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Review Article

Growth-related changes in the upper and lower jaw: clinical implications for treatment timing

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ABSTRACT

Jaw growth is a complex, multifactorial process involving cellular remodeling through buildup and breakdown. It fundamentally shapes facial structure and occlusal interactions. The maxilla and mandible exhibit different growth patterns, where the maxilla completes its growth earlier than the mandible. These differential growth rates, influenced by genetic and environmental factors, have profound implications for the development of malocclusions. Most importantly, the optimal timing of orthodontic treatment, especially during pubertal growth spurts, is critical for enhancing therapeutic benefits and achieving stable, long-lasting outcomes. Understanding these age-specific changes and the interplay of various contributing factors is central to effective orthodontic intervention. This review aims to explore the key growth-related changes that occur in the upper and lower jaw from early development through adolescence. Furthermore, it seeks to discuss the clinical implications of these changes, particularly concerning the optimal timing of various orthodontic interventions. Thus, provide an updated, thorough understanding of the interplay between natural growth and treatment efficacy.

Keywords: Craniofacial growth, Orthodontic treatment, Mandibular growth, Maxillary growth, Occlusion

INTRODUCTION

Jaw growth is a dynamic biological process that involves bone remodeling through formation and breakdown. It is highly crucial in orthodontics, as it directly influences facial appearance, occlusion, and stability of treatment outcomes.[1,2] Getting a better understanding of the underlying mechanisms behind jaw growth will help orthodontists to accurately diagnose malocclusions and plan effective treatment strategies that are tailored to patients based on their developmental stage.[3] Jaw growth occurs over several different phases, starting before birth and continuing after, with the postnatal phase being critical for shaping its structure and function. During the prenatal phase, the fundamental components of both the maxilla (upper jaw) and mandible (lower jaw) are formed, then the jaw undergoes rapid linear and vertical growth during infancy and early childhood, followed by intensified growth during adolescence.[4] A comprehensive understanding of the patterns of various growth phases offers the opportunity for enhancing decision-making and predicting future changes. Thus, improving patient outcomes.[5] Given that the appropriate timing of intervention can have a substantial impact on treatment effectiveness, outcome stability, and patient compliance, orthodontic treatment must be coordinated with particular growth phases. Correcting skeletal disparities with optimal timing frequently simplifies therapy and may eliminate the need for more intrusive procedures, such as orthognathic surgery, by utilizing the jaws' inherent growth potential.[6] For instance, some growth modification devices work more efficiently when used during times of active growth, allowing for beneficial jaw remodeling.[7] On the contrary, premature interventions may lead to prolonged treatment duration, patient fatigue, and increase the potential for relapse. Moreover, delayed intervention may lead to missing the optimal timing for growth modification and requiring invasive procedures that could have been avoided. On that account, assessment of treatment timing based on individual growth is essential for effective orthodontic practice, lowering risks and enhancing therapeutic outcomes.[6,7]

Assessing the growth phase of each patient allows clinicians to anticipate future skeletal alterations and integrate them into their treatment protocols, as well as assess whether the chosen appliance is biologically compatible and effective for the patient's current growth phase.[6] For instance, in growing patients with Class II malocclusions, functional appliances have been reported to encourage mandibular advancement, enhancing pubertal growth.[7]

This review aims to explore the key growth-related changes that occur in the upper and lower jaw from early development through adolescence. Furthermore, it seeks to discuss the clinical implications of these changes, particularly concerning the optimal timing of various orthodontic interventions. Thus, provide an updated, thorough understanding of the interplay between natural growth and treatment efficacy.

This review is based on a comprehensive literature search performed on 1st October 2025, in the PubMed and ClinicalKey databases, as well as Google Scholar. Utilizing MeSH (Medical Subject Headings) and relevant keywords such as “craniofacial growth”, “orthodontic treatment”, “mandibular growth”, “maxillary growth”, “occlusion”. The search aimed to explore studies on the key growth-related changes that occur in the upper and lower jaw from early development through adolescence. It seeks to discuss the clinical implications of these changes, particularly concerning the optimal timing of various orthodontic interventions. Thus, provide an updated, thorough understanding of the interplay between natural growth and treatment efficacy. The search was not restricted by date, language, or type of publication to ensure a broad exploration of the available literature.

UPPER AND LOWER JAW GROWTH PATTERNS

Maxillary growth involves an increase in size and a change in shape throughout different ages.[8] Since the maxilla is located at the center of the face, its growth and development are influenced by the simultaneous growth of the adjacent bones.[9] During Early childhood, the maxilla increases significantly in size between 0 and 5 years of age, with rapid changes occurring during the first year, followed by a slow and steady growth.[10]

On the contrary, growth slows down and becomes more stable during Late childhood to adolescence. In detail, after 5 years, vertical growth becomes more prominent, while rapid width growth occurs after seven and peaks by the age of 12.[11]

Maxillary width and length undergo significant changes during puberty, with peak growth occurring at approximately 11 years in females and 14 years in males. Males exhibit larger maxillary dimensions.[3] Posterior remodeling of the maxillary tuberosity further contributes to sagittal lengthening. The development of the cranial base creates additional space for the maxilla and the eruption of teeth.[12]

During early years, the mandible undergoes significant vertical and horizontal changes and remodeling, which are essential for functional balance.[13] Mandibular growth reaches its peak during adolescence, occurring between 13.6 and 14.5 years for boys and between 10 and 12 years for girls. Additionally, the mandibular condylar cartilage that influences facial morphology and jaw deviations, undergoes various changes.[14] Other Mandibular secondary cartilages also appear in various regions, like the condyle and symphysis.[7] Mandibular growth is influenced by various external stimuli, which can activate chondrogenesis and adaptive remodeling until it fully matures at the age of 16 for males and 14 for females.[8,15]

The maxilla and mandible grow at different rates. Maxillary growth is complete before mandibular growth. In detail, the maxilla reaches adult dimensions by approximately 12 years of age, while the dimensions of the mandible may continue to increase until the age of 18. These differences in timing are critical in orthodontics because they can contribute to malocclusions. If improper maxillary growth negatively impacts the position and development of the mandible, leading to discrepancies between the jaws.[16] Understanding these different growth patterns and the contributing factors allows orthodontists to plan treatments and anticipate future jaw discrepancies.

FACTORS INFLUENCING GROWTH

Various factors influence the pattern of craniofacial growth, including genetic composition, proper breathing, environmental factors, lifestyle, and early childhood habits. In detail, genetic variations play a vital role in growth rates. For instance, mandibular prognathism is inherited in a polygenic manner among families.[17,18] Associations between inherited genetic factors and growth variations should inform personalized predictions of growth patterns.[19] In addition, environmental factors also contribute to genetic variations. For instance, nutrition plays a role, where protein deficiency results in altered facial morphology, as reported by Tanikawa et al in a study conducted on 115 Japanese women.[20] Unhealthy oral habits such as thumb sucking, prolonged pacifier use, tongue thrusting, as well as mouth breathing can exert additional forces on developing dentition and alveolar bone, leading to the development of open bites, posterior crossbites, and changes in the maxillary arch.[21] Moreover, reduced masticatory function due to a soft diet might impact jaw development due to decreased bone stimulation.[22,23] Exploring the factors influencing jaw growth is the first step towards identifying its clinical implications.

CLINICAL IMPLICATIONS OF JAW AGE-RELATED CHANGES

Optimal timing of treatment

The proper timing for orthodontic intervention has been an issue of debate. It should be assessed with regard to long-term treatment outcomes, not only immediate results.[24] Aligning treatment with growth phases has been proven to improve the long-term effectiveness of treatment. Early orthodontic intervention prevents further development of early malocclusions and reduces their severity.

Thus, simplifying upcoming treatment phases. Early intervention is beneficial for overall oral health, as it relieves teeth crowding, which enhances oral hygiene. Orthopedic appliances are more effective during the growth phase. Not only does early intervention prevent incorrect jaw development, but it also has a positive psychological effect on children who are bullied for their facial or dental appearance. Given the crucial benefits of early diagnosis, the American Association of Orthodontists recommends screening by the age of seven.[24]

Despite being recommended by the American Association of Orthodontists, many orthodontists prefer to postpone treatment in the mixed dentition phase until all the temporary teeth have been replaced. Consequently, eliminating the need to compensate for late variation due to further growth. Taking this into consideration, not all malocclusions require early treatment; some are equally effective with definitive treatment in late mixed or early permanent dentition, which reduces overall treatment duration.[25] However, delayed treatment can miss growth spurts and require invasive surgical interventions.[26] Accurate assessment of biological age, using the cervical vertebral maturation (CVM) analysis, can identify the optimal timing for orthodontic treatments.[27]

Growth assessment

Accurate determination of the growth stage is critical for timing orthodontic treatment. Considering the wide individual variations in maturation, chronological age is not a reliable factor for determining the stage of growth. Biological indicators such as the CVM method and hand-wrist radiographs offer a more precise estimation of skeletal development. CVM assessment, introduced by Baccetti and colleagues, evaluates the morphology of the second, third, and fourth cervical vertebrae on lateral cephalograms to identify six distinct stages that correspond to different phases of the pubertal growth curve.[28,29] In clinical practice, periodic evaluation of CVM stages allows orthodontists to anticipate growth potential, determine retention timing, and decide on treatment plans. Combining CVM assessment with serial cephalometric records provides a reliable, non-invasive, and cost-effective approach to growth. Planning interventions around CVM stages enhances treatment outcomes.[30]

Class II malocclusions

Class II malocclusions are a common type of malocclusion, accounting for an incidence rate of 19.56% globally. The highest prevalence of 22.9% was reported in Caucasians.[31] Class II malocclusion is based on the sagittal alignment of the permanent dental arch, which is primarily influenced by the initial position of the first permanent molars. It features a bilateral distal molar relationship and is divided into two classes according to the alignment of the maxillary incisors: Division 1, with proclined maxillary incisors, and Division 2, with retroclined maxillary incisors. Cases with a unilateral distal molar relationship are classified as Class II (Division 1 or 2) subdivision.[32] Children with Class II division 1 malocclusions are often subject to bullying due to their facial appearance, which affects their quality of life. Prominent maxillary incisors are also vulnerable to various traumatic injuries.[33]

Early treatment of Class II malocclusions is prevalent in certain regions of the world. In early intervention, orthopedic appliances, such as headgear, are used to limit maxillary growth. On the contrary, functional appliances can be used to promote mandibular growth.

In addition to correcting disrupted functions and enhancing perioral muscle activity, early treatment with these approaches promotes early profile improvement by aligning the incisors and achieving a normal overjet and overbite. Another approach for the treatment of class II malocclusions is the use of functional appliances, followed by fixed ones, without a period of retention in the late mixed or early permanent stage.[24]

Class III malocclusions

Class III malocclusions present clinically with the mandibular teeth extending forward more than the maxillary teeth, which can result from an underdeveloped maxilla, an overdeveloped mandible, or both. It is mostly inherited. The global prevalence of Class III malocclusions is approximately 6%, with three times higher rates in Asia compared to other regions. Class III occlusions pose a challenge for clinicians, as it is essential to differentiate a true skeletal base Class III occlusion from dental anterior crossbite and pseudo-Class III malocclusions.[34]

Many clinicians have employed an early treatment approach for Class III malocclusions with inconsistent levels of success. The primary benefit of early Class III treatment is the decrease in the severity of the discrepancy, which simplifies the malocclusion and lowers the necessity for surgical procedures. Early management of Class III during mixed dentition utilizes devices such as the Frankel functional regulator (FR-3) or orthopedic tools like a facemask or chin cup, based on the type of skeletal discrepancy. There is no clear evidence supporting early intervention for Class III malocclusion. For instance, no significant differences were detected by Nucci et al in-treatment outcomes in a clinical trial involving children aged between 7 and 13 years with dentoskeletal Class III malocclusion treated with the modified SEC III (Splints, Elastic, and Chin cup).[35]

Pseudo-class III malocclusion

This is caused by the mandible shifting forward to maintain maximum intercuspation. It results from occlusal interferences that block posterior contact, such as retroclined maxillary incisors and proclined mandibular incisors. Timely assessment and intervention of this condition prevent anterior mandibular displacement, freeing the maxillary incisors and permitting unrestricted growth of the maxilla. In contrast, postponing treatment for pseudo-Class III may result in the maxillary arch collapsing, a decline in self-esteem, and structural harm to the connected tooth and periodontium, and the development of actual Class III malocclusion. An observational study of 25 patients with a 5-year follow-up after early correction of pseudo-Class III malocclusions using 2×4 appliances showed that all patients maintained their treatment outcomes.

Deep bite

Being a prevalent malocclusion, deep bite poses a persistent challenge in clinical practice. An overbite measuring 2 to 4 mm or 5 to 25% of the overlap of the lower incisors is considered normal, while 25 to 40% overlap is considered acceptable. Overlap exceeding 40% is classified as a deep bite. It may have harmful effects on the periodontium, causing recession of the labial gingiva in lower anterior teeth and the lingual gingiva in upper anterior teeth. Furthermore, it may lead to localized gum recession and movement of the affected tooth.36 Being influenced by both genetic and environmental factors, the etiology of deep bite is multifaceted. Deep bite can be classified into skeletal and dental deep bite. Early intervention during perpetual development has been shown to result in favorable muscular adjustment. In contrast, if left unaddressed, a deep bite results in inadequate periodontal health where contact of the mandibular incisor with the palatal tissue causes palatal bone loss and labial movement of the maxillary.[24]

Future prospects

The underlying mechanisms of growth and development have emphasized the clinical significance of age-related craniofacial growth changes. Three-dimensional cone beam computed tomography and statistical shape modeling allow precise visualization and analysis of images of teeth, jaws, and surrounding structures. Thus, enabling individualized prediction of changes.[37] Recent advances in deep learning have enabled machine learning–based growth prediction, which showed promising accuracy in predicting mandibular length and rotation using early cephalometric data.[38]

Additionally, incorporating genetic biomarkers with 3D imaging and clinical evaluations can enhance the timing and effectiveness of treatment through the development of personalized treatment approaches.[39] Intradisciplinary collaboration with otolaryngologists for managing airway obstructions or pediatricians for coping with systemic conditions, as well as geneticists for identifying personalized genetic biomarkers, is of great importance. The integration of predictive systems with biological indicators, such as CVM, while taking into account individual genetic variations, could enhance the decision-making and personalization of orthodontic treatment.[40]

CONCLUSION

Optimal timing of orthodontic intervention is crucial for improving effectiveness and achieving stable, long-lasting outcomes. Given that understanding the dynamic nature of craniofacial growth is crucial for enhancing treatment outcomes and predicting future variations, clinicians must remain updated on the latest scientific evidence regarding growth patterns with their individual variations and responses to environmental factors.

Emerging AI technologies and interdisciplinary collaborations between other medical fields and managing health conditions influencing the progression of malocclusions, can provide the tools needed to achieve optimal intervention timing and enhanced long-term treatment outcomes.

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REFERENCES

1. Proffit WR, Fields HW, Sarver DM. Contemporary orthodontics. Elsevier Health Sciences. 2006.
2. Liang C, Profico A, Buzi C. Normal human craniofacial growth and development from 0 to 4 years. Scientific Reports. 2023;13(1):9641.

3. Niemann K, Lazarus L, Rennie CO. Developmental changes of the facial skeleton from birth to 18 years within a South African cohort (A computed tomography study). J Forensic and Legal Med. 2021;83:102243.
4. Laowansiri U, Behrents RG, Araujo E, Oliver DR, Buschang PH. Maxillary growth and maturation during infancy and early childhood. Angle Orthod. 2013;83(4):563-71.
5. Barbhuiya S, Das BB. Life Cycle Assessment of construction materials: Methodologies, applications and future directions for sustainable decision-making. Case Studies in Construction Materials. 2023;19:e02326.
6. Franchi L, Nieri M, McNamara JA, Giuntini V. Predicting mandibular growth based on CVM stage and gender and with chronological age as a curvilinear variable. Orthodont Craniofac Res. 2021;24(3):414-20.
7. Charreau JL. Distal mandibular position treatment in adolescence: use of twin blocks. MOJ Orthoped Rheumatol. 2023;15(5):172-80.
8. Albert AM, Payne AL, Brady SM, Wrighte C. Craniofacial changes in children-birth to late adolescence. ARC J Forensic Sci. 2019;4(1):1-19.
9. Liang C, Profico A, Buzi C. Normal human craniofacial growth and development from 0 to 4 years. Scientific Reports. 2023;13(1):9641.
10. Laowansiri U, Behrents RG, Araujo E, Oliver DR, Buschang PH. Maxillary growth and maturation during infancy and early childhood. Angle Orthodontist. 2013;83(4):563-71.
11. Backes EP, Bonnie RJ, editors. The promise of adolescence: Realizing opportunity for all youth. 2019.
12. Fan Y, Han B, Zhang Y. Natural reference structures for three-dimensional maxillary regional superimposition in growing patients. BMC Oral Health. 2023;23(1):655.
13. Gupta A. Tracing the transformation: A comprehensive review of craniofacial growth from childhood to adulthood (5-25 Years). International J Appl Dental Sci. 2025;11(3):273-6.
14. Mizoguchi I, Toriya N, Nakao Y. Growth of the mandible and biological characteristics of the mandibular condylar cartilage. Japan Dental Sci Rev. 2013;49(4):139-50.
15. Esfehani M, Tofangchiha M, Poorsayyah N. Relationship between posterior permanent dentition pattern and radiographic changes of the mandibular condyle. Methods Prot. 2022;5(6):97.
16. Manabe A, Ishida T, Kanda E, Ono T. Evaluation of maxillary and mandibular growth patterns with cephalometric analysis based on cervical vertebral maturation: A Japanese cross-sectional study. Plos One. 2022;17(4):265272.
17. Al-Obaidi S, Papageorgiou SN, Saade M. Influence of genetic and environmental factors on transverse growth. Eur J Orthod. 2025;47(2):76.
18. Gupta A. Tracing the transformation: A comprehensive review of craniofacial growth from childhood to adulthood (5-25 Years). Int J Appl Dental Sci. 2025;11:273-6.
19. Hartsfield JK, Jr., Jacob GJ, Morford LA. Heredity, Genetics and Orthodontics-How Much Has This Research Really Helped. Semin Orthod. 2017;23(4):336-47.
20. Tanikawa C, Kurata M, Tanizaki N, et al. Influence of the nutritional status on facial morphology in young Japanese women. Sci Rep. 2022;12(1):18557.
21. 21. <EJMD-VOL.-11-ISSUE-3-September-December-2022.pdf>.
22. Parikh V, Gonchar M, Gibson TL, Grayson BH, Cutting CB, Shetye PR. One-year stability of lefort i advancement in patients with complete cleft lip and palate using a standardized clinical and surgical protocol. J Craniofac Surg. 2021;32(7):2491-5.
23. Lin L, Zhao T, Qin D, Hua F, He H. The impact of mouth breathing on dentofacial development: A concise review. Front Public Health. 2022;10:929165.
24. Hamidaddin MA. Optimal Treatment Timing in Orthodontics: A Scoping Review. Eur J Dent. 2024;18(1):86-96.
25. Fleming PS. Timing orthodontic treatment: early or late. Aust Dent J. 2017;62(1):11-9.
26. Naderi Y, Karami E, Chamani G, Amizadeh M, Rad M, Shabani M. Temporomandibular treatments are significantly efficient in improving otologic symptoms. BMC Oral Health. 2023;23(1):913.
27. Hezenci Y, Bulut M. Correlation of skeletal development and midpalatal suture maturation. Eur J Med Res. 2024;29(1):461.
28. Baccetti T, Franchi L, McNamara JA. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. Sem Orthod. 2005;2:986.
29. Zhang Y, Shu S, Gu Q. Cervical vertebral maturation (CVM) stage as a supplementary indicator for the assessment of peak height velocity (PHV) in adolescent idiopathic scoliosis (AIS). Quantitative Imag Med Surg. 2019;10(1):96-105.
30. Ferrillo M, Curci C, Roccuzzo A, Migliario M, Invernizzi M, de Sire A. Reliability of cervical vertebral maturation compared to hand-wrist for skeletal maturation assessment in growing subjects: A systematic review. J Back Musculoskel Rehabil. 2021;34(6):925-36.
31. Alhammadi MS, Halboub E, Fayed MS, Labib A, El-Saaidi C. Global distribution of malocclusion traits: A systematic review. Dental Press J Orthodont. 2018;23(6):40-1.
32. Hägg U, Wong RWK. Strategies for Treatment of Adolescent Patients with Class II Malocclusions. In: Nanda R, ed. Esthetics and Biomechanics in Orthodontics (Second Edition). St. Louis: W.B. Saunders. 2015:197-204.
33. Silva LF, Thomaz EB, Freitas HV, Pereira AL, Ribeiro CC, Alves CM. Impact of malocclusion on

the quality of life of Brazilian adolescents: a population-based study. PLoS One. 2016;11(9):162715.
34. Wang J, Wang Y, Yang Y. Clinical effects of maxillary protraction in different stages of dentition in skeletal class III children: A systematic review and meta-analysis. Orthodon Craniofac Res. 2022;25(4):549-61.
35. Nucci L, Costanzo C, Carfora M, d'Apuzzo F, Franchi L, Perillo L. Dentoskeletal effects of early class III treatment protocol based on timing of intervention in children. Prog Orthod. 2021;22(1):49.
36. Rafiuddin S, Biswas S, Prabhu SS. Iatrogenic damage to the periodontium caused by orthodontic treatment procedures: an overview. Open Dentist J. 2015;9:228-34.
37. Klop N, Schreurs R, De Jong G. An open-source, three-dimensional growth model of the mandible. Comp Biol Med. 2024;175:108455.
38. Lyros I, Vastardis H, Tsolakis IA, Kotantoula G, Lykogeorgos T, Tsolakis AI. Growth Prediction in Orthodontics: ASystematic Review of Past Methods up to Artificial Intelligence. Children (Basel). 2025;12(8):45.
39. Derwich M, Minch L, Mitus-Kenig M, Zoltowska A, Pawlowska E. Personalized Orthodontics: From the Sagittal Position of Lower Incisors to the Facial Profile Esthetics. J Pers Med. 2021;11(8):857.
40. Liu Z, Luo X, Xu R. Interaction between immuno-stem dual lineages in jaw bone formation and injury repair. Front Cell Dev Biol. 2024;12:1359295.

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