JOURNAL OF HEALTHCARE SCIENCES
Volume 4 Issue 12 2024, Article ID: JOHS2024001007
http://dx.doi.org/10.52533/JOHS.2024.41244
e-ISSN: 1658-8967

Review

Effect of Maxillofacial Surgery on Facial Growth and Development

Manal Hussain Alhashem[1*], Majed Mansour Alsuwaida[2], Mohammad Abdulrahman Algamdi[3], Abdulhakeem Ali Alhaddad[4], Abdulrahman Rasmi Khairi[5], Abdulrahman Mudaysh Bajawi[6]

[1] *Dental Department, Safwa General Hospital, Safwa, Saudi Arabia*
[2] *Dental Department, Ministry of Health, Mecca, Saudi Arabia*
[3] *General Dental Clinic, Balala Primary Healthcare Center, Al Baha, Saudi Arabia*
[4] *Safwa & Rastanorah Primary Healthcare Center, Safwa General Hospital, Safwa, Saudi Arabia*
[5] *Dental Department, Rabigh General Hospital, Rabigh, Saudi Arabia*
[6] *Dental Department, Samtah General Hospital, Jazan, Saudi Arabia*

Correspondence should be addressed to **Manal Hussain Alhashem**, Dental Department, Safwa General Hospital, Safwa, Saudi Arabia. Email: miralandhashim@yahoo.com

Received: 09 December 2024, Reviewed: 18 December 2024, Accepted: 30 December 2024, Published: 31 December 2024.

Abstract

Maxillofacial surgery significantly impacts craniofacial growth, function, and aesthetics, especially in patients undergoing treatment during active growth phases. The interplay between surgical interventions and natural growth dynamics is complex, requiring careful consideration of timing, technique, and individualized patient needs. Early surgeries, such as cleft repairs or corrections for craniosynostosis, can effectively address functional deficits but may risk growth disturbances due to scar tissue formation and skeletal remodeling. Conversely, delayed procedures reduce growth interference but may leave patients with prolonged functional or psychosocial challenges. Advances in surgical methods, such as distraction osteogenesis, allow for controlled skeletal modifications that integrate more seamlessly with ongoing growth. This technique has shown promise in addressing severe deformities in growing patients while minimizing relapse and maximizing long-term stability. Functional adaptations post-surgery includes enhanced mastication, speech, and airway patency, particularly in cases of orthognathic interventions targeting malocclusions or obstructive sleep apnea. However, long-term stability of these functional improvements is not guaranteed, with variability in condylar remodeling and joint mechanics necessitating regular follow-up care. Aesthetic outcomes are equally significant, as facial morphology profoundly influences psychological well-being and social integration. Precision in surgical planning, aided by digital simulation tools, helps achieve symmetry and proportionality while anticipating soft tissue adaptations. Despite these advancements, challenges such as suboptimal tissue draping or scar formation persist, often requiring adjunctive treatments to refine results. Multidisciplinary approaches and technological innovations, including growth prediction models and three-dimensional imaging, have enhanced the ability to balance therapeutic benefits with growth preservation. By addressing the intricate relationship between surgical interventions and craniofacial development, these advancements pave the way for more effective, individualized treatment strategies that optimize functional, aesthetic, and psychosocial outcomes.

Keywords: *Maxillofacial surgery, craniofacial growth, functional outcomes, aesthetic development, surgical timing*

Introduction

Maxillofacial surgery plays a pivotal role in correcting facial deformities and functional impairments, such as malocclusion, asymmetry, and airway obstructions. While the primary aim of such surgical interventions is to restore or enhance facial aesthetics and function, their implications on facial growth and development have garnered significant attention over the years. The human craniofacial complex is a highly dynamic structure, with growth and remodeling processes occurring continuously during childhood and adolescence. Surgical manipulation of this complex at critical growth periods can potentially alter natural developmental trajectories, making the timing and type of surgery crucial considerations in treatment planning (1, 2). The influence of maxillofacial surgery on facial growth is multifaceted and varies depending on the type of surgical procedure, the patient's age, and the underlying condition being addressed. For instance, procedures such as mandibular setback surgeries for Class III malocclusion may inhibit mandibular growth, whereas distraction osteogenesis techniques can stimulate growth in hypoplastic regions (3, 4). Similarly, surgical interventions to address cleft lip and palate often involve multiple staged procedures, each carrying potential long-term effects on craniofacial morphology and growth dynamics (5). These complexities highlight the need for a comprehensive understanding of the interplay between surgical intervention and natural growth processes to optimize outcomes (1, 4).

Growth-related changes in the maxillofacial region are also influenced by biomechanical forces, such as mastication, respiration, and soft tissue dynamics. Surgical alterations to skeletal or soft tissue components may disrupt these forces, potentially leading to adaptive or maladaptive changes over time (2-4). Furthermore, variations in surgical techniques and postoperative care protocols contribute to differing outcomes in terms of facial growth and development. Advances in imaging technologies, such as three-dimensional cephalometry and finite element analysis, have enabled clinicians to better predict and evaluate these changes, paving the way for more precise and personalized treatment approaches (1, 3, 4). The impact of maxillofacial surgery on facial growth extends beyond structural considerations to encompass functional and psychosocial aspects. Changes in facial morphology can significantly influence speech, chewing, and airway patency, which are critical for overall health and quality of life (3, 4). Additionally, facial appearance plays a vital role in social interactions and psychological well-being. Understanding how surgical interventions influence these dimensions is essential for holistic treatment planning and long-term patient satisfaction (2, 5).

As maxillofacial surgery continues to evolve with advances in surgical techniques and biomaterials, there is a growing emphasis on evidence-based practices to minimize adverse effects on facial growth. A thorough exploration of existing literature is essential to elucidate the underlying mechanisms, identify gaps in knowledge, and guide future research in this field. By examining the interplay between maxillofacial surgery and craniofacial development, clinicians can better navigate the delicate balance between therapeutic benefits and potential growth-related consequences (1-5).

Review

The effects of maxillofacial surgery on facial growth and development are heavily influenced by the timing of the intervention and the surgical technique employed. For example, early surgical correction in patients with cleft lip and palate, while essential for functional restoration, can sometimes result in growth disturbances due to scar tissue formation and its restrictive effect on skeletal and soft tissue development (6). This underscores the importance of a multidisciplinary approach, where the timing of surgical procedures is carefully coordinated with orthodontic and growth monitoring to minimize adverse outcomes and optimize both aesthetic and functional results. Advances in surgical techniques, such as distraction osteogenesis, have provided innovative solutions to stimulate growth in underdeveloped facial regions while maintaining or even enhancing natural growth trajectories. Unlike traditional osteotomies,

http://dx.doi.org/10.52533/JOHS.2024.41244

distraction osteogenesis enables gradual bone elongation, reducing the risk of relapse and facilitating better integration with soft tissue adaptations (7). Moreover, this technique has shown promising outcomes in addressing severe craniofacial deficiencies, particularly in growing patients, where it allows for simultaneous correction of deformities and encouragement of natural growth processes. These findings highlight the delicate balance between correcting deformities and preserving growth potential, emphasizing the need for personalized treatment plans that account for the unique growth patterns and developmental needs of each patient.

Impact of Surgical Timing on Craniofacial Growth Patterns

Surgical timing plays a crucial role in determining the outcomes of maxillofacial interventions, especially in growing patients. The dynamic nature of craniofacial growth demands careful consideration of when surgical corrections are performed to balance the benefits of early intervention against potential growth disturbances. The craniofacial complex develops through intricate interactions between skeletal, soft tissue, and functional components, making the timing of surgical intervention critical for maintaining harmony in this growth process (8). Early surgical interventions are often necessary to address severe anomalies, such as cleft lip and palate, syndromic craniosynostosis, or severe malocclusions. These procedures aim to correct functional deficits that could impede breathing, eating, or speech. However, studies have shown that surgeries performed too early in life, particularly during periods of rapid skeletal growth, can disrupt natural growth trajectories. Scar tissue formation following surgery can impair bone development and lead to asymmetries, which may necessitate additional corrective procedures later in life (9). For instance, cleft palate repairs performed before the complete maturation of the maxillary bone can restrict forward maxillary growth, resulting in midface hypoplasia.

Conversely, delaying surgery until skeletal maturity may minimize the risk of growth disturbances but can exacerbate psychosocial challenges for patients. Facial deformities often affect self-esteem and social interactions, which are particularly sensitive during childhood and adolescence. Therefore, clinicians must weigh the immediate need for functional and aesthetic improvements against the potential for long-term consequences on growth and development. This dilemma is particularly pronounced in orthognathic surgeries, where procedures such as mandibular setback or maxillary advancement can significantly influence craniofacial morphology. Research has indicated that growth-inhibitory effects are more pronounced in procedures involving the mandible, particularly in younger patients, where ongoing mandibular growth may be restricted following surgical intervention (10). Technological advancements have enabled a more nuanced approach to timing surgical interventions. Growth prediction models and imaging techniques, such as three-dimensional cephalometry and growth simulation software, allow clinicians to forecast craniofacial growth patterns with greater accuracy. This information aids in determining optimal timing, minimizing the likelihood of growth disruption while achieving the desired surgical outcomes. For example, distraction osteogenesis has emerged as a viable option for young patients requiring significant skeletal advancement. This technique accommodates continued growth by incrementally lengthening the bone, rather than creating static structural changes, which can integrate better with the natural growth process (11).

Collaborative care involving surgeons, orthodontists, and other specialists is critical for optimizing timing decisions. Regular monitoring of growth milestones ensures that surgeries align with developmental stages, particularly in complex cases such as syndromic conditions. Overall, the timing of maxillofacial surgery requires a personalized approach that accounts for the unique needs and growth trajectories of each patient **(Table 1)**. Continuous advancements in predictive tools and surgical techniques, combined with multidisciplinary collaboration, are paving the way for more effective and individualized care strategies.

http://dx.doi.org/10.52533/JOHS.2024.41244

Table 1: Comparison of Surgical Timing and Its Impact on Craniofacial Growth and Development

Timing of Surgery	Advantages	Disadvantages	Examples of Procedures
Early Childhood	Corrects functional deficits early (e.g., breathing, feeding), prevents psychosocial challenges	Risk of growth disturbances due to scar tissue or restricted skeletal growth	Cleft lip and palate repair, craniosynostosis correction
Adolescence	Aligning with slower growth rates for improved stability, allows better patient cooperation	May require interim treatments or staging for optimal results	Orthognathic surgery for malocclusion
Adulthood (Post-Growth)	Minimal impact on natural growth, facilitates definitive corrections	Delays correction of functional/aesthetic issues, increased psychosocial impact if deformities persist	Orthognathic procedures, jaw reconstructions

Post-Surgical Morphological Adaptations in Facial Structures

The structural changes following maxillofacial surgery extend beyond the immediate site of intervention and often involve complex adaptations in surrounding skeletal and soft tissues. These morphological changes are driven by the interplay between surgical modifications, intrinsic growth potential, and functional forces, which collectively shape the post-operative outcomes. Understanding these adaptations is essential for anticipating long-term results and managing patient expectations effectively (12, 13).

Skeletal remodeling following maxillofacial surgery is a prominent feature that influences the overall success of the procedure. The craniofacial skeleton is highly dynamic, with a remarkable ability to adapt to biomechanical stresses. For example, studies have shown that maxillary advancements using Le Fort I osteotomy led to significant remodeling in the maxillary region, with adjacent bones such as the zygoma and nasal structures undergoing secondary changes to achieve functional and aesthetic harmony (14). These compensatory adjustments underscore the need for precision in surgical planning to ensure symmetry and stability in the remodeled facial framework. Soft tissues play a critical role in the post-surgical adaptation process. Facial soft tissues, including the skin, muscles, and fat, respond to the repositioning of underlying skeletal structures. This response is influenced by factors such as elasticity, thickness, and preoperative tension. For instance, in procedures involving mandibular setback, the overlying soft tissue may show a lag in adapting to the reduced skeletal projection, occasionally resulting in suboptimal contouring or folds in the skin (15). Advances in imaging and simulation technologies, such as three-dimensional stereophotogrammetry, have enabled surgeons to predict soft tissue behavior more accurately, allowing for better alignment of surgical goals with patient outcomes.

Functional forces exerted by mastication, speech, and respiration significantly influence the morphological adaptation of facial structures post-surgery. These forces can accelerate the remodeling process by inducing changes in bone density and alignment. For example, mandibular advancement surgeries often lead to improved oral function and stability in the temporomandibular joint region, facilitating adaptive remodeling in the condyle and surrounding structures. However, this process is not always linear, as excessive or imbalanced forces may contribute to relapse or joint-related complications, emphasizing the importance of careful functional rehabilitation following surgery (16).

The relationship between scar tissue formation and post-surgical morphology also warrants attention. Surgical interventions involving significant incisions or dissections can lead to the development of fibrous tissue, which may restrict the natural mobility of adjacent soft tissues or distort skeletal contours over time. In procedures such as cleft palate repair or midface reconstructions, scar tissue

http://dx.doi.org/10.52533/JOHS.2024.41244

formation has been identified as a contributing factor to growth inhibition and aesthetic irregularities in the long term. Efforts to minimize scarring, such as the use of minimally invasive techniques and meticulous suturing, have shown promise in mitigating these effects (2). Collectively, these factors highlight the complex and multifaceted nature of post-surgical morphological adaptations. Each patient's unique physiological and functional characteristics contribute to the variability in outcomes, necessitating a tailored approach to surgical planning and

Long-Term Outcomes of Maxillofacial Surgery on Functional and Aesthetic Development

The long-term implications of maxillofacial surgery extend across both functional and aesthetic domains, often requiring a nuanced evaluation of the surgical outcomes. These effects are shaped by factors including the type of surgical intervention, patient-specific growth patterns, and the post-surgical adaptation of facial tissues. Functional improvements and aesthetic refinements often coexist, yet their interdependence is intricate and multifactorial (17).

Functional rehabilitation following maxillofacial surgery has demonstrated significant benefits for oral and respiratory mechanics. Orthognathic procedures aimed at correcting skeletal malocclusions, such as mandibular advancements or maxillary impactions, frequently enhance masticatory efficiency and phonation. Research has highlighted the role of stable occlusal relationships in improving long-term chewing function and reducing strain on the temporomandibular joint (18). Similarly, surgeries to address conditions like obstructive sleep apnea through mandibular or maxillary advancement yielded sustained airway improvements, contributing to better sleep quality and reduced cardiovascular risks associated with chronic hypoxia.

From an aesthetic standpoint, the impact of maxillofacial surgery transcends physical appearance, often influencing psychological and social dimensions. Patients undergoing surgeries for facial asymmetry or disproportionality commonly report enhanced self-confidence and social integration. Studies indicate that symmetric and proportionate facial features not only fulfill aesthetic ideals but also align with subconscious perceptions of health and attractiveness (19). The integration of digital planning tools, including facial morphing software, has further refined aesthetic outcomes by enabling precise pre-surgical visualization and patient collaboration. However, the complexity of soft tissue dynamics introduces variability in aesthetic results. Surgical repositioning of skeletal elements alters the contours and tension of overlying soft tissues, which may adapt differently depending on age, elasticity, and individual healing responses. Procedures such as Le Fort I osteotomy or bimaxillary surgeries, while effective in correcting skeletal imbalances, require careful consideration of soft tissue draping to achieve a harmonious facial profile. Research underscores the importance of post-surgical monitoring and adjunctive treatments, such as soft tissue fillers or skin-tightening procedures, to refine aesthetic results where soft tissue adaptation is suboptimal (20).

Functional improvements achieved through surgery are not immune to the influence of time. Studies on mandibular advancement procedures suggest that the condylar region undergoes gradual remodeling in response to new functional demands, with variability in the degree of long-term stability. While most patients retain improved occlusal function, a subset may experience relapse or altered joint mechanics, necessitating additional interventions. Longitudinal follow-ups have been emphasized as critical in identifying these changes early, enabling timely corrective measures (21). These long-term outcomes illustrate the dual nature of maxillofacial surgery as both a reconstructive and an aesthetic endeavor, with its success measured not only in terms of immediate postoperative results but also through its enduring impact on function, appearance, and patient well-being.

Conclusion

Maxillofacial surgery profoundly influences facial growth, functional restoration, and aesthetic

http://dx.doi.org/10.52533/JOHS.2024.41244

development. Careful surgical timing, precise techniques, and multidisciplinary planning are critical to achieving optimal outcomes while minimizing adverse effects. Long-term success depends on monitoring growth adaptations, addressing potential relapses, and tailoring care to individual needs. Advancements in imaging and predictive tools continue to enhance the precision and effectiveness of these interventions.

Disclosure

Conflict of interest

There is no conflict of interest.

Funding

No funding.

Ethical consideration

Non applicable.

Data availability

Data that support the findings of this study are embedded within the manuscript.

Author contribution

All authors contributed to conceptualizing, data drafting, collection and final writing of the manuscript.

References

1. Proffit WR, Phillips C, Douvartzidis N. A comparison of outcomes of orthodontic and surgical-orthodontic treatment of Class II malocclusion in adults. American Journal of Orthodontics and Dentofacial Orthopedics. 1992;101(6):556-65.

2. Shi B, Losee JE. The impact of cleft lip and palate repair on maxillofacial growth. International journal of oral science. 2015;7(1):14-7.

3. Tuncay OC. Essentials of facial growth. Implant Dentistry. 1996;5(4):303.

4. Enlow DH. Essentials of facial growth. Saunders Company. 1996.

5. McCarthy JG, Schreiber J, Karp N, Thorne CH, Grayson BH. Lengthening the human mandible by gradual distraction. Plastic and reconstructive surgery. 1992;89(1):1-8.

6. Robin NH, Baty H, Franklin J, Guyton FC, Mann J, Woolley AL, et al. The multidisciplinary evaluation and management of cleft lip and palate. Southern medical journal. 2006;99(10):1111-21.

7. Ilizarov GA. The tension-stress effect on the genesis and growth of tissues: Part II. The influence of the rate and frequency of distraction. Clinical Orthopaedics and Related Research (1976-2007). 1989;239:263-85.

8. Kaban LB, Moses MH, Mulliken JB. Surgical correction of hemifacial microsomia in the growing child. Plastic and reconstructive surgery. 1988;82(1):9-19.

9. Bishara SE, Sierk DL, Huang K-S. Longitudinal changes in the dento-facial relationships of unilateral cleft lip and palate subjects. The Cleft Palate Journal. 1979;16(4):391-401.

10. Wolford LM, Karras SC, Mehra P. Considerations for orthognathic surgery during growth, part 1: mandibular deformities. American Journal of Orthodontics and Dentofacial Orthopedics. 2001;119(2):95-101.

11. Cohen SR, Rutrick RE, Burstein FD. Distraction osteogenesis of the human craniofacial skeleton: initial experience with a new distraction system. Journal of Craniofacial Surgery. 1995;6(5):368-74.

12. Eggensperger NM, Lieger O, Thüer U, Iizuka T. Soft tissue profile changes following mandibular advancement and setback surgery an average of 12 years postoperatively. Journal of oral and maxillofacial surgery : official journal of the American Association of Oral and Maxillofacial Surgeons. 2007;65(11):2301-10.

13. Verbeni M, Sánchez O, Mollica E, Siegl-Cachedenier I, Carleton A, Guerrero I, et al. Morphogenetic action through flux-limited spreading. Physics of Life Reviews. 2013;10(4):457-75.

14. Tabbenor O. Essentials of orthognathic surgery. Nature Publishing Group UK London; 2011.

http://dx.doi.org/10.52533/JOHS.2024.41244

15. Ajmera DH, Singh P, Leung YY, Gu M. Three-dimensional evaluation of soft-tissue response to osseous movement after orthognathic surgery in patients with facial asymmetry: A systematic review. Journal of Cranio-Maxillofacial Surgery. 2021;49(9):763-74.

16. Goncalves JR, Wolford LM, Cassano DS, Da Porciuncula G, Paniagua B, Cevidanes LH. Temporomandibular joint condylar changes following maxillomandibular advancement and articular disc repositioning. Journal of Oral and Maxillofacial Surgery. 2013;71(10):1759. e1-. e15.

17. Kutcipal E. Pediatric oral and maxillofacial surgery. Dental Clinics. 2013;57(1):83-98.

18. Panula K, Somppi M, Finne K, Oikarinen K. Effects of orthognathic surgery on temporomandibular joint dysfunction: A controlled prospective 4-year follow-up study. International Journal of Oral & Maxillofacial Surgery. 2000;29(3):183-7.

19. Sforza C, Peretta R, Grandi G, Ferronato G, Ferrario VF. Soft tissue facial volumes and shape in skeletal Class III patients before and after orthognathic surgery treatment. Journal of plastic, reconstructive & aesthetic surgery. 2007;60(2):130-8.

20. Harada K, Baba Y, Ohyama K, Omura K. Soft tissue profile changes of the midface in patients with cleft lip and palate following maxillary distraction osteogenesis: a preliminary study. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2002;94(6):673-7.

21. Hoppenreijs TJ, Freihofer HPM, Stoelinga PJ, Tuinzing DB, van't Hof MA. Condylar remodelling and resorption after Le Fort I and bimaxillary osteotomies in patients with anterior open bite: A clinical and radiological study aesthetic and reconstructive surgery. International journal of oral and maxillofacial surgery. 1998;27(2):81-91.

http://dx.doi.org/10.52533/JOHS.2024.41244