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Age-Related Characteristics of Upper and Lower Jaw Growth

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Abstract: The growth and development of jaw bones are among the most important processes in the formation of the human facial skeleton and are crucial for the development of a normal bite, facial aesthetics, and the function of the chewing system. The upper jaw (maxille) and lower jaw (mandibula) develop from mesenchymal tissue originating from the first and second gill arches and undergo a complex process of osteogenesis and morphogenesis, beginning in the womb and continuing until the completion of facial growth at the end of the second decade of life.

Keywords: Jaw growth; age characteristics; upper jaw; lower jaw; growth direction; gender differences; ortodontic treatment; puberty period; dentofacial anomalies

The purpose of this review is to analyze current data on the age-related characteristics of upper and lower jaw growth, including the mechanisms regulating the growth process, developmental directions, age-related periodization, gender differences, and the clinical significance of this knowledge for orthodontist practice.

Introduction. The process of jaw growth is characterized by heterochrony, that is, uneven development in different age periods, with periods of intensive growth, periods of delayed growth, and periods of stabilization being distinguished [4]. The most active growth of the upper and lower jaws occurs in the prepubertal and pubertal periods, when, under the influence of hormonal factors, in particular, growth hormone and sex hormones, a maximum increase in the size of the jaw bones is observed [2, 5].

Knowing the patterns of jaw growth is crucial for ortodontic treatment, as timely initiation of ortodontic intervention during periods of intensive growth allows for the use of the natural growth process to correct occlusion anomalies, achieving better results with less effort and time spent on treatment [6, 7]. Furthermore, understanding the age-related characteristics of jaw growth is essential for correctly diagnosing dentoalveolar anomalies, predicting their development, and choosing appropriate treatment tactics for different age periods [1, 8].

Between the upper and lower jaws, there are characteristics of growth and development: the upper jaw grows predominantly in a vertical direction and in the forward and downward direction relative to the anterior cranial fossa, while the lower jaw develops along the infra-occlusive growth arc, mainly in the forward, downward, and backward directions [3, 9]. Sex differences in the rate and intensity of jaw growth, with more intensive growth predominating in boys compared to girls, are especially noticeable during periods of active puberty [2, 5].

The growth of jaw bones is carried out by two main mechanisms: appositional growth (the application of new bone tissue to the surface of the bone) and endostal growth (the resorption of bone tissue on the inner surfaces) [2]. The upper jaw grows mainly due to apical and posterior growth at the point of articulation with the base of the skull, as well as due to the restructuring of the alveolar process in response to the growth of teeth [3, 10].

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Genetic factors play a dominant role in determining jaw growth potential: the heritability of jaw size is 60-80%, which indicates significant genetic control over the osteogenesis process of jaw bones [1, 6]. Hormonal factors, including growth hormone (somatotropin), insulin-like growth factor-1 (IGF-1), thyroid hormones, and sex hormones (estrogen and testosterone), significantly influence jaw growth intensity and direction [2, 4, 11].

Environmental factors, including the nature of nutrition, functional loads during chewing, breathing, and the position of the tongue, also influence jaw development, although their role is secondary to genetic factors [7, 12]. Disruption of functional loads on the jaws, for example, in oral breathing or tongue position anomalies, can lead to changes in the direction and intensity of jaw bone growth, contributing to the development of dentofacial anomalies [5, 8].

The upper jaw develops and grows in various directions, with the main growth vector directed forward, downward, and to the sides of the skull base, while the rotation point of the upper jaw is located in the nasal area and near the temporal line [3, 9]. Maximum growth of the upper jaw in the sagittal plane (in the forward direction) occurs during the prepubertal and pubertal stages of development, approximately 0.5-1.0 mm per year at 7-12 years of age, and slows down after 16-18 years [1, 6, 10].

Vertical growth of the maxilla is achieved by the vertical extension of the lateral process of the lower edge of the maxillary sinus and the apical growth of the alveolar process [2, 4]. The transverse growth of the maxilla (increase in width) occurs more slowly than the sagittal growth and is mainly due to the displacement of the palatine processes and growth along the sagittal suture [7, 9].

The mandible grows along its characteristic arc trajectory, which is described as rotation around the center of rotation located in the region of the mandibular grooves or slightly ahead of them [3, 9]. In the straight growth type, the lower jaw rotates forward and downward (clockwise, if viewed from the side), while in the vertical growth type, rotation occurs counterclockwise, which can lead to an increase in the frontal height of the face [1, 5, 8].

The main growth vector of the mandible is directed in the sagittal plane (forward) and is carried out by the apical growth in the area of the gills and the posterior edge of the mandibular branch [2, 6]. The sagittal growth rate of the lower jaw is approximately 0.5-1.5 mm per year at different age periods, with the maximum growth rate at 9-13 years for girls and 12-15 years for boys [1, 4, 10].

Vertical growth of the mandible is achieved through the elongation of the mandibular branch and the apical growth of the alveolar ridge in response to tooth eruption [3, 7]. The increase in the length of the mandibular body occurs more slowly than the increase in the height of the branch, which can affect the development of various types of facial profile and the ratio of the sizes of different parts of the mandible [2, 9]. The process of jaw growth can be divided into several age periods with characteristic growth features:

Early childhood period (3-6 years): During the emergence of temporary teeth, there is an increase in the size of both jaws under the influence of growing teeth and tissues developing with their support [1, 4]. The growth rate during this period is moderate, approximately 0.3-0.5 mm per year for the sagittal jaw size [10].

The period of transitional occlusion (6-12 years): During this period, the transition from temporary occlusion to permanent occlusion is observed, with jaw growth intensifying to accommodate large permanent teeth [2, 5]. The growth rate of the upper and lower jaws is approximately 0.5-1.0 mm per year, varying depending on the sex and individual developmental characteristics [6, 8].

The period of puberty (12-18 years): This is the period of the most intensive growth of the jaws under the influence of sex hormones, when annual increases can reach 1.0-1.5 mm in the sagittal direction [1, 4]. The period of puberty begins earlier in girls (10-12 years old) and later in boys (12-14 years old), which is reflected in the differences in the periods of peak growth [2, 5].

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Postpubertal period (18 years and older): After puberty is complete, jaw growth slows down sharply or practically stops, although small changes in jaw size can be observed up to the third decade of life [3, 7, 9].

Boys and girls have significant differences in the rate, intensity, and direction of jaw growth, which is related to differences in the timing and duration of puberty [2, 5, 11]. Girls reach their peak growth at an earlier age (average 11-12 years), while boys' peak growth occurs at 13-14 years [1, 6]. Boys are characterized by a more intensive and prolonged period of jaw growth, resulting in larger jaw sizes compared to girls [4, 8, 10].

Sex differences are manifested both in the absolute sizes of the jaws (boys have an average of 3-5 mm greater lower jaw length and 2-3 mm greater upper jaw width) and in the proportions of different parts [2, 5, 7]. Differences in the direction of growth between the sexes are less pronounced, but boys often exhibit a more sagittal direction of lower jaw growth, while girls often exhibit a more vertical direction of growth [3, 9].

Classical methods for studying jaw growth include the analysis of orthopantomograms and lateral teleradiographs in different age periods, allowing for the determination of growth rates and directions based on changes in the linear and angular dimensions of jaw structures [6, 8, 10]. The cephalometric analysis based on lateral teleradiographs is the standard method for assessing the growth of the upper and lower jaws, allowing for the determination of the size, direction, and growth vector [1, 4, 7].

Modern methods for studying jaw growth include three-dimensional computed tomography (TCT), which allows for obtaining a complete picture of jaw bone development with high accuracy and revealing developmental asymmetries and anomalies [2, 5, 9]. Methods of biomechanical modeling and finite elemental analysis (FEA) allow for predicting the direction and intensity of jaw growth based on anatomical parameters and biomechanical characteristics [3, 11].

Timely initiation of ortodontic treatment during periods of intensive jaw growth allows for the use of the natural growth process to correct dentofacial anomalies, achieving better results with less ortodontic force [1, 6, 7, 8]. The use of devices that utilize jaw growth (growth-stimulating and growth-limiting devices) during active growth allows for more effective correction of skeletal anomalies of the upper and lower jaws [2, 4, 5]. Understanding the direction of lower jaw growth (by types: gonadal angles) is important for predicting changes in facial profile and choosing adequate ortodontic treatment tactics, especially when planning orthognathic surgery in combination with ortodontics [3, 9, 10]. Knowing the timing of jaw growth completion (average 16-18 years for girls and 18-20 years for boys) is necessary to determine the optimal time for orthognathic surgery, when jaw growth is practically complete [1, 11].

CONCLUSIONS: thus, jaw growth is the result of a complex interaction of genetic, hormonal, and environmental factors, with genetic factors determining 60-80% of jaw size variability. The upper jaw grows predominantly forward, downward, and to the sides of the skull base, with maximum growth rates during prepubertal and pubertal development (annually 0.5-1.0 mm). The lower jaw develops along a characteristic arc trajectory with rotation around the center of rotation, with the main growth vector directed sagittally at a rate of 0.5-1.5 mm per year in different age periods. Age-specific periodization of jaw growth includes the periods of early childhood, transitional occlusion, puberty, and postpartum age, each with its own characteristic growth rate and direction.

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