

OVERVIEW

Interarch Maxillary Molar Distalization Appliances for Class II Correction

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(Editor's Note: In this quarterly column, JCO provides overview of a clinical topic of interest to orthodontists. Contributions and suggestions for future subjects are welcome.)

Class II malocclusion, which affects approximately one-third of patients seeking orthodontic treatment, often reflects both dental and skeletal deviations from the norm.¹⁻³ Because it frequently involves excessive overjet,⁴ it is easily recognized by lay persons, leading to its overrepresentation in orthodontic practices. According to the National Health and Nutrition Estimates Survey III, in which nearly 14,000 U.S. individuals were studied, an overjet of 5mm or more, suggesting Class II malocclusion, occurs in approximately 23% of children, 15% of adolescents, and 13% of adults.⁵ Consequently, considerable effort has been devoted to identifying the etiologic factors involved in Class II malocclusion.

Although the Angle classification of maloc-

clusion is based solely on an occlusal litmus test, the skeletal and dentoalveolar components of interarch discrepancy are far more complicated. In planning treatment for a Class II patient, consideration must be given to incisor proclination, space requirements, vertical dimension, transverse relationship, and overall facial esthetics, in addition to the interarch molar relationship.

Contemporary edgewise extraction treatment (upper premolars or upper and lower premolars) almost always results in forward displacement of the maxillary molars as the molar relationship is corrected. In contrast, edgewise nonextraction treatment predictably results in an absolute distal displacement (bodily movement and tipping) of the maxillary molars.⁶ For a variety of reasons, scientific or not, orthodontic treatment in the past few decades has tended toward nonextraction. Today, practitioners have at their fingertips a variety of techniques and interarch appliances that can be employed to distalize maxillary molars. The following is an overview of some of the most commonly used interarch devices.

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Elastics and Wires

Class II elastics generally are regarded as the mainstay of Class II correction with comprehensive fixed appliances, especially in growing patients. The classic elastic system involves two full edgewise arches, with bilateral elastics stretched between the maxillary canines and mandibular molars⁷ (Fig. 1). Variations on this system include direct attachment of the elastic to an archwire (with a hook, loop, or spur) and an assortment of maxillary and mandibular attachment positions. Although force levels vary greatly depending on the type and placement of the elastic used, forces delivered by a newly placed latex elastic typically range from 50g to 300g.⁹

Class II elastics are widely used because of their simplicity and anteroposterior effectiveness,¹⁰ as well as the relative ease with which they can be incorporated into contemporary edgewise fixed appliance systems. Usually placed after the initial leveling and alignment stages of treatment, Class II elastics can be used with utility arches, sliding jigs, and continuous working archwires. The amount of maxillary molar distalization that Class II elastics produce depends largely on the point of maxillary force application; for example, a maxillary jig will have a more direct molar effect, whereas a continuous maxillary archwire will distribute the distalizing force more evenly over the entire arch. Primary effects of Class II elastics include forward

movement and proclination of the mandibular dentition, along with distal movement and retroclination of the maxillary dentition. Secondary effects include buccal uprighting and widening of the lower molars due to the slight transverse component of force. In the mixed dentition, when Class II malocclusion often is associated with maxillary constriction,¹¹⁻¹³ elastics can be a useful treatment adjunct as the axial inclination of the posterior teeth is corrected and the curve of Wilson is leveled.

Unlike the Herbst* and Jasper Jumper** appliances, Class II elastics exert a pulling force across the occlusal plane (Fig. 2). The vertical component of this pulling force may extrude the maxillary incisors and mandibular molars. Consequently, the effect on the occlusal plane is a clockwise rotation, with a resultant downward and backward rotation of the mandible.¹⁰ In hyperdivergent Class II individuals with steep mandibular plane angles, mechanics that tend to extrude posterior teeth are contraindicated.⁸ The extrusive vertical component of force may be lessened by increasing the span between the maxillary and mandibular attachment points of the elastics, thus making the line of force more parallel to the occlusal plane. Modifying the mandibular attach-

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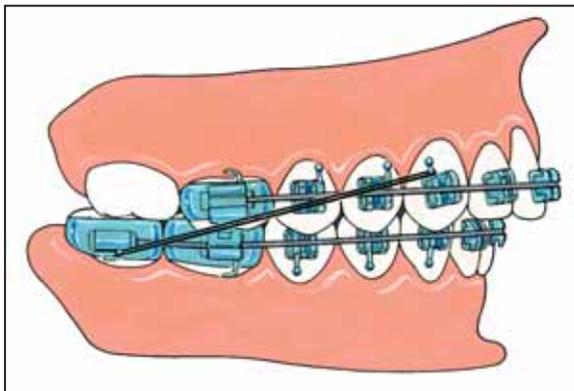


Fig. 1 Typical placement of elastics for Class II correction (Figs. 1-8 reprinted by permission⁸).

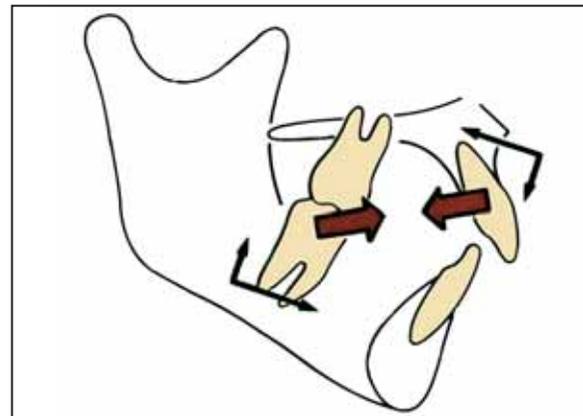


Fig. 2 Pulling forces exerted by Class II elastics.

ment point of the Class II elastic from the first molar to the second molar (Fig. 1), for example, reduces the vertical component of force from 27% to 20%.¹⁰ A variety of auxiliary jigs also have been shown to reduce the vertical component of Class II elastic force.¹⁴⁻¹⁶

The Herbst Appliance

The Herbst appliance, developed more than a century ago, was designed to “jump the bite” of Class II patients.¹⁷ Reintroduced by Panchez in the late 1970s, the modern Herbst appliance incorporated thick bands on the maxillary first molars, con-

nected to bands on the mandibular first premolars by a rigid plunger-in-tube system that forced the lower jaw into a forward position during closure.¹⁸ Subsequent banded designs have incorporated bands on the lower first molars as well (Fig. 3).

Today, a variety of alternative Herbst designs are in use, including the cast appliance,¹⁹ the acrylic splint appliance^{20,21} (Fig. 4), and the stainless steel crown appliance²² (Fig. 5). Despite the considerable variation in appliance design and in the timing and duration of use, the general treatment effects are similar, with most clinical studies indicating an equal division of dentoalveolar and skeletal effects and the involvement of both arches.

The telescoping mechanism of the Herbst appliance places an upward and posteriorly directed force on the maxillary molars (Fig. 6). Interestingly, studies have failed to show a clinically significant

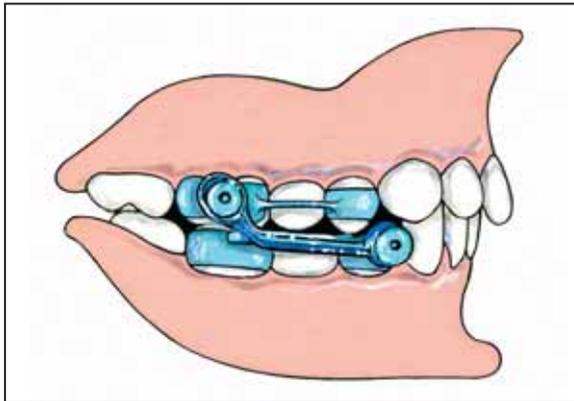


Fig. 3 Banded Herbst appliance.

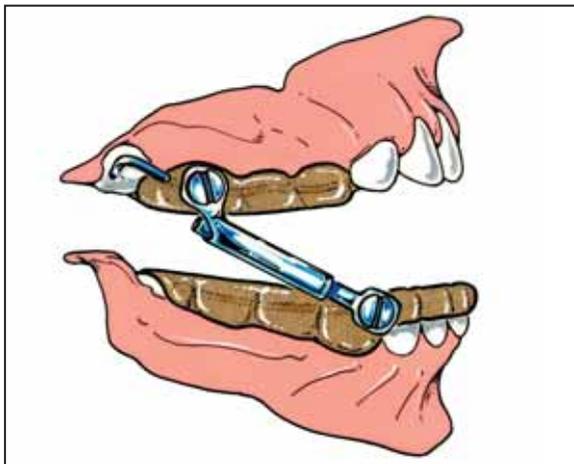


Fig. 4 Acrylic splint Herbst appliance.

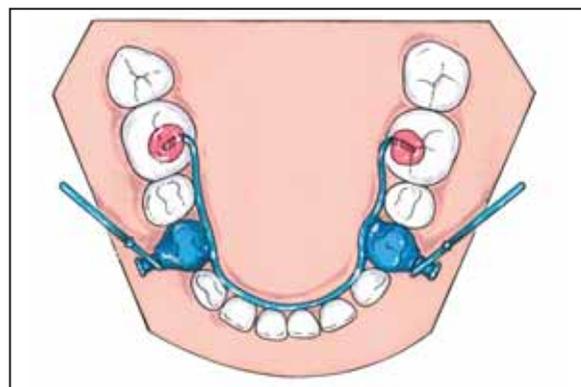
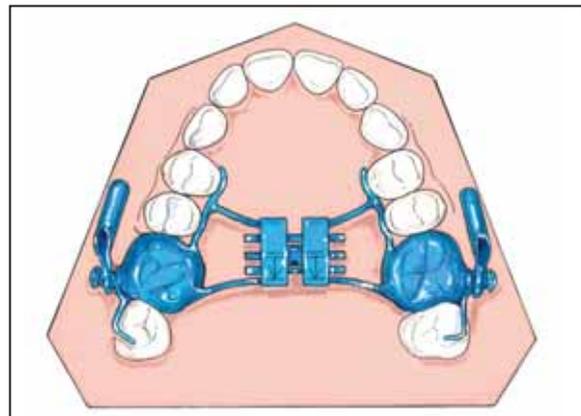


Fig. 5 Stainless steel crown Herbst appliance.

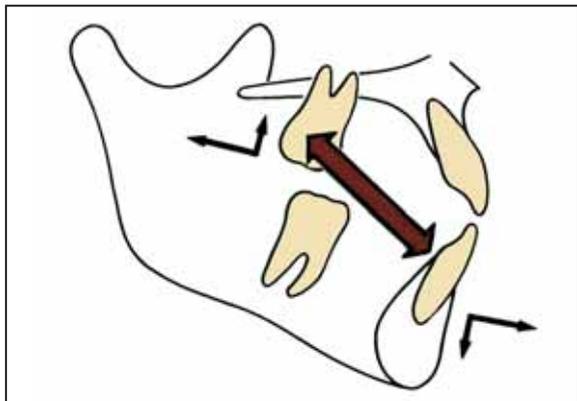


Fig. 6 Pushing forces exerted by Herbst telescoping mechanism.

skeletal effect on maxillary position.²³⁻²⁵ Dentoalveolar changes always can be expected, however, in the maxillary posterior segments. The upper molars may be distalized as much as 5-6mm if the maxillary molars are connected directly and solely to the Herbst without any intra-arch consolidation, as would occur with a rapid palatal expander or full edgewise appliances. When the appliance is used during comprehensive edgewise orthodontic treatment, maxillary molar movement generally is much less, in the range of 1-3mm.^{20,22,26,27} A vertical component of maxillary molar movement also has been observed. Several studies have shown that Herbst treatment will intrude the molars—or limit their eruption—by about 1mm in the vertical dimension.^{20,28} This makes the Herbst appliance an attractive option in the treatment of patients with vertical growth patterns.

Statistically significant skeletal changes in mandibular length and position have been well documented during the active phase of Herbst treatment.^{19,21,24,27} Most clinical studies have found an increase in mandibular length of 2-3mm and an increase in SNB of 1-2° in Herbst patients compared to untreated controls. After active treatment, however, the rate of mandibular skeletal growth drops below the normal rate. Some investigators have reported that the remaining increase in mandibular length is only an average of 1mm.^{21,29,30} Dental changes in the lower arch are more pronounced, with the lower first molars moving 1-2mm

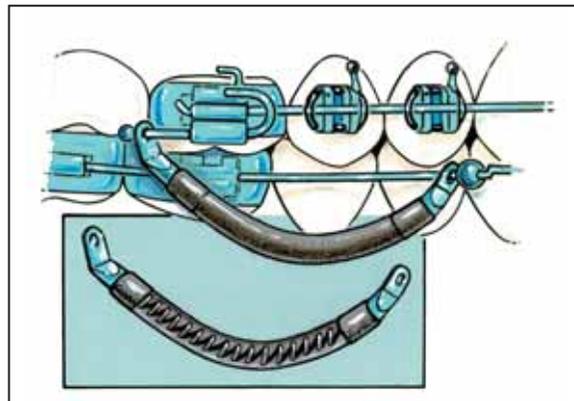


Fig. 7 Jasper Jumper and cross-section of force module.

more mesially than in untreated controls.^{22,27,31} Because posterior movement of the mandibular molars has been observed in long-term follow-up studies,²² many clinicians recommend significant overcorrection in the expectation of dentoalveolar rebound. Still, the reversion to a Class II relationship after Herbst appliance treatment, with a predictable relapse of mandibular proclination and maxillary distalization, remains a major concern.^{30,32}

The Jasper Jumper and Related Appliances

In 1987, J.J. Jasper developed and patented the Jasper Jumper (Fig. 7), which featured a stainless steel compression spring housed in a polyurethane sheath.³³ The Jasper Jumper was viewed by the inventor as a modification of the Herbst “bite-jumping” mechanism that would permit greater freedom of mandibular movement³⁴ (Fig. 8). The compression module, which is available in multiple lengths, may be anchored to the main archwire, attached directly to teeth, or connected with various jig modifications.³⁴⁻³⁶

The Jasper Jumper can be incorporated relatively easily into traditional edgewise orthodontic treatment, as long as headgear tubes are present on the maxillary first molar bands. Generally, fixed appliances do not need to be removed and replaced to accommodate the Jumper. The device also may be used in the mixed dentition if a transpalatal arch

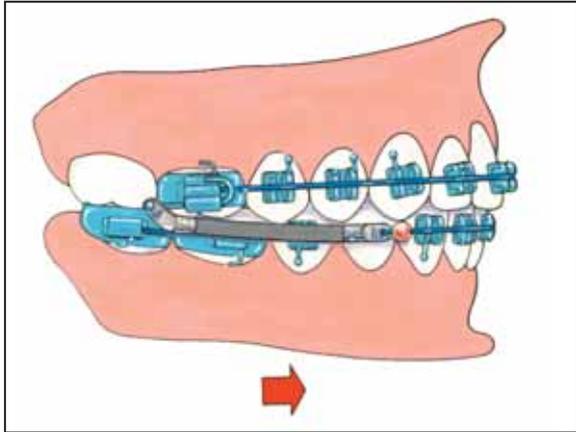


Fig. 8 Application of Jasper Jumper forces.

and lower lingual arch are used to limit unfavorable molar and incisor tipping.³⁴

Like the Herbst appliance, and unlike Class II elastics, the Jasper Jumper produces intrusive intra-arch forces by pushing apart the points of attachment (Fig. 6). Because the vector of this pushing force crosses the plane of occlusion, one component of that force is necessarily intrusive—which can be beneficial in treating patients with vertical growth patterns. Epidemiological studies estimate that 30-50% of pretreatment Class II dentitions have excessive vertical development.³⁷ In contrast to the Herbst appliance, however, the Jasper Jumper is flexible, and in fact obtains its force-generating potential from its flexibility. Because the appliance bends, it is activated when the patient's mandible is elevated from an open position. This activation, a build-up of internal stress, is released continuously during periods of mandibular closure or near-closure. The appliance is designed to deliver approximately 60-250g of force.³⁴

Although not nearly as well studied as the Herbst, the Jasper Jumper has demonstrated more dentoalveolar than skeletal effects.^{36,38-40} The few clinical studies of the Jumper indicate that its occlusal correction is achieved by a combination of posterior maxillary displacement, distal movement and tipping of the maxillary molars, mesial translation and tipping of the mandibular molars, retroclination of the maxillary incisors, and pro-

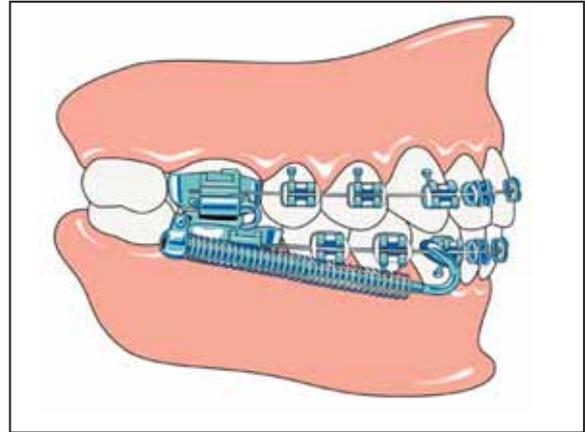


Fig. 9 Forsus Fatigue Resistant Device.

clination of the mandibular incisors. The short-term effects have been estimated to be 60% orthodontic and 40% orthopedic.³⁶

One noteworthy disadvantage of the original Jasper Jumper was its high breakage rate—nearly 10%.^{36,40} The Forsus Spring^{***} and Forsus Fatigue Resistant Device^{***} (FRD), two appliances that are conceptually similar to the Jasper Jumper but hardier, were developed to address that problem.^{41,42} The FRD is a two-piece telescoping piston assembly housed within an open-coil stainless steel spring cylinder (Fig. 9). As the patient closes in maximum intercuspation, the coil spring is compressed, releasing stored energy along the long axis of its orientation. At nearly full compression (10-12mm), it has been shown to apply approximately 200g of force.⁴³ Because the springs rarely are compressed fully in clinical situations, however, the level of actual force delivery is comparable to that of heavy Class II elastics.^{8,44} The manufacturer's assertion that the device is less prone to breakage than the Jasper Jumper has yet to be validated independently.⁴⁹

Mandibular Anterior Repositioning Appliance

Another increasingly popular appliance for correction of Class II malocclusion is the Mandib-

^{***}Trademark of 3M Unitek, 2724 S. Peck Road, Monrovia, CA 91016; www.3mUnitek.com.

ular Anterior Repositioning Appliance† (MARA), a fixed device fabricated on stainless steel crowns that commonly are placed over the maxillary and mandibular first permanent molars (Fig. 10). Reintroduced in its present form in 1991 by Drs. Douglas Toll (Germany) and James Eckhart (United States), it is indicated for use throughout the late mixed dentition and into adulthood.⁴⁶

The MARA's extension arms prevent the patient from closing in a natural Class II relationship, requiring mandibular hyperpropulsion to achieve intercuspation.⁴⁷ The MARA is classified as a functional appliance in part because it causes forward repositioning of the lower jaw for the duration of its use.

The MARA has been reported to have effects generally similar to those of the Herbst appliance, with a few exceptions.⁴⁸ Whereas maxillary molar intrusion is a characteristic feature of the Herbst,^{20,28} this finding has not been reported with the MARA. In addition, the MARA has a greater dentoalveolar effect on the mandibular incisors. Although the MARA and Herbst appliances both produce significant change in the horizontal position of the mandibular incisors compared to untreated controls, the MARA produces less incisal flaring.⁴⁸ The anteroposterior treatment effect of the MARA is achieved through both skeletal and dental changes. The skeletal changes involve increased mandibular length, but negligible maxillary effects. In contrast, the dental changes are due mainly to maxillary molar distalization, which accounts for about 77% of the total dental correction, with the remaining 23% due to mesial mandibular molar movement.⁴⁸

The MARA's design can lead to undesirable dental movements. In the sagittal plane, distal rotation of the upper molars and mesial rotation of the lower molars may be observed. These movements can be controlled, however, by adding support from a transpalatal arch or a lower lingual holding arch. In the vertical dimension, relative intrusion of the molars due to impingement of the freeway space often is observed after removal of the stainless steel crowns, but this phenomenon usually self-corrects in a short time.⁴⁸

†AOA Orthodontic Appliances, P.O. Box 725, Sturtevant, WI 53177; www.aolab.com.

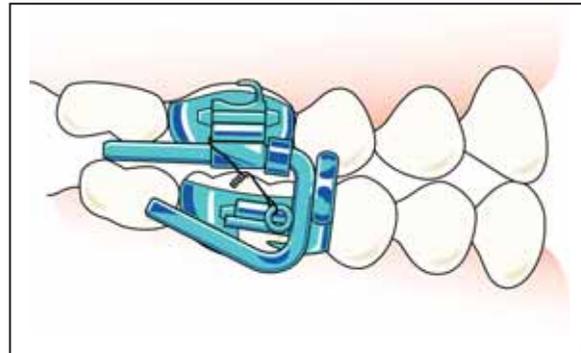


Fig. 10 Mandibular Anterior Repositioning Appliance.

Diagnostic Considerations and Treatment Timing

The issue of optimal Class II treatment timing and its biological rationale is one of the most studied and widely debated topics in the recent orthodontic literature.^{49,50} An investigation using peer assessment ratings of Class II, division 1 cases treated in the early mixed, late mixed, and permanent dentitions revealed that late treatment and fixed appliances were more efficient than earlier treatment and removable appliances.⁵¹ A more recent and remarkably comprehensive study by the Cochrane Collaboration, based on 592 patients who presented with Class II, division 1 malocclusions, concluded that “providing early orthodontic treatment for children with prominent upper front teeth is no more effective than providing one course of orthodontic treatment when the child is in early adolescence”.⁵² Perhaps not surprisingly, cephalometric studies have shown that the therapeutic effectiveness of most Class II correction appliances is greatest when these appliances are used during the circum-pubertal growth period.⁵³⁻⁵⁶ All of the Class II correction appliances discussed in the present overview may be used in the permanent dentition, in conjunction with fixed edgewise appliances.

The key indicator of success over the long term, as many see it, is holding the Class I relationship once it is achieved. Pancherz is given credit for the revival of the Herbst appliance, nearly 30 years ago, with a cephalometric study of its use in growing boys who were selected in part

because they had yet to exhibit maximum pubertal growth.¹⁸ More recently, Pancherz has shifted toward advocating Herbst treatment in the permanent dentition *after* the pubertal growth peak to ensure stable post-treatment intercuspation and to reduce the length of retention.⁵⁷ Avoidance of Class II relapse is known to be a challenge,⁵⁸ but studies have demonstrated that good cuspal interdigitation is an excellent predictor of stability.³²

Conclusion

Biomechanics, patient compliance, timing, and practice management considerations are factors that commingle to render orthodontic appliance systems clinically effective or otherwise. The Class II molar distalization appliances discussed here are no exception. Intermaxillary adjuncts designed to correct the molar relationship all have advantages and disadvantages, indications and contraindications. None by itself is suited to every situation. Moreover, direct comparisons between appliance systems are difficult, in part because of the scarcity of studies on some of these systems. The clinician who utilizes any of the molar distalization appliances discussed here would be well served to select an appliance that complements treatment that is effective as well as efficient.

As the use of temporary anchorage devices becomes more widespread,⁵⁹ modifications of these intermaxillary devices to allow one or more implant-based attachment points are likely. This may enable the correction of Class II malocclusion without the unintended consequences that currently complicate and prolong treatment.

REFERENCES

1. Abd-el Samad Younes, S.: Maxillary arch dimensions in Saudi and Egyptian population sample, *Am. J. Orthod.* 85:83-88, 1984.
2. Kelly, J.E.; Sanchez, M.J.; and Van Kirk, L.E.: *An Assessment of the Occlusion of the Teeth of Children 6-11 Years, United States*, National Center for Health Statistics, Rockville, MD, 1973.
3. Moyers, R.E.; Riolo, M.L.; Guire, K.E.; Wainwright, R.L.; and Bookstein, F.L.: Differential diagnosis of Class II malocclusions, Part I: Facial types associated with Class II malocclusions, *Am. J. Orthod.* 78:477-494, 1980.
4. Brunelle, J.A.; Bhat, M.; and Lipton, J.A.: Prevalence and distribution of selected occlusal characteristics in the US population, 1988-1991, *J. Dent. Res.* 75:706-713, 1996.
5. Proffit, W.R.; Fields, H.W. Jr.; and Moray, L.J.: Prevalence of malocclusion and orthodontic treatment need in the United States: Estimates from the NHANES III survey, *Int. J. Adult Orthod. Orthog. Surg.* 13:97-106, 1998.
6. Johnston, L.E. Jr.: A comparative analysis of Class II treatments, in *Science and Clinical Judgment in Orthodontics*, ed. P.S. Vig and K.A. Ribbens, Center for Human Growth and Development, University of Michigan, Ann Arbor, 1986, pp. 103-148.
7. Thurow, R.C.: *Atlas of Orthodontic Principles*, 2nd ed., C.V. Mosby, St. Louis, 1977.
8. McNamara, J.A. Jr. and Brudon, W.L.: *Orthodontics and Dentofacial Orthopedics*, Needham Press, Ann Arbor, MI, 2001.
9. Dermaut, L.R. and Beerden, L.: The effects of class II elastic force on a dry skull measured by holographic interferometry, *Am. J. Orthod.* 79:296-304, 1981.
10. Philippe, J.: Mechanical analysis of Class II elastics, *J. Clin. Orthod.* 29:367-372, 1995.
11. Haas, A.: Entrevista: Dr. Andrew J. Haas, *Rev. Dent. Press Ortod. Ortop. Facial* 6:1-10, 2001.
12. Staley, R.N.; Stuntz, W.R.; and Peterson, L.C.: A comparison of arch widths in adults with normal occlusion and adults with Class II, Division 1 malocclusion, *Am. J. Orthod.* 88:163-169, 1985.
13. Tollaro, I.; Baccetti, T.; Franchi, L.; and Tanasescu, C.D.: Role of posterior transverse interarch discrepancy in Class II, Division 1 malocclusion during the mixed dentition phase, *Am. J. Orthod.* 110:417-422, 1996.
14. Gulati, S.; Kharbanda, O.P.; and Parkash, H.: Dental and skeletal changes after intraoral molar distalization with sectional jig assembly, *Am. J. Orthod.* 114:319-327, 1998.
15. Brickman, C.D.; Sinha, P.K.; and Nanda, R.S.: Evaluation of the Jones jig appliance for distal molar movement, *Am. J. Orthod.* 118:526-534, 2000.
16. Haydar, S. and Uner, O.: Comparison of Jones jig molar distalization appliance with extraoral traction, *Am. J. Orthod.* 117:49-53, 2000.
17. Herbst, E.: *Atlas und Grundriss der Zahnärztlichen Orthopädie*, Lehmann, Munich, 1910.
18. Pancherz, H.: Treatment of Class II malocclusions by jumping the bite with the Herbst appliance: A cephalometric investigation, *Am. J. Orthod.* 76:423-442, 1979.
19. Wieslander, L.: Intensive treatment of severe Class II malocclusions with a headgear-Herbst appliance in the early mixed dentition, *Am. J. Orthod.* 86:1-13, 1984.
20. McNamara, J.A. Jr.; Howe, R.P.; and Dischinger, T.G.: A comparison of the Herbst and Fränkel appliances in the treatment of Class II malocclusion, *Am. J. Orthod.* 98:134-144, 1990.
21. Lai, M. and McNamara, J.A. Jr.: An evaluation of two-phase treatment with the Herbst appliance and preadjusted edgewise therapy, *Semin. Orthod.* 4:46-58, 1998.
22. Burkhardt, D.R.; McNamara, J.A. Jr.; and Baccetti, T.: Maxillary molar distalization or mandibular enhancement: A cephalometric comparison of comprehensive orthodontic treatment including the pendulum and the Herbst appliances, *Am. J. Orthod.* 123:108-116, 2003.
23. Pancherz, H.: The Herbst appliance—Its biologic effects and clinical use, *Am. J. Orthod.* 87:1-20, 1985.
24. Windmiller, E.C.: The acrylic-splint Herbst appliance: A cephalometric study, *Am. J. Orthod.* 70:1-10, 1976.

- alometric evaluation, *Am. J. Orthod.* 104:73-84, 1993.
25. Valant, J.R. and Sinclair, P.M.: Treatment effects of the Herbst appliance, *Am. J. Orthod.* 95:138-147, 1989.
 26. Pancherz, H. and Anehus-Pancherz, M.: The headgear effect of the Herbst appliance: A cephalometric long-term study, *Am. J. Orthod.* 103:510-520, 1993.
 27. Pancherz, H.: The mechanism of Class II correction in Herbst appliance treatment: A cephalometric investigation, *Am. J. Orthod.* 82:104-113, 1982.
 28. Pancherz, H.: Vertical dentofacial changes during Herbst appliance treatment: A cephalometric investigation, *Swed. Dent. J. Suppl.* 15:189-196, 1982.
 29. Pancherz, H. and Fackel, U.: The skeletofacial growth pattern pre- and post-dentofacial orthopaedics: A long-term study of Class II malocclusions treated with the Herbst appliance, *Eur. J. Orthod.* 12:209-218, 1990.
 30. Wieslander, L.: Long-term effect of treatment with the headgear-Herbst appliance in the early mixed dentition: Stability or relapse? *Am. J. Orthod.* 104:319-329, 1993.
 31. Pancherz, H. and Hansen, K.: Occlusal changes during and after Herbst treatment: A cephalometric investigation, *Eur. J. Orthod.* 8:215-228, 1986.
 32. Pancherz, H.: The nature of Class II relapse after Herbst appliance treatment: A cephalometric long-term investigation, *Am. J. Orthod.* 100:220-233, 1991.
 33. Jasper, J.J.: *The Jasper Jumper—A Fixed Functional Appliance*, American Orthodontics, Sheboygan, WI, 1987.
 34. Jasper, J.J. and McNamara, J.A. Jr.: The correction of interarch malocclusions using a fixed force module, *Am. J. Orthod.* 108:641-650, 1995.
 35. Blackwood, H.O. III: Clinical management of the Jasper Jumper, *J. Clin. Orthod.* 25:755-760, 1991.
 36. Weiland, F.J. and Bantleon, H.P.: Treatment of Class II malocclusions with the Jasper Jumper appliance—A preliminary report, *Am. J. Orthod.* 108:341-350, 1995.
 37. McNamara, J.A. Jr.: Components of Class II malocclusion in children 8-10 years of age, *Angle Orthod.* 51:177-202, 1981.
 38. Cope, J.B.; Buschang, P.H.; Cope, D.D.; Parker, J.; and Blackwood, H.O. III: Quantitative evaluation of craniofacial changes with Jasper Jumper therapy, *Angle Orthod.* 64:113-122, 1994.
 39. Covell, D.A. Jr.; Trammell, D.W.; Boero, R.P.; and West, R.: A cephalometric study of Class II Division 1 malocclusions treated with the Jasper Jumper appliance, *Angle Orthod.* 69:311-320, 1999.
 40. Stucki, N. and Ingervall, B.: The use of the Jasper Jumper for the correction of Class II malocclusion in the young permanent dentition, *Eur. J. Orthod.* 20:271-281, 1998.
 41. Dionne, D.G.: Clinical Trial Report: Forsus Fatigue Resistant Device, *Orthod. Persp.* 9:11-12, 2002.
 42. Cleary, J. and Wyllie, B.: Forsus Fatigue Resistant Device: Fatigue resistant by design, *Orthod. Persp.* 9:13, 2002.
 43. El-Sheikh, M.M.; Godfrey, K.; Manosudprasit, M.; and Vivatantapita, N.: Force-deflection characteristics of the fatigue-resistant device spring: An in vitro study, *World J. Orthod.* 8:30-36, 2007.
 44. Vogt, W.: The Forsus Fatigue Resistant Device, *J. Clin. Orthod.* 40:368-377, 2006.
 45. Nikutowski, E. (3M Unitek): Personal communication, 2006.
 46. Allen-Noble, P.S.: *Clinical Management of the MARA: A Manual for Orthodontists and Staff*, Alleesee Orthodontic Appliances/Pro Lab andOrmco Corp., February 2002.
 47. McSherry, P.F. and Bradley, H.: Class II correction-reducing patient compliance: A review of the available techniques, *J. Orthod.* 27:219-225, 2000.
 48. Pangrazio-Kulbersh, V.; Berger, J.L.; Chermak, D.S.; Kaczynski, R.; Simon, E.S.; and Haerian, A.: Treatment effects of the mandibular anterior repositioning appliance on patients with Class II malocclusion, *Am. J. Orthod.* 123:286-295, 2003.
 49. Proffit, W.R. and Tulloch, J.F.: Preadolescent Class II problems: Treat now or wait? *Am. J. Orthod.* 121:560-562, 2002.
 50. Carlson, D.S.: Biological rationale for early treatment of dentofacial deformities, *Am. J. Orthod.* 121:554-558, 2002.
 51. Pancherz, H. and von Bremen, J.: Efficiency of Class II, division 1 therapy in relation to treatment timing and modality, in *Treatment Timing: Orthodontics in Four Dimensions*, ed. J.A. McNamara, Jr., and K.A. Kelly, Monograph 39, Craniofacial Growth Series, Needham Press, Ann Arbor, MI, 2002.
 52. Harrison, J.E.; O'Brien, K.D.; and Worthington, H.V.: Orthodontic treatment for prominent upper front teeth in children, *Cochrane Database Syst. Rev.* 3, 2007, p. CD003452.
 53. McNamara, J.A. Jr.; Bookstein, F.L.; and Shaughnessy, T.G.: Skeletal and dental changes following functional regulator therapy on Class II patients, *Am. J. Orthod.* 88:91-110, 1985.
 54. Malmgren, O.; Omblus, J.; Hagg, U.; and Pancherz, H.: Treatment with an orthopedic appliance system in relation to treatment intensity and growth periods: A study of initial effects, *Am. J. Orthod.* 91:143-151, 1987.
 55. Hagg, U. and Pancherz, H.: Dentofacial orthopaedics in relation to chronological age, growth period and skeletal development: An analysis of 72 male patients with Class II division 1 malocclusion treated with the Herbst appliance, *Eur. J. Orthod.* 10:169-176, 1988.
 56. Baccetti, T. and Franchi, L.: Maximizing esthetic and functional changes in Class II treatment by appropriate treatment timing, in *Frontiers of Dental and Facial Esthetics*, ed. J.A. McNamara, Jr., and K.A. Kelly, Monograph 38, Craniofacial Growth Series, Needham Press, Ann Arbor, MI, 2001.
 57. Pancherz, H.: The Herbst appliance: A paradigm change in Class II treatment, *World J. Orthod.* 6(Suppl):8-10, 2005.
 58. Devreese, H.; De Pauw, G.; Van Maele, G.; Kuijpers-Jagtman, A.M.; and Dermaut, L.: Stability of upper incisor inclination changes in Class II division 2 patients, *Eur. J. Orthod.* 29:314-320, 2007.
 59. Kinzinger, G.; Wehrbein, H.; Byloff, F.K.; Yildizhan, F.; and Diedrich, P.: Innovative anchorage alternatives for molar distalization—An overview, *J. Orofac. Orthop.* 66:397-413, 2005.