available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/odw

ELSEVIER

Orthodontic Waves

Review

Growth: Is it a friend or foe to orthodontic treatment?

Peter Ngan *

West Virginia University, Department of Orthodontics, Health Science Center North, P.O. Box 9480, Morgantown, WV 26506, USA

ARTICLE INFO

Article history:
Received 30 October 2008
Accepted 31 October 2008
Published on line 25 December 2008

Keywords:
Growth and development
Orthopedics
Maxillary protraction

ABSTRACT

The understanding of facial growth and occlusal development plays an important role in orthodontic diagnosis and treatment planning of problems encountered in dental and skeletal malocclusions. This article reviews the growth of the craniofacial complex, how we can modify growth in the maxilla and mandible, and suggests possible ways to enhance orthopedic changes in our every day orthodontic practice.

Contents

1. Where is orthodontics going in the next 50 years?

Technological advances such as reduced friction (self-ligation) brackets, temporary anchorage (TAD) devices and clear aligners have provided additional options for treatment of orthodontic patients [1–4]. However, none of these can replace the impact of applying growth and development to the treatment of skeletal malocclusions [5,6]. Orthopedic appliances such as removable functional appliances, Herbst and protraction facemask have been used to modify growth in an attempt to normalize skeletal discrepancies [7–10]. The immediate results are quite promising, but the long-term benefits of these appliances are still awaiting results from clinical trials.

2. What do we know about growth of our young patients that are applicable to orthodontic and orthopedic treatment?

The sagittal intermaxillary relationships in Class II [11] and Class III [12] malocclusions were established before 8 years

* Tel.: +1 304 293 3222; fax: +1 304 293 2327.
E-mail address: pngan@hsc.wvu.edu.

1344-0241/$ – see front matter
doi:10.1016/j.odw.2008.10.003

of age and did not change significantly through puberty. The craniofacial skeleton is derived from mainly endochondral bone formation, which is the process of converting cartilage into bone; and intramembranous bone formation, which is the process of bone formation from undifferentiated mesenchymal tissue. Bone can form directly from osteoblasts, a process called intramembranous ossification, or have a cartilaginous precursor called endochondral ossification [13].

2.1. *Growth of the cranial base*

The growth of the cranial base affects the position of the maxilla and mandible. Growth of the cranial base occurs through a system of synchondroses. A synchondrosis is a cartilaginous joint where the hyaline cartilage divided and subsequently is converted into bone. Most of the synchondroses close before birth. The spheno-ethmoidal synchondrosis closes around 6 years of age, and the spheno-occipital synchondrosis closed by 13–15 years of age. Studies have shown that the flexure of the cranial base increased in Class II patients compared to normal skeletal pattern and decreased in Class III patients [11,14].

2.2. *Growth of the nasomaxillary complex*

The maxillary bones are connected to the surrounding bones by circummaxillary sutures that include the zygomaticomaxillary, frontomaxillary, pterygomaxillary, and the median palatal sutures (Fig. 1A and B). These sutures allow the displacement as well as growth of the maxilla. Theoretically, they are patent until the third or fourth decade. However, the sutures start to interlock after the pubertal growth spurt and are difficult to separate using orthopedic forces [15]. Treatment directed at the maxilla should be attempted before the pubertal growth period.

2.3. *Growth of the mandible*

Growth of the mandible is both endochondral and intramembranous. Growth at the head of the condyle occurs in an upward and backward direction. Mandibular growth is expressed as a downward and forward displacement. Bjork examined the growth rotation of the mandible [16]. Patients with forward and upward growth rotation, when taken to extreme, can result in a severe overbite and short lower face (Fig. 2). Similarly, patients with downward and backward

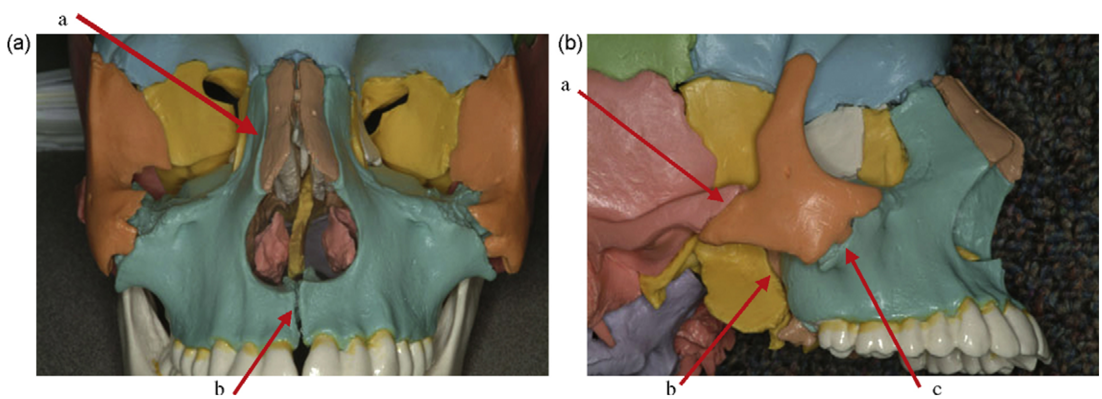

Fig. 1 – (A) Circummaxillary sutures connecting the maxilla to the adjacent bones (frontal view), a: frontomaxillary suture; b: Median palatal suture. (B) Circummaxillary sutures connecting the maxilla to the adjacent bones (lateral view), a: zygomaticotemporal suture; b: pterygomaxillary suture; c: zygomaticomaxillary suture.

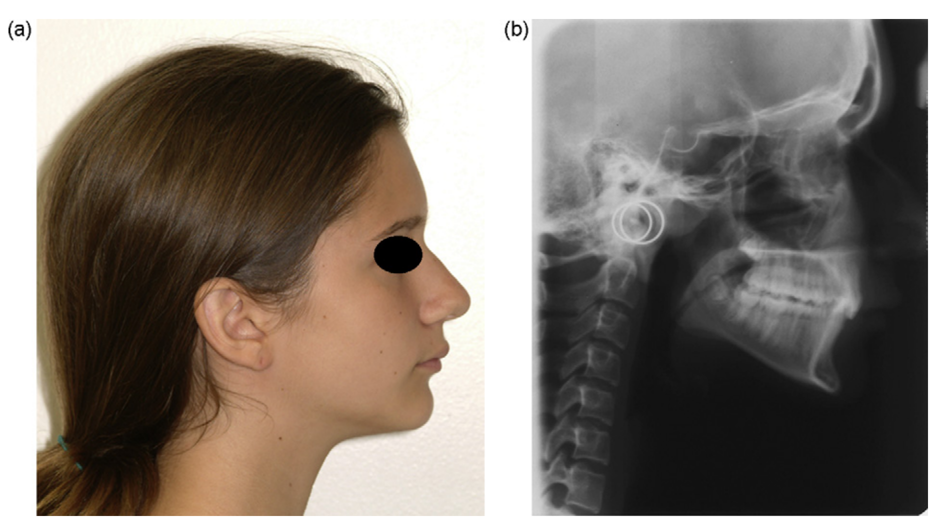

Fig. 2 – (A and B) Patient with a hypodivergent growth pattern (forward and upward rotator).

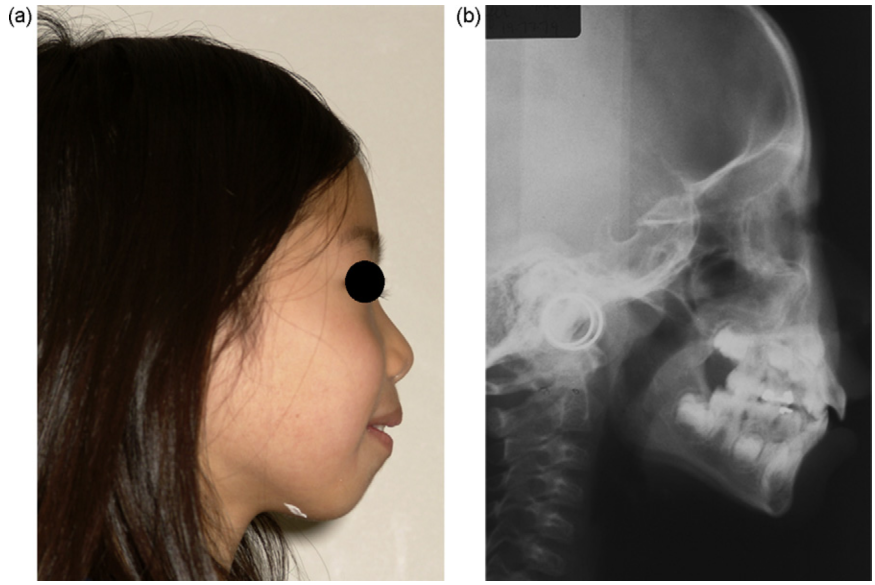

Fig. 3 – (A and B) Patient with a hyperdivergent growth pattern (downward and backward rotator).

rotation of the mandible can results in an anterior open bite and long lower face (Fig. 3). In order for the teeth to fit together, the jaws have to be lined up. In patients with anteroposterior jaw discrepancies, one can modify growth with orthopedic devices. Growth modification on the maxilla using appliances such as headgears and protraction facemask has been shown to be quite successful [17,18]. The suture, in most instances, responds to orthopedic force resulting in displacement of the maxilla. Growth modification on the mandible, on the other hand, is not as stable because it is genetically controlled. Treatment with appliances such as activators, Herbst and chin cups often result in relapse after treatment [19,8]. Sugawara et al. [20] evaluated the results of chin cup therapy on skeletal profile concluded that the skeletal profile was greatly improved during the initial stage of therapy, but such was not maintained in most cases. Chin cup force seldom alters the inherited prognathic characteristics of skeletal Class III profiles after growth. Mitani [21] hypothesized that compressive force on the condyle, if released before growth completion, will lead to recovery or rebound growth after chin cup use.

Several investigators attempted to predict mandibular growth potential using skeletal maturation [12,22–24]. The error between the predicted and actual increments was 1.45–2.91 mm. Using serial radiographs such as the Growth Treatment Response Vector (GTRV) analysis may help to improve the accuracy of prediction [10].

3. How do we modify growth in the maxilla?

Patients with protrusive and deficient maxilla can be treated by headgears and protraction facemask, respectively. Orthopedic force from the headgear restrains the forward and downward growth of the maxilla and allows the mandible to catch up if the mandible has forward and upward growth potential. The maxilla is connected to multiple pieces of bones by sutural joints. Orthopedic forces or tension on the maxilla can pull the maxilla away from the other connected bones such as in the case of a facemask. Similarly, compression forces on the maxilla can restrain forward and downward growth of the maxilla. Results seem to be stable long-term [25].

4. How do we modify growth in the mandible?

Patients with deficient and protrusive mandible can be treated by functional appliance and chin cup appliance, respectively. Protrusion of the mandible with functional appliances increases the proliferation of the condylar cartilage leading to bone formation [26]. On the other hand, compressive forces on the condyle with chin cup slow down condylar growth and may even modify the growth direction of the mandible [27]. The draw back of removable functional appliances is the need for patient cooperation. In order to obtain good skeletal and dental changes, patients have to wear the appliance for a significant period of time. In addition, condylar growth is genetically control. If patient does not have a forward and upward growth potential, the correction of mandibular deficiency will not be forthcoming. Similarly, if patient has a Class III growth tendency or excessive mandibular growth, relapse after chin cup therapy will most likely occur.

5. What do we need to do to increase orthopedic changes in the future?

For treatment of mandibular deficiency greater orthopedic changes can be obtained with fixed instead of removable appliances. Studies have shown that greater skeletal Class II corrections can be obtained with fixed appliances such as the Herbst appliance instead of removable functional appliances because of better patient cooperation (Figs. 4 and 5). Greater skeletal changes can be reported with step-wise advancement

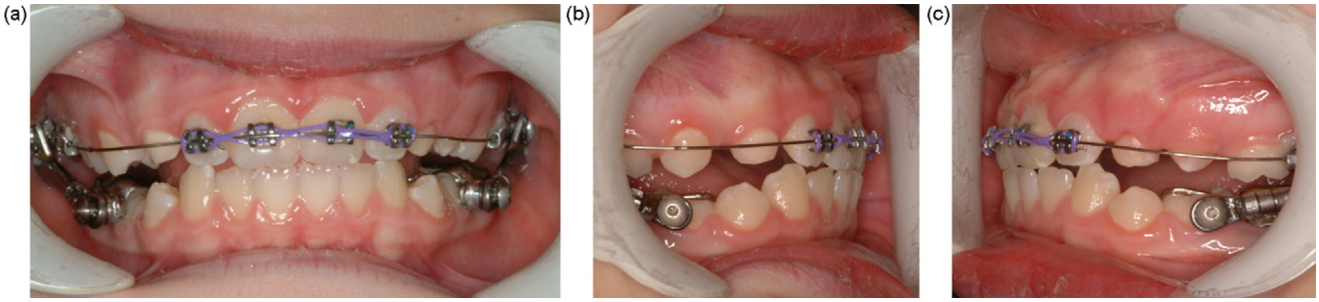

Fig. 4 – (A–C) Edgewise Herbst appliance for treatment of patients with mandibular deficiency. The mandible was advanced stepwise to an end-to-end incisal relationship for overcorrection.

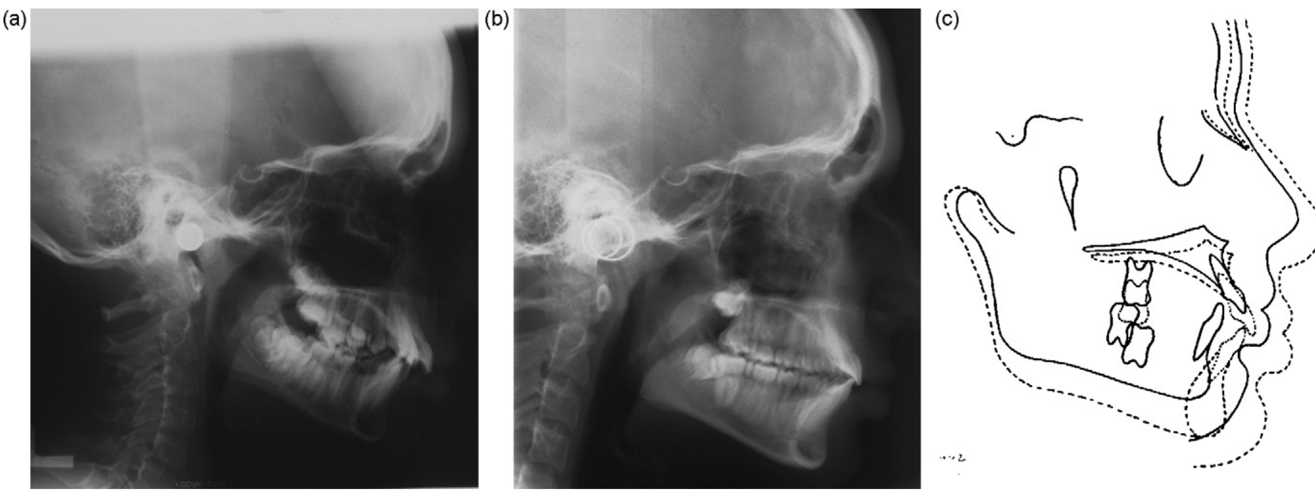

Fig. 5 – (A and B) Pre- and post-treatment radiographs of patient treated with the edgewise Herbst appliance showing the improvement in overjet and molar relationship. (C) Superimposition of radiographs before treatment and after 8 months of treatment with the Herbst appliance showing a restraint in forward maxillary growth and stimulation of mandibular growth.

of the mandible during fixed or removable functional therapy [28,29]. Overcorrection of the mandible during functional appliance therapy seems to provide stability for mandibular advancement [8]. In vitro studies have shown that continuous orthopedic forces can stimulate remodeling in the glenoid fossa [6]. Normally, remodeling in the glenoid fossa is downward and backward. Treatment with the Herbst appliance stimulates remodeling in a forward and downward manner bring the mandible in a more forward position.

Table 1 – Repeated expansion and constriction protocol for maxillary distraction [32,33].

Week 1	Expand 4 turns/day × 7 days (total 7 mm)
Week 2	Constrict 4 turns/day × 7 days
Week 3	Expand 4 turns/day × 7 days
Week 4	Constrict 4 turns/day × 7 days
Week 5	Expand 4 turns/day × 7 days
Week 6	Constrict 4 turns/day × 7 days
Week 7	Expand 4 turns/day × 7 days, protract with facemask on protraction spring 14 h/day × 6 months

For treatment of maxillary deficiency, greater orthopedic changes can be obtained with distraction of the skeletal units and increase the stability of the anchorage units for maxillary distraction. In the case of Class III patients with maxillary deficiency, literature have shown that protraction of the maxilla can be more effective if the maxillary sutures are

Fig. 6 – A double-hinge maxillary expansion appliance.

"disarticulated" or loosen up" with an expansion appliance [30]. Liou presented a protocol of repeated expansion and constriction of the maxilla for sutural distraction (Table 1) [31,32]. He also advocated the use of a double-hinge expansion appliance and a protraction spring for greater orthopedic changes (Fig. 6). Maxillary protraction in conjunction with one time expansion resulted in an average of 1.0–3.0 mm of forward movement of the maxilla [9,25,30,33]. Liou reported an average of 5.5 mm of forward movement of the maxilla with his technique [31,32]. Finally, with the help of temporary anchorage device such as mini-implants or miniplates, the stability of the maxillary distraction unit can be improved with fewer side effects [34].

REFERENCE

[1] Cornelis MA, Scheffler NR, De Clerck HJ, Tulloch JF, Behets CN. Systematic review of the experimental use of temporary skeletal anchorage devices in orthodontics. Am J Orthod Dentofacial Orthop 2007 April;131(4 Suppl.):S52–8.

[2] Boyd RL, Oh H, Fallah M, Vlaskalic V. An update on present and future considerations of aligners. J Calif Dent Assoc 2006 October;34(10):793–805.

[3] Henao SP, Kusy RP. Frictional evaluations of dental typodont models using four self-ligating designs and a conventional design. Angle Orthod 2005 January;75(1): 75–85.

[4] Franchi L, Baccetti T, Camporesi M, Lupoli M. Maxillary arch changes during leveling and aligning with fixed appliances and low-friction ligatures. Am J Orthod Dentofacial Orthop 2006;130(1):88–91.

[5] Cevidanes LH, Franco AA, Gerig G, Proffit WR, Slice DE, Enlow DH, et al. Comparison of relative mandibular growth vectors with high-resolution 3-dimensional imaging. Am J Orthod Dentofacial Orthop 2005, July;128(1):27–34.

[6] Voudouris JC, Woodside DG, Altuna G, Kuftinec MM, Angelopoulos G, Bourque PJ. Condyle-fossa modifications and muscle interactions during herbst treatment, part 1. New technological methods. Am J Orthod Dentofacial Orthop 2003 June;123(6):604–13.

[7] Pancherz H. The Herbst appliance: a paradigm change in Class II treatment. World J Orthod 2005;6(Suppl. 8–10).

[8] VanLaecken R, Martin CA, Dischinger T, Razmus T, Ngan P. Treatment effects of the edgewise Herbst appliance: a cephalometric and tomographic investigation. Am J Orthod Dentofacial Orthop 2006 November;130(5):582–93.

[9] Baccetti T, McGill JS, Franchi L, McNamara Jr JA, Tollaro I. Skeletal effects of early treatment of Class III malocclusion with maxillary expansion and face-mask therapy. Am J Orthod Dentofacial Orthop 1998 March;113(3): 333–43.

[10] Ngan P, Wei SH. Early treatment of class III patients to improve facial aesthetics and predict future growth. Hong Kong Dental J 2007;1:24–30.

[11] Ngan PW, Byczek E, Scheick J. Longitudinal evaluation of growth changes in Class II division 1 subjects. Semin Orthod 1997 December;3(4):222–31.

[12] Chen F, Terada K, Wu L, Saito I. Longitudinal evaluation of the intermaxillary relationship in Class III malocclusions. Angle Orthod 2006;76:955–61.

[13] Enlow DH. Growth of the craniofacial skeleton. In: Riolo ML, Avery JK, editors. Essentials for orthodontic practice. Ann Arbor: EFOP Press; 2003. p. 111–34.

[14] Reyes BC, Baccetti T, McNamara Jr JA. An estimate of craniofacial growth in Class III malocclusion. Angle Orthod 2006 July;76(4):577–84.

[15] Melsen B, Ousterhout DK. Anatomy and development of the pterygopalatomaxillary region, studied in relation to Le Fort osteotomies. Ann Plast Surg 1987;19:16–28.

[16] Bjork A, Skieller V. Normal and abnormal growth of the mandible. A synthesis of longitudinal cephalometric implant studies over a period of 25 years. Eur J Orthod 1983;5:1–46.

[17] Phan KL, Bendeus M, Hagg U, Hansen K, Rabie AB. Comparison of the headgear activator and Herbst appliance—effects and post-treatment changes. Eur J Orthod 2006 December;28(6):594–604.

[18] Turley PK. Managing the developing Class III malocclusion with palatal expansion and facemask therapy. Am J Orthod Dentofacial Orthop 2002 October;122(4):349–52.

[19] Mitani H, Sakamoto T. Chin cap force to a growing mandible. Long-term clinical reports. Angle Orthod 1984 April;54(2):93–122.

[20] Sugawara J, Asano T, Endo N, Mitani H. Long-term effects of chincap therapy on skeletal profile in mandibular prognathism. Am J Orthod Dentofacial Orthop 1990;98:127–33.

[21] Mitani H. Recovery growth of the mandible after chin cup therapy: fact or fiction? Semin Orthod 2007;13:186–99.

[22] Mito T, Sato K, Mitani H. Cervical vertebral bone age in girls. Am J Orthod Dentofacial Orthop 2002;122:380–5.

[23] Mito T, Sato K, Mitani H. Predicting mandibular growth potential with cervical vertebral bone age. Am J Orthod Dentofacial Orthop 2003;124:173–7.

[24] Sato K, Mito T, Mitani H. An accurate method of predicting mandibular growth potential based on the bone maturity. Am J Orthod Dentofacial Orthop 2001;120:286–93.

[25] Westwood PV, McNamara Jr JA, Baccetti T, Franchi L, Sarver DM. Long-term effects of Class III treatment with rapid maxillary expansion and facemask therapy followed by fixed appliances. Am J Orthod Dentofacial Orthop 2003 March;123(3):306–20.

[26] McNamara Jr JA. Dentofacial adaptations in adult patients following functional regulator therapy. Am J Orthod 1984 January;85(1):57–71.

[27] Mitani H, Fukazawa H. Effects of chincap force on the timing and amount of mandibular growth associated with anterior reversed occlusion (Class III malocclusion) during puberty. Am J Orthod Dentofacial Orthop 1986 December;90(6):454–63.

[28] Wey MC, Bendeus M, Peng L, Hagg U, Rabie AB, Robinson W. Stepwise advancement versus maximum jumping with hedgear activator. Eur J Orthod 2007;29:283–93.

[29] Banks P, Carmichael G. Stepwise overjet reduction with a modified twin-block appliance. J Clin Orthod 1999;33:620–3.

[30] Nartallo-Turley PE, Turley PK. Cephalometric effects of combined palatal expansion and facemask therapy on Class III malocclusion. Angle Orthod 1998 June;68(3):217–24.

[31] Liou EJ. Effective maxillary orthopedic protraction for growing Class III patients: a clinical application simulates distraction osteogenesis. Prog Orthod 2005;6(2):154–71.

[32] Liou EJ, Tsai WC. A new protocol for maxillary protraction in cleft patients: repetitive weekly protocol of alternate rapid maxillary expansions and constrictions. Cleft Palate Craniofac J 2005 March;42(2):121–7.

[33] Ngan PW, Hagg H, Yiu C, Wei SHY. Treatment response and long-term dentofacial adaptations to maxillary expansion and protraction. Semin Orthod 1997;4:255–64.

[34] Cha BK, Lee NK. Choi DS: maxillary protraction treatment of skeletal Class III children using miniplate anchorage. Korea J Orthod 2007;37:73–81.