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Longitudinal eruptive and posteruptive tooth movements, studied on oblique and lateral cephalograms with implants

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Introduction: The purpose of this study was to investigate the eruptive and posteruptive tooth displacements of untreated growing subjects longitudinally and the potential connections between posteruptive displacement of the maxillary and mandibular first molars and skeletal facial growth. **Methods:** The sample comprised 11 series of right 45° oblique cephalograms and lateral cephalograms of untreated children with metallic implants of the Björk type obtained from the archives of a growth study. Cephalograms generated at approximately 2-year intervals between the ages of 8.5 and 16 years were selected and traced. Superimpositions of serial tracings of oblique cephalograms on stable intraosseous implants were made to determine the displacements of buccal segment teeth in both arches, and superimpositions of serial tracings of lateral cephalograms were used to evaluate growth of the jaws. **Results:** Continuous mesial tipping of the maxillary molars was observed from 8.5 to 16 years of age, averaging 8.2° ± 5.5° for the first molars and 18.3° ± 8.5° for the second molars. Compared with the maxillary molars, the mandibular first molars showed less change in angulation except in the later mixed dentition when more than half of the subjects had accelerated forward tipping of the first molar in the late mixed dentition associated with migration into the leeway space. Average amounts of cumulative eruption from 8.5 to 16 years of age were 12.1 ± 2.1 mm downward and 3.8 ± 1.7 mm forward for the maxillary first molar. The mandibular first molar showed 8.6 ± 2.3 mm of eruption and 4.4 ± 1.9 mm of mesial migration. Peak velocity of vertical eruption of the maxillary and mandibular first molars corresponded to the skeletal vertical growth spurt. The maxillary canines and first premolars showed remarkable and continuous uprighting migration during eruption, averaging 9.5° ± 5.0° and 10.5° ± 6.7°, respectively. However, when they erupted into the occlusion, their changes in angulation reverted to forward tipping. The same tendency was also found in the mandibular canines and first premolars. **Conclusions:** Remarkable eruption and migration occur to the teeth of both arches during childhood and adolescence. Rates of first molar eruption during adolescence follow the general pattern of somatic growth. We infer that maintaining the original distal crown angulation of the maxillary molars may be an effective protocol for preservation of anchorage. (Am J Orthod Dentofacial Orthop 2018;153:673-84)

Knowledge of craniofacial growth and development of the dentition is an essential part of orthodontics. Longitudinal craniofacial growth studies with intraosseous implants, a method developed by Björk et al[1-5] at the Royal Dental College in Copenhagen, Denmark, considerably increased the accuracy of longitudinal cephalometric analysis of growth patterns and provided important information about the growth patterns of the jaws.[1-9] Superimposing cephalometric radiographs on metal implants allows precise observation of changes in the position of 1 bone relative to another, changes in the external contours of individual bones, and displacements of the teeth within the bones, such as tooth eruption.

Using this method, Björk and Skieller[3] found the connection between the differential vertical eruption of the molars and the incisors, and drew the conclusion that the rotation of the face necessitates compensatory adaptation of the paths of eruption of the teeth. They pointed out that malocclusions are due to incomplete

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Table I. Sample demographics at each time point

	Time point				
	1	*2*	*3*	*4*	*5*
Sample size (n)	10	11	11	11	8
Nominal age at film (y)	8.5	10.5	12.5	14.5	16
Actual age (y)	8.5 ± 0.4	10.5 ± 0.3	12.5 ± 0.5	14.5 ± 0.4	16.2 ± 0.5
Boys/girls (n)	6/4	7/4	7/4	7/4	6/2

compensatory guidance of eruption to a greater extent than to dysplastic deformation of the dental arches. But in the literature, few longitudinal data are available to guide dental professionals concerning tooth migration and eruption during growth. Siersboek-Nielsen[10], using the method of Björk and Skieller, reported the rates of eruption of the central incisors in 8 boys during the years around puberty. Iseri and Solow[11] described the average and individual patterns of continued eruption of the maxillary incisors and first molars in a longitudinal sample of girls, which comprised 14 series of lateral cephalometric films of girls from 9 to 25 years of age obtained from the archives of the implant study of Björk.[1]

Because of jaw rotation and modeling and remodeling changes on the maxillary and mandibular surfaces, strictly speaking, the path and the degree of eruption of the maxillary teeth cannot be analyzed without the use of implants. Thus far, the longitudinal growth sample with implants is the best available material for the study of tooth eruption. But with conventional lateral cephalograms, superimposition of bilateral tooth structures makes it difficult to trace the contours of the teeth precisely. Starting in 1967, Dr J. Rodney Mathews in the Section on Orthodontics, School of Dentistry, University of California San Francisco, conducted the first long-term study in the United States of growing children with metallic implants of the Björk type. In that sample, left and right 45° oblique cephalograms and lateral and posteroanterior cephalograms were collected at each time point, which provided the perfect materials for the tooth eruption study, because using 45° oblique cephalograms, superimposition of the contralateral teeth was eliminated, and visualization of 1 side of the buccal segment of the teeth (from canine to third molar) was enhanced.

The oblique cephalometric radiograph was introduced by Cartwright and Harvold.[12] It is taken in the same cephalostat as the one used for lateral cephalograms, but the patient is rotated 45° toward the film so that only 1 side of the face is in focus. Barber et al[13] studied the image distortion of the 45° exposure and found that magnifications varied from 0.64% to 5.15% in the mandible and from 0.5% to 7.93% in the maxilla, depending on which part of these structures was studied. They concluded that the degree of distortion for oblique film was less severe than that encountered with the standard lateral head film, and confirmed the reliability of using oblique film as a valid means for studying the rate of tooth eruption. Wyatt et al[14] preferred oblique radiographs when greater clinical accuracy was needed.

The series of 45° oblique cephalograms collected by Mathews which might be the first and last radiographies of longitudinal oblique cephalograms with metallic implants of the Björk type, was used to investigate the eruptive and posteruptive tooth displacements of untreated growing subjects in this study. The correlation between posteruptive displacement of the maxillary and mandibular first molars and the differential growth of the maxilla and the mandible were also explored.

MATERIAL AND METHODS

The primary record set from which the data used in this study consists of lateral, frontal, and 45° cephalograms taken at approximately annual intervals for 36 growing subjects, who were the same sample used in a series of growth studies described previously.[6-9] Before the acquisition of the first cephalograms for each subject, maxillary and mandibular implants of the Björk type were placed using open surgical methods. The subjects were recalled at annual intervals between the ages of 7 and 18 years, although few have records at more than 8 time points. A subset of 11 subjects, including 4 girls and 7 boys, was selected from the total group of 36 based on the following criteria: no orthodontic intervention including serial extraction and space maintaining (except for 1 subject treated after the observed period) and no missing teeth except third molars. They were growing children with a moderately severe Class I or Class II malocclusion, 3 of which were skeletal Class II with ANB angles initially greater than 5.0°; the rest of them were skeletal Class I with ANB angles initially between 0° and 5.0°. Cephalograms at approximately 2-year intervals between the ages of 8.5 and 16 years were chosen for