The Role of the Headgear in Growth Modification

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A review of the literature reveals that the use of a cervical facebow headgear can modify growth of the maxilla. Orthopedic forces that may be employed with headgears not only distalize the molars but may have a restraining effect on growth at the maxillary sutures. Short-term use of the headgear may not produce a sustained growth modification. There is also the "catch-up effect " once the headgear has been discontinued. Our research has shown that the negative effects attributed to the cervical headgear, such as the downward tipping of the palatal, occlusal, and mandibular planes that may increase the facial convexity and lower anterior facial height, may be avoided or attenuated if the outer facebow is adjusted alternately up and down in relation to the occlusal plane during the treatment. In the treatment of Class II malocclusions, the use of cervical pull headgear deserves special consideration because when used appropriately, it is a reliable method of molar distalization and restraining of maxillary growth without collateral negative effects. However, patient cooperation is an important issue that requires both patient motivation and parental involvement. (Semin Orthod 2006;12:25-33.)

Class II Division 1 (Class II-1) presents as one of the most common skeletal or dental deformities that the orthodontist is routinely challenged to manage. While the dental Class II malocclusion can be effectively treated with extractions, correction of the skeletal Class II deformity may require other approaches that include orthopedic restraint of maxillary growth and enhancement of mandibular growth in adolescent patients and orthognathic surgery in adults.

Orthopedic restraint of maxillary growth can be achieved by extraoral traction using facebow headgear. The headgear has been used for Class II correction since the 19th century.[1,2] Its use was briefly abandoned in the early 20th century with the introduction of intermaxillary elastics. This was not because the headgear was ineffective, but was considered an unnecessary complexity.

The introduction of cephalometrics to orthodontics has helped clinicians to evaluate the results achieved from headgear usage effectively.[3,4] Such comprehensive documentation using cephalometric data started to appear in the 1940s.[5] Dr. Silas Kloehn was one of the early advocates when he demonstrated successful results from cervical headgear use.[6] Since then, a variety of headgear applications have been recommended to treat different malocclusions.

Some questions have been raised concerning the effectiveness of the headgear and these include type of movement achieved and how the headgear affects craniofacial sutures, possibility of catch-up growth on removal of the restraining force, and stability of the skeletal component and that of the retracted molars. Another important question that has been asked is how orthopedic force to the maxilla may affect mandibular

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growth. These questions are to be addressed in the discussion that follows.

Skeletal Changes and Evaluation of Orthopedic Changes

While it is accepted that distal movement of maxillary molars can be achieved by use of the headgear, it is also true that the maxillary tuberosity is appositional during growth. Maxillary growth is described as downward and forward.[7] The anterior aspect of the maxilla is resorptive and the posterior is appositional, and it is the growth from the posterior portion that in part results in the downward and forward growth. Looking at this growth prospective, the following questions may be asked: When forces are applied through the molars, are these teeth moved distal or are they held at the same position during growth? Which components of the maxillofacial complex are most affected by headgear use?

Due to the difficulty associated with making ultimate determinations in living beings, holographic and finite element studies have been conducted to elucidate if the forces applied through the maxillary first molars are transmitted to the rest of the maxillofacial complex.[8] Also, animal studies on monkeys have been conducted to determine headgear effects to the maxilla.[9,10] The holographic, finite element and animal studies have shown that the forces applied through the maxillary molars can be absorbed by the different sutural articulations of the maxilla, temporal, zygomatic, and sphenoid bones. These forces are distributed as vertical and horizontal stresses. The vertical forces result in shear stress and the horizontal forces are absorbed as normal forces.[8]

The SNA angle presents an easy way to evaluate the position of the maxilla and sella-nasion length (SN) is a measure of anterior cranial base length. Studies conducted during maximum growth periods have shown an increase in cranial base length (SN length) during treatment and a reduction in SNA angle during use of the headgear.[11,12] However, there is limited discussion as to how this reduction occurs: either as a result of maxillary restraint, resorption at A-point due to distal movement of the maxillary anterior teeth, or lengthening of the cranial base. The effective change in maxillary length that has not been discussed extensively is important because A-point is a dentoalveolar landmark and can be affected by dental movements.[13-15] It is not a true reflection of absolute maxillary position. It is the authors' opinion that ANS would be a more reliable landmark for measurement of maxillary length. Location of ANS can be difficult, however, and one requires good cephalograms to accurately visualize that anatomic landmark.

The palatal plane is a reliable reference plane since its inclination to the cranial base changes very little during growth.[16,17] It has been observed that the palatal plane tips down to a more horizontal position during use of the headgear.[18-20] This is due to its clockwise rotation, which culminates from ANS moving down as well as distal.[21] That movement is an orthopedic effect achieved through use of the headgear since similar change has not been observed in children without Class II deformity. Also, children with Class II malocclusion who have not received headgear treatment do not show such change.[11]

Reduction in ANS is not localized to that anatomic location but is also a result of remodeling at the pterygomaxillary (PTM) suture.[22] Remodeling of the suture has been documented by the observed distal movement of PTM in treated cases. The sphenoid bone is also affected with resultant clockwise rotation. Similar phenomena have not been observed in untreated patients.

The bony changes provide testimony to the presumption that the movement of the molars cannot alone account for the Class II correction.[22] One can conclude from these observations that the forces applied to the maxillary molars are not limited to movement of the maxillary teeth alone, but to the whole maxillofacial complex. Suffice to say that for such a result to be achieved, the headgear has to be used consistently and for long periods of time.

Headgear Types

The facebow headgear can be designed in one of three ways, dependent on the direction of pull of force: high pull (occipital), straight pull, or low pull (cervical). The terms *occipital* and *cervical* have synonymously been used to mean high and low pull, respectively. *High* or *low pull*

may be better terms since these terms describe the point and direction of application of force with respect to the center of resistance of either the molars or the maxilla.

The practitioner should use the appropriate type of headgear in as far as the direction of force is concerned. Knowledge of the centers of resistance of the maxillary first molars and the maxilla can help the orthodontist deliver the appropriate force. Figure 1 demonstrates the resultant forces and moments that can be achieved from headgear use, dependent on the point of application of force.[23,24]

The cervical or low-pull headgear is the most commonly used of all three types of headgear. It also is the one that has been studied the most and is still a subject of study. This type of headgear is effective in restraining maxillary growth as well as distal movement of the maxillary molars. It has the unwanted side effect, however, of molar extrusion and distal tipping of the crown. That unwanted side effect can be controlled by alternate adjustment of the outer bow at each subsequent visit.[18,19] Investigators have shown that bending the outer bow upward of the occlusal plane an average of 10 ° to 20° can minimize distal tipping of the maxillary molars.[25]

The cervical headgear is commonly referred to as the "Kloehn type" headgear due to its association with Dr. Silas Kloehn. Efficacy of the method used by Dr. Kloehn was evaluated at the University of Oklahoma by using records from his office.[18,19] All patients who were evaluated were either in the transitional or early permanent dentition before headgear treatment. A common protocol that was followed in all the patients was alternate adjustment of the outer bow above or below the occlusal plane every 6 to 12 weeks. By so doing, there was minimal extrusion or distal tipping of the maxillary molars. The anterior face height was not affected, but there was a small change in the palatal plane (1.5°).

While the low-pull facebow headgear is more effective in achieving maxillary restraint and distal molar movement compared with the high-pull headgear, the high-pull headgear is effective in controlling the vertical dimension.[26,27] The facebow headgear with a high-pull component can be used to treat skeletal openbite pa-

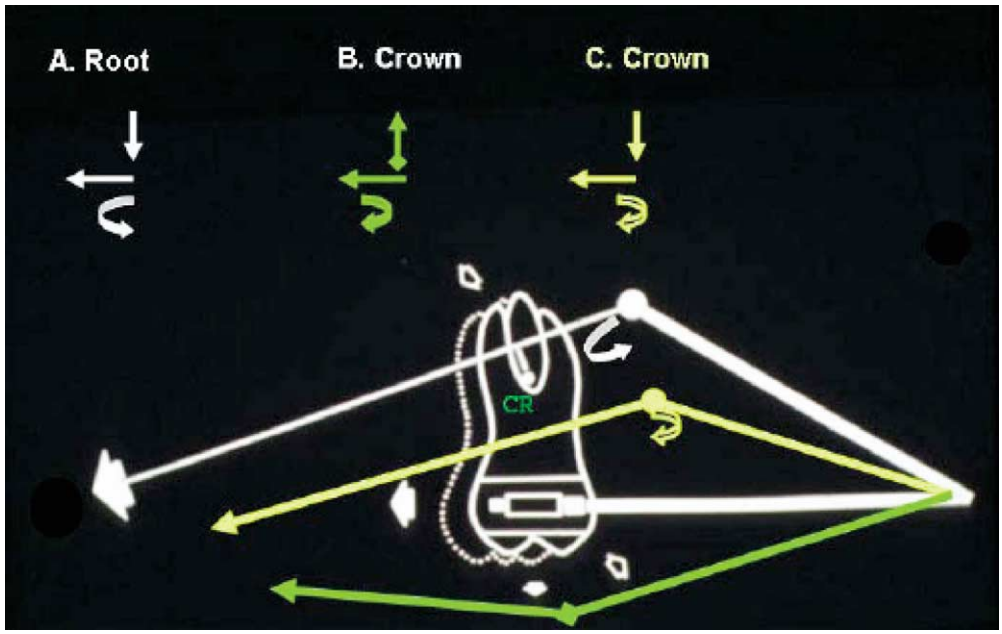

Figure 1. Forces and moments generated from the headgear. (A) Force is above center of resistance (CR); the result is extrusion, mesial moment, and distal movement of the root. (B) Force below CR in upward direction; the effect is distal crown movement, clockwise moment, and an intrusive effect. (C) Force below CR in downward direction; the effect is extrusion, distal crown movement, and clockwise moment. (Color version of figure is available online.)

tients if they also have a Class II malocclusion since openbite can be diagnosed as early as 6 years of age.[28] An unwanted side effect from the use of the high-pull facebow headgear is the compensatory eruption of the mandibular molars. The compensatory eruption of the mandibular molars, however, can be controlled through concomitant use of the fixed lingual arch.[29] A combination of high-pull and low-pull headgears can yield a force that is a resultant of both headgears.[23,24]

Arch Width and Arch Length Changes with HG Treatment

Class II malocclusion may be accompanied by a narrow maxilla that may or may not require expansion. "Narrow" in this description does not refer to the existence of a crossbite. Orthodontists routinely expand the maxillary arch so as to improve arch form and "to loosen" the sutures before engagement of the headgear. Another reason to expand is the belief that expansion can augment Class II correction. While it is true that molar derotation aids in the treatment of Class II malocclusion, the same may not be true about expansion.[30]

Investigations into the use of the headgear have shown that maxillary expansion can be achieved by use of the headgear alone without use of the expander.[31,32] Such expansion can be achieved by active expansion of the inner bow and that expansion may not be limited only to the dentoalveolar portion. It extends to the nasal cavity and the whole maxilla.[31] The dentoalveolar changes include increases in intermolar and intercanine widths. Arch width in general and length increase and an appreciable reduction in overjet can be obtained by use of the headgear alone.[32]

Figure 2 demonstrates a patient who had a narrow, tapered arch that was treated by headgear. The patient used the headgear for a period of 1 year with no other appliances placed in the maxillary arch. At the end of treatment, the maxillary arch was well rounded and the molars were in Class I.

The changes in arch length during headgear use should be interpreted with caution since different investigators have reported conflicting results. Some investigators have reported little change in overjet,[33-35] while others have observed a reduction.[32,36] This may be due to differential positioning of the bow: against or 3 mm away from the incisor teeth. Lengthening of the arch can be due to either distal movement of the molars with the incisors remaining static or flaring of the maxillary incisors.[33-35] Comprehensive treatment with fixed appliances, however, will be required for intrusion of the anterior segment in deep bite cases and for complete alignment. Such movements cannot be achieved by the headgear alone.

Treatment Timing

There are important factors that should be taken into consideration when determining time of treatment and these include severity of malocclusion, facial morphology (deep or open bite), patient compliance, and age of the patient.

Two types of data have been used to determine facial types: longitudinal and cross-sectional. Longitudinal material provides the best approximation of individual variability in growth. Such material has been used to understand the development of facial types and malocclusions. An understanding of the age at which serious malocclusions or adverse facial types can be diagnosed provides an opportunity to the dental specialist to handle these cases early.

Class II malocclusions can be diagnosed as early as the primary dentition. Disto-occlusions never develop into normal Class I but remain Class II whereas a flush terminal plane can go either way.[37] Once established at an early age, Class I occlusion can be maintained irrespective of the different growth velocities of the two jaws. Kim and coworkers[38] have shown that the dentoalveolar complex can compensate for adverse growths of the maxilla and mandible. For example, Class I occlusion was maintained in subjects that had excessive growth of one jaw with respect to the other. This indicated that it was important to establish Class I occlusion early.

The type of treatment can also be determined by the facial type: long face or short face. Nanda[28] has shown that facial morphology can be diagnosed as early as age 6 years. He showed that openbite patients have higher lower face height compared with upper face height while the opposite is true for deep-bite patients.

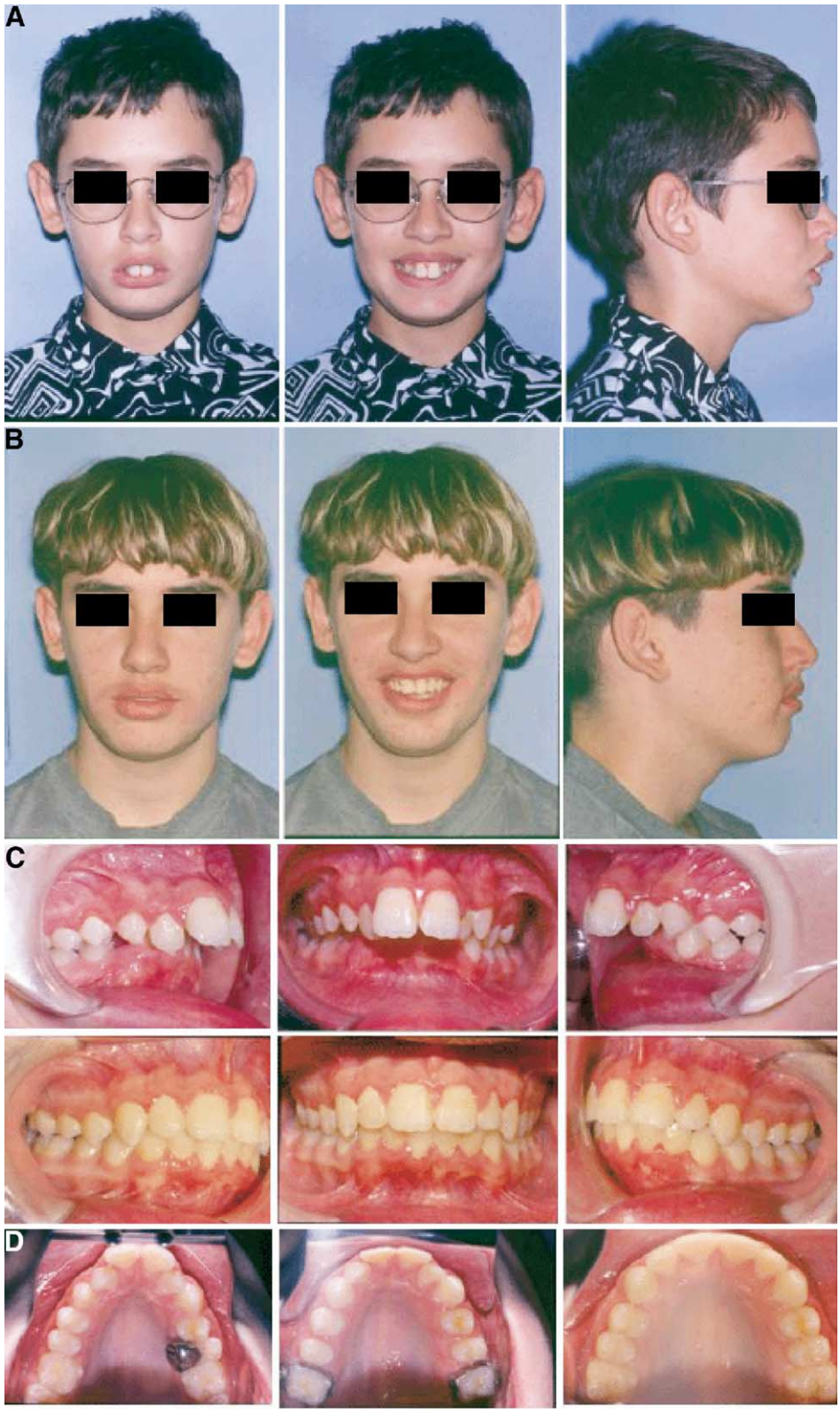

Figure 2. A Class II-1 malocclusion treated by headgear. (A) Pretreatment extraoral photographs. (B) Posttreatment extraoral photographs. (C) Pretreatment and posttreatment intraoral photographs. (D) Pre-, progress, and posttreatment maxillary occlusal photographs. Take note of the change in arch form as the treatment progressed from pretreatment to finish. (Color version of figure is available online.)

Knowledge of the facial morphology in a Class II patient can help determine the type of headgear to be used. A low-pull headgear may be appropriate in low angle patients but is contraindicated in openbite cases due to its extrusive effects to the maxillary molars.

Orthopedic effects can be achieved if treatment is delivered at the appropriate age. As such, the young preadolescent patient[39,40] may be the best candidate to whom headgear treatment should be administered because of two important reasons: compliance and the ability to modify growth. The young preadolescent patient is more compliant compared with the adolescent and postadolescent patients, and girls tend to have better compliance scores compared with boys.[41]

SNA is affected more if treatment is started at an early age with a significant reduction in angle ANB being observed at the younger age compared with the older age group.[42] In a study conducted by Kirjavainen and coworkers,[11] younger patients (7.2 years) responded better than older patients (12.4 years). They demonstrated a statistically significant reduction in SNA.

The noncompliant patient may not get the maximum benefit from use of the headgear since the amount of maxillary retraction by the headgear is affected by the duration the headgear is used: the longer the time that the appliance is used, the more effective will the treatment be.[39] Treatment time in the study conducted by Kirjavainen and coworkers[11] was from 0.9 years to 3.1 years.

Caution should be exercised concerning the length of time that the headgear can be used. The authors have observed that use of the headgear for an extended period of time may result in delayed eruption of the second molars. Figure 3 demonstrates a case that was treated with headgear for a period of 6 years. Treatment was completed when the patient was 13 years of age and the second molars had not yet erupted. Out of concern, the orthodontist consulted a pediatric dentist who felt that the second molars would never erupt due to their adverse inclination. A follow-up radiograph at 21 years of age showed that the second molars had erupted. In this case, prolonged use of the headgear resulted in delayed eruption of the second molars.

Chronological age may be an easy way to judge compliance, but skeletal age is the best method to assess skeletal response.[12] Appearance and ossification of the sesamoid bone[43] is a positive indicator of the completion of growth. While the pubertal growth spurt of both jaws relates well to that of other long bones, maxillary growth terminates earlier than that of the mandible.[44-46] Maxillary orthopedic treatment, then, should be initiated early. The best response is obtained during maximum growth velocity as judged by hand-wrist radiographs. This is the period 4 to 7 as described by Fishman[47] using skeletal maturation indicators.

Retention After HG Use

Although there is no question as to the successful correction of Class II malocclusion by headgear, maintenance of the achieved results is debated. Some investigators have followed their patients over 10-year periods and found the headgear results to be stable.[48] On the other hand, other investigators have described a catch-up period[49] in which the observed growth direction changes to the original but at a much faster rate than in untreated individuals. In one such study, Melsen and Dalstra[50] reported a downward and backward rotation of the maxilla during cervical traction, which returned to downward and forward direction after removal of the headgear.

The distal molar movement obtained through use of the headgear may be lost on removal of the restraining force of the headgear. The observed relapse is limited to the teeth and not the maxillary complex, however, suggesting that the skeletal effect is permanent. Other authors have reported a mesial drift of the molars but not necessarily to a previous position.[50] The conclusion from these authors[50] was that the Class II correction was maintained through a more pronounced growth in the mandible and not necessarily from the molar correction. As such, Melsen and Dalstra[50] have questioned the results obtained from headgear use. The reference sample was treated for 7 months.

A clinical study on 8-year-old children conducted by Wieslander[51] that involved headgear use and the Herbst appliance showed relapse in the mandible but stable results in the maxilla.

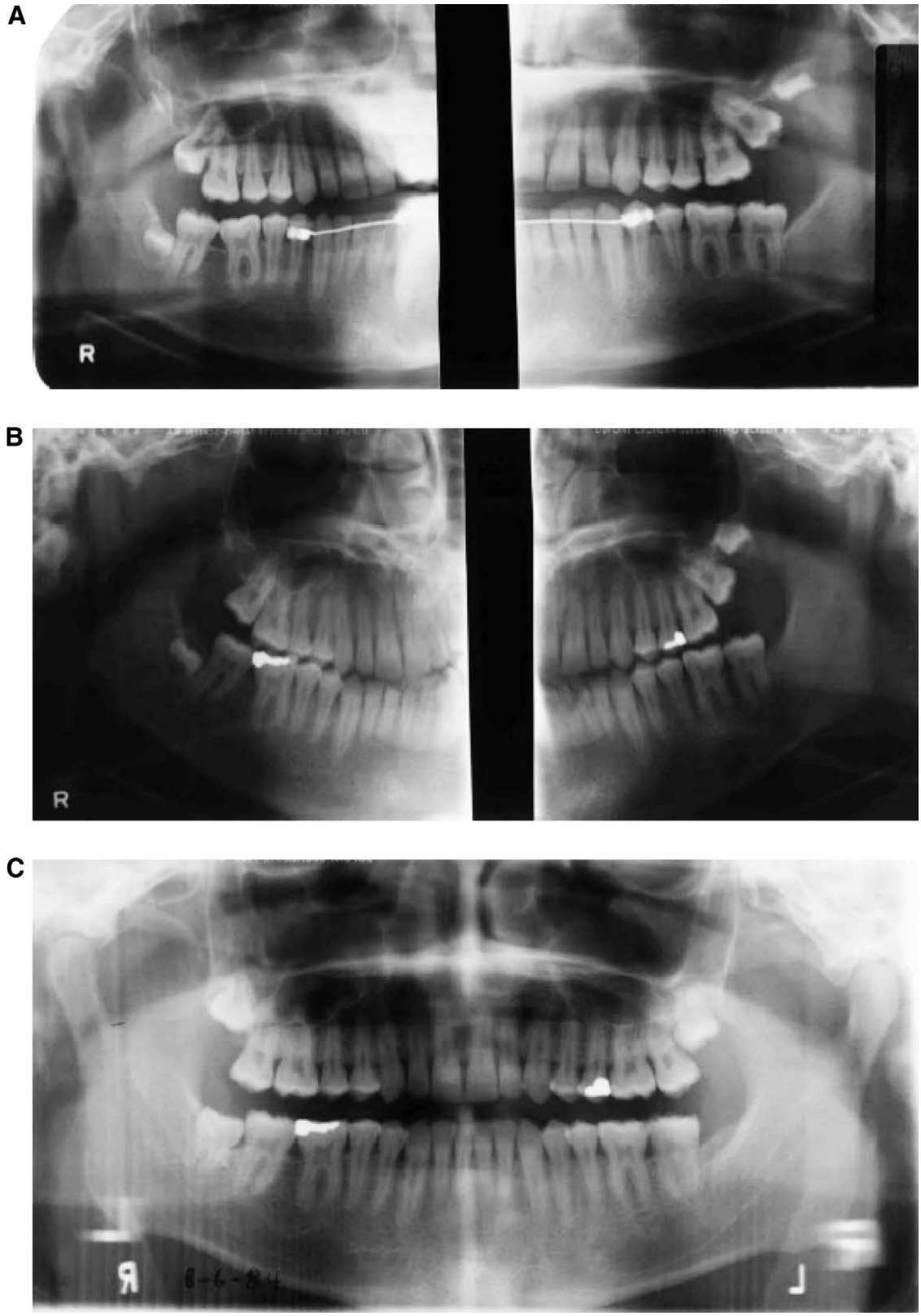

Figure 3. Orthopantomographs of a patient who had Class II-1 malocclusion that was treated with cervical headgear. (A) Treatment was initiated at age 7 and was completed at age 13. (B) Follow-up radiograph at 16 years of age indicated that the molars were at fairly the same position and were not erupting. (C) A follow-up radiograph at 21 years of age showed that the second molars had eventually erupted.

Again, this indicated that orthopedic effects from headgear could be maintained.

Wheeler and coworkers[41] showed more relapse in patients treated with headgear compared with activator. They also showed that half-cusp Class II relationships are more likely to self-correct compared with full-cusp relationships. Both headgear and activator can effectively correct Class II malocclusion,[52] but the common problem in both cases is retention. Without retention, treatment achieved may be lost, and as previously mentioned, that loss is attributed to dental rather than skeletal movements.[41,52] The skeletal changes can be considered to be permanent. As such, the best time to treat with headgear may be the late transitional dentition with a close follow-up with comprehensive full appliance treatment.

Kim and coworkers[38] have shown that the occlusion established early may not change despite the differential growth of the jaws. People can have greater mandibular growth than maxillary or vice versa, but the occlusion can be maintained. As such, the authors believe it is important to correct Class II Division 1 malocclusions early and maintain the Class I. For patients treated with headgear, the headgear itself may be the best form of retention until such time that fixed appliances can be used.

An appliance routinely used to hold the retracted maxillary molars is the Nance holding arch. The Nance appliance is not as effective in holding the molars back in the maxilla as the fixed lingual arch is in maintaining E-space in the mandible. A modified Nance holding appliance, the vertical holding appliance (VHA),[53,54] may be more successful in such instances since the force exerted by the tongue is vertical and directed to the posterior.

Summary and Conclusion

In summary, the following can be concluded about the headgear:

1. It is effective in distal movement of the molars.
2. The observed correction of Class II is not due to distal movement of the molars alone but that of the maxilla as a whole.
3. To achieve effective and long-term results, the headgear needs to be used consistently and over a long period of time. A 6-month period can be considered to be the minimum.
4. If used in the early transitional dentition, it is advisable to use the headgear to retain the achieved result till the rest of the permanent teeth erupt.
5. Alternatively, treatment can be initiated during the late transitional dentition and during the maximum skeletal growth spurt. The maximum skeletal growth spurt can be verified by means of the hand and wrist x-ray.

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