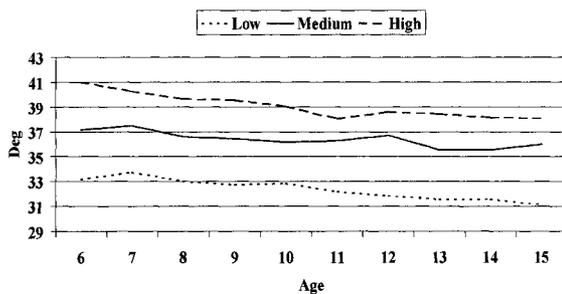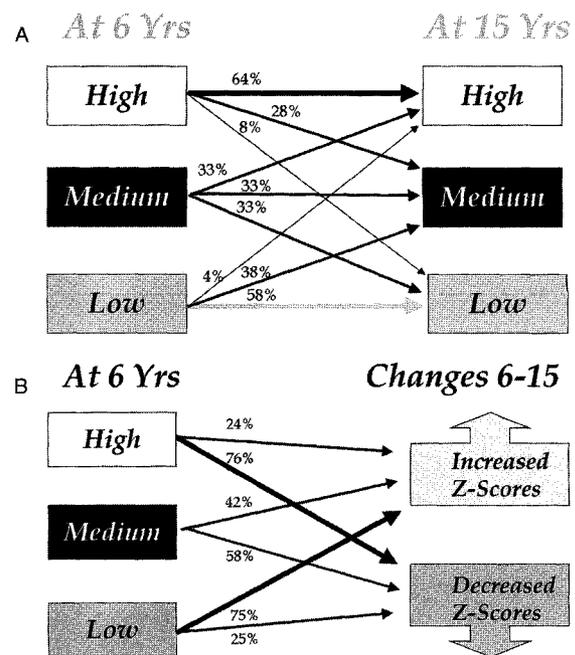Longitudinal analyses show that boys with high angles display significantly less true or total



Figure 3. (A) Frequencies of subjects with high, medium, and low MPAs (S-N/Go-Me) at 6 and 15 years of age. (B) Frequency of MPA (S-N/Go-Me) increasing and decreasing between 6 to 15 years for subjects classified with high, medium and low MPA (S-N/Go-Me) at 6 years.

forward rotation than low angle boys, with the difference being most pronounced during childhood.[98] Changes in the MPA angle also show significant group differences during childhood but not during adolescence. Spady et al[99] showed that true mandibular rotation was significantly greater during childhood than adolescence; rotation was particularly marked during the transition from primary to early mixed dentitions.

As shown, Hyp-OB patients often present with excessive maxillary and mandibular dentoalveolar heights. Relative intrusion of the teeth, especially mandibular teeth that show less eruption potential than their maxillary counterparts, may require considerable time for extreme cases. For example, the average mandibular incisor erupts 5.0 mm for boys and 3.7 mm for girls between 8 to 15 years of age; the first molar erupts 0.5 to 0.7 mm more than the incisor.[100] Relative intrusion over extended periods of growth could serve as an important and potent treatment modality.



Figure 2. Future growth changes for 6-year-old children with low (<1 SD), medium (± 1 SD) and high (>1 SD) mandibular plane angles (S-N/Go-Me).

## Early Treatment Results

It is becoming increasingly clear that treatments for Hyp-OB patients should be directed toward the mandible. Naumann et al[101] have shown that mandibular skeletal changes were twice as important as mandibular dental changes and 2.5 times as important as maxillary changes in affecting overbite changes. Vertical mandibular growth was shown to be more important than mandibular rotation in determining overbite changes. Their models suggest using appliances that limit anterior vertical mandibular growth and augment its forward rotation, rather than appliances that restrict maxillary growth.

Complex problems require complex treatment approaches. Sankey and coworkers[102] recently reported outcomes for patients treated with lip seal exercises, a lower Crozat/lip bumper, a bonded palatal expander constructed to serve as a bite block, and a high-pull chin cup. A sample of children 8.2 ± 1.2 years with average MPAs of 40.1° ± 1.2° performed lip seal exercises for 60 consecutive minutes each day. The Crozat/lip bumper appliance was cemented in place with 2 to 3 mm activation (after 8 weeks, it was reactivated 1 mm every 8 weeks). At the same time, the upper arch was expanded slowly (1/4 turn per week, 1 mm per month) for approximately 6 months. The expander infringed on the freeway space approximately 2 to 3 mm and was ramped to produce progressively thicker occlusal coverage on the palatal half of the appliance. A high-pull chin cup (force directed approximately 45° to occlusal plane) delivering 16 to 20 oz was worn at least 14 hours per day. The patients were compared with controls matched for age, gender, and MPA.

After 1.3 ± 0.3 years of treatment, condylar growth had been increased and changed toward a more anterosuperior direction. Maxillary expansion did not increase vertical dimensions. The mandible showed almost three times more forward rotation than expected, posterior facial height increased significantly more, the molars showed relative intrusion, the articular angle increased, the gonial angle decreased, and the chin moved forward almost twice as much as in the controls. Overjet decreased and overbite increased, especially for the patients with severe open-bite malocclusions. The aggregate of changes implies corrections in all three planes

of space that combine to produce a remarkable treatment result. Interestingly, a subsample of patients that performed clenching exercises sufficient to produce marks on the expander's acrylic did not wear high-pull chin cups but showed similar treatment outcomes.

The potential importance of clenching exercise in the treatment of Hyp-OP patients should not be underestimated. Tran and coworkers[103] recently completed a prospective clinical trial evaluating the effects of light clenching exercises as adjunctive treatment for HPHG and rapid palatal expansion in young children. Although HPHG without exercise produced dentoalveolar effects in the maxilla only, HPHG in combination with exercises also increased true mandibular autorotation and produced significant reductions in the ANB and gonial angles. Because there was no evidence of increased muscle strength, it was suggested that exercise might have altered the postural position of the mandible, which in turn influenced its rotational and remodeling patterns.

## Conclusions

Although early treatment of hyperdivergent open-bite cases is theoretically appealing and practically possible, it remains poorly understood and must be approached with caution. More clinical and experimental research is required to establish the psychosocial benefits and to precisely define the long-term consequences of early treatment. The stability of early treatment will undoubtedly be related to the orthodontist's ability to correct the original cause of the problem. To that end, open-mouth posture associated with habits, weak muscles, or respiratory obstructions must be eliminated to avoid relapse. This implies additional studies necessary to develop sensitive and specific diagnostic indicators. Growth is clearly a critical period that holds great potential for orthopedic and orthodontic corrections as well as for relapse toward the original condition.

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