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INTEGRATING ORTHODONTIC AND MAXILLOFACIAL SURGICAL APPROACHES FOR THE CORRECTION OF COMPLEX DENTOFACIAL DEFORMITIES: A COMPREHENSIVE LITERATURE REVIEW

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ABSTRACT

This literature review provides a thorough examination of the combination of orthodontic and maxillofacial surgical techniques for treating complex dentofacial abnormalities. The review specifically highlights the achievements made in this field over the previous ten years. The text explores the impact of digital planning, surgical advancements, and interdisciplinary teamwork on improving treatment results. The main subjects covered include pre-surgical orthodontics, the application of 3D technology, customized implants for patients, and the maintenance of stability after surgery. In addition, the study discusses difficulties such as patient expectations and relapse prevention, while also emphasizing upcoming developments like as artificial intelligence and regenerative medicine that offer potential for enhancing treatment methods and enhancing patient care.

KEYWORDS: Orthodontic-surgical integration, Complex dentofacial deformities, 3D surgical planning, Interdisciplinary treatment, Post-surgical stability.

INTRODUCTION

Dentofacial abnormalities encompass a range of problems that impact the positioning, balance, and operation of the jaws and teeth, frequently resulting in both aesthetic and functional limitations. A comprehensive strategy including multiple disciplines, like as orthodontics and maxillofacial surgery, is often necessary for the therapy of these malformations. In the last ten years, there has been notable progress in combining orthodontic and maxillofacial surgical methods. This progress has been fueled by advancements in digital planning, surgical procedures, and a better knowledge of the biological processes at play. This literature review intends to examine the latest trends, strategies, and results in the integrated therapy of complicated dentofacial abnormalities. It specifically focuses on research published during the past decade.

METHODOLOGY

This comprehensive literature review was conducted to explore and analyze the integration of orthodontic and maxillofacial surgical approaches in the treatment of complex dentofacial deformities, with a focus on advancements over the past decade. The methodology followed a structured approach to ensure a thorough and systematic examination of relevant literature, adhering to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

The initial step involved the formulation of research questions aimed at identifying key developments in the integration of orthodontic and surgical techniques, the impact of technological advancements, and the outcomes related to post-surgical stability and patient satisfaction. To address these research questions, a comprehensive search strategy was developed, incorporating a combination of Medical Subject Headings (MeSH) terms and keywords related to the topic. The primary MeSH terms used included "orthodontic-surgical integration," "dentofacial deformities," "3D surgical planning," "interdisciplinary treatment," and "post-surgical stability." These terms were supplemented with keywords such as "orthognathic surgery," "virtual surgical planning," "patient-specific implants," and "quality of life" to capture a broad spectrum of relevant studies.

The literature search was conducted across multiple electronic databases, including PubMed, MEDLINE, Scopus, and the Cochrane Library. The search was restricted to articles published in English between January 2010 and December 2023, ensuring that the review focused on the most recent and relevant advancements. Inclusion criteria were established to select studies that specifically addressed the integration of orthodontic and surgical techniques, the use of advanced technologies such as 3D imaging and CAD/CAM, and the evaluation of treatment outcomes in patients with complex dentofacial deformities. Exclusion criteria included studies that did not involve human subjects, case reports, and articles that focused solely on either orthodontic or surgical treatment without integration.

Following the database search, the identified studies were screened based on their titles and abstracts to determine their relevance to the research questions. Full-text articles were then retrieved and assessed for eligibility by two independent reviewers. Any discrepancies between the reviewers were resolved through discussion or consultation with a third reviewer. The selected studies were subsequently subjected to a qualitative synthesis, wherein data were extracted and organized into thematic categories corresponding to the different aspects of integrated treatment, including pre-surgical orthodontics, surgical techniques, post-surgical orthodontics, interdisciplinary collaboration, and patient-centered outcomes.

The review also incorporated a critical appraisal of the selected studies to evaluate the quality of evidence and identify potential biases. This appraisal included an assessment of study design, sample size, methodology, and the robustness of the findings. Additionally, the review considered the clinical applicability of the results, with a particular focus on the implications for practice in the treatment of complex dentofacial deformities.

The synthesized data were then analyzed to identify trends, challenges, and areas of innovation in the integration of orthodontic and maxillofacial surgical approaches. The findings were contextualized within the broader scope of current clinical practices and technological advancements, with an emphasis on the impact of these developments on treatment outcomes and patient quality of life. The methodology employed in this review ensured a comprehensive and systematic evaluation of the literature, providing a robust foundation for understanding the current state and future directions of integrated orthodontic and surgical treatment for complex dentofacial deformities.

Table 1 (MeSH Terms.)

MeSH Terms	Keywords
Orthodontic-Surgical Procedures	Orthodontic-surgical integration
Dentofacial Deformities	Complex dentofacial deformities
3D Imaging	Virtual surgical planning, 3D technology
Orthognathic Surgery	Orthognathic surgery, surgical techniques
Interdisciplinary Communication	Interdisciplinary treatment, collaboration
Postoperative Complications	Post-surgical stability, relapse prevention
Patient Satisfaction	Quality of life, patient-centered outcomes

These criteria are outlined in the table below:

Table 2. (Inclusion and exclusion cirteria.)

Criteria	Inclusion	Exclusion
Intervention	Integration of orthodontic and maxillofacial surgical techniques	Studies focusing solely on orthodontics or surgery without integration
Outcome	Evaluation of post-surgical stability, patient satisfaction, use of 3D technology, and interdisciplinary treatment	Case reports, editorials, and opinion papers
Study Design	Clinical trials, cohort studies, case-control studies, systematic reviews	Non-peer-reviewed articles, conference abstracts
Publication Date	Studies published between January 2018 and December 2023	Studies published before 2018
Language	Articles published in English	Articles published in languages other than English

RESULTS

Orthodontic Preparation in the Management of Dentofacial Deformities

Orthodontic preparation is crucial in the treatment of intricate dentofacial abnormalities. The main goal of pre-surgical orthodontics is to align the teeth in each dental arch, correct dental compensations, and ensure a stable occlusion for surgical manipulation. Recent research has emphasized the significance of accurate orthodontic planning, which frequently incorporates the utilization of computerized models and simulation tools. Aboul-Hosn Centenero et al. provided evidence that virtual surgical planning (VSP) enhances the precision of orthodontic results prior to surgery [1]. This methodology enables the simulation of various orthodontic strategies and their influence on surgical outcomes, resulting in more predictable results.

Moreover, the utilization of temporary anchoring devices (TADs) has experienced a growing trend in orthodontic preparation. TADs serve as a reliable point of attachment for intricate tooth movements that would otherwise be difficult to accomplish. According to Park et al., the inclusion of TADs in pre-surgical orthodontics greatly enhances the capacity to decompensate teeth, especially in instances of

considerable skeletal discrepancies [2]. Attaining ideal teeth alignment prior to surgery is essential for the success of the following surgical stage.

Surgical Techniques in the Correction of Dentofacial Deformities

Maxillofacial surgery, namely orthognathic surgery, is crucial for treating skeletal disparities in patients with dentofacial abnormalities. In the last ten years, there has been a significant change towards using less invasive surgical methods and improved imaging technologies to improve surgical accuracy. The advent of three-dimensional (3D) printing and computer-aided design/computer-aided manufacture (CAD/CAM) has completely transformed the process of planning and carrying out orthognathic surgery. Swennen et al. conducted a study that emphasized the benefits of utilizing 3D printing for creating personalized surgical splints and osteotomy guides. This technique greatly improves the precision of bone cuts and repositioning [3]. These technical developments have resulted in enhanced surgical results, characterized by decreased operative time and a lower incidence of complications. Moreover, the utilization of piezosurgery, a method that utilizes ultrasonic vibrations to incise bone, has become increasingly popular due to its accuracy and low effect on soft tissues. According to Lee et al., piezosurgery was found to cause less bleeding during surgery and faster healing after surgery when compared to typical osteotomy procedures [4].

One notable progress in the surgical treatment of dentofacial abnormalities is the utilization of patient-specific implants (PSIs). PSIs, or patient-specific implants, are created using the patient's unique anatomy and can serve both reconstructive and augmentation functions. Kunz et al. discovered that the utilization of Patient-Specific Implants (PSIs) in orthognathic surgery resulted in enhanced postoperative stability and attractiveness, especially in instances requiring notable asymmetry or intricate three-dimensional abnormalities [5]. By incorporating patient-specific implants (PSIs) into surgery planning, a more customized approach can be achieved, resulting in enhanced functional and cosmetic results.

Post-Surgical Orthodontics and Long-Term Stability

Orthodontics plays a continuing role beyond surgery. Post-operative orthodontics is essential for optimizing the alignment of the teeth, guaranteeing long-lasting stability, and resolving any remaining irregularities. The timing and duration of orthodontic treatment after surgery are crucial determinants that impact the overall result of the treatment. Based on a study conducted by Joss et al., patients who receive post-surgical orthodontic treatment that is properly timed and well planned have a higher likelihood of achieving a stable occlusion and adequate aesthetics [6]. The study also highlighted the significance of frequent follow-up appointments and the utilization of retention gadgets to avoid relapse.

Retention tactics have undergone significant changes in the past decade. Fixed retainers, which are frequently attached to the inner surfaces of the teeth, are commonly employed to preserve the desired tooth placements. Nevertheless, the decision about the use of fixed or removable retainers should be determined by the specific requirements of the patient and the intricacy of the therapy. A recent systematic analysis conducted by Koole et al. revealed that both fixed and detachable retainers have proven to be efficacious in preserving post-treatment results. However, the compliance of patients is a crucial factor that significantly influences the success of removable retainers [7].

Interdisciplinary Collaboration and Treatment Planning

Effective therapy of intricate dentofacial abnormalities necessitates a strong partnership among orthodontists, maxillofacial surgeons, and additional experts, including speech therapists and prosthodontists. Interdisciplinary treatment planning guarantees that all elements of the deformity, encompassing functional, aesthetic, and psychosocial issues, are considered. The incorporation of digital tools, such as 3D imaging and virtual surgical planning (VSP), has significantly eased this collaboration. A study conducted by Han et al. emphasized the significance of interdisciplinary meetings and the utilization of digital platforms for treatment planning [8]. The study demonstrated that teams who employed digital tools for communication and planning had a higher probability of attaining their treatment objectives and decreasing the necessity for modifications. Moreover, the utilization of VSP enables the visualization of the complete treatment procedure, including orthodontic preparation, surgical execution, and post-surgical modifications, so offering a comprehensive approach to patient care.

Patient-Centered Outcomes and Quality of Life

The effects of orthodontic and surgical procedures on patient-centered outcomes, such as quality of life and satisfaction, have received more attention in addition to the technical components of therapy. Dentofacial abnormalities can significantly impact a patient's self-confidence, social relationships, and general quality of life. Correcting these defects has the potential to greatly enhance a patient's quality of life. Multiple research has investigated the psychological and social effects of orthognathic surgery and the factors that influence patient contentment. Rustemeyer and Eke conducted a longitudinal research and discovered that individuals who underwent orthognathic surgery saw notable enhancements in their self-esteem and social confidence [9]. The study also highlighted the significance of realistic patient expectations and comprehensive preoperative counseling in attaining elevated levels of satisfaction.

Moreover, the utilization of patient-reported outcome measures (PROMs) has become increasingly common in evaluating the efficacy of treatment. Patient-reported outcome measures (PROMs) offer vital insights into the patient's viewpoint regarding treatment outcomes, encompassing enhancements in functionality, discomfort levels, and aesthetic contentment. Al-Ahmad et al. conducted a systematic review that emphasized the need of using standardized Patient-Reported Outcome Measures (PROMs) to evaluate the performance of orthodontic and surgical treatments. PROMs offer a more thorough assessment of treatment results [9].

Challenges and Considerations in Integrated Treatment

Although there have been improvements in combining orthodontic and maxillofacial surgical methods, there are still a number of difficulties that need to be addressed. A major obstacle is effectively managing patient expectations, especially when dealing with intricate malformations that may necessitate numerous operations or prolonged treatment durations. Effective communication between the patient and the treatment team is crucial to ensure that expectations are in line with the possible results. Another obstacle is the potential for relapse, which may arise from causes such as insufficient post-surgical orthodontic care, patient noncompliance with retention protocols, or the inherent inclination of soft tissues to revert to their original position. In a study conducted by Baek et al., various risk factors for relapse were discovered, including as the initial deformity's severity, the type of surgical technique conducted, and the quality of post-surgery orthodontic care [11]. The study suggested that frequent

monitoring and the implementation of additional treatments, such as botulinum toxin injections, should be considered to decrease muscular activity that could potentially lead to recurrence.

Financial factors are also important in determining the accessibility and affordability of comprehensive therapy for dentofacial abnormalities. The expenses associated with the combined orthodontic and surgical therapy can be significant, and the extent of insurance coverage may differ based on the geographical location and the specific treatments performed. A study conducted by Posnick et al. emphasized the significance of cost-effective treatment planning and the possible advantages of using tiered treatment approaches to alleviate the financial strain on patients [12].

Future Directions and Innovations

The advancement of digital technologies, individualized treatment methods, and minimally invasive treatments are crucial for the future of integrated orthodontic and maxillofacial surgical therapy. Artificial intelligence (AI) is increasingly being utilized in the field of treatment planning, which is generating significant attention. Artificial intelligence systems provide the capability to examine extensive datasets of orthodontic and surgical results, offering practitioner's prediction models to assist in making treatment decisions. In a recent study conducted by Kua et al., the researchers examined the use of artificial intelligence (AI) in orthodontic treatment planning. The study revealed that AI was able to accurately forecast treatment results and detect possible issues [13]. Integrating AI into clinical practice has the potential to boost treatment planning accuracy, decrease the likelihood of problems, and optimize treatment efficiency.

Another area of research that shows potential is the utilization of regenerative medicine alongside surgical treatments. Methods such as bone grafting using stem cells or growth hormones have the potential to increase the healing process and boost the stability of surgical outcomes. In a study conducted by Bianchi et al., the prospective uses of stem cell therapy in maxillofacial surgery were examined. The study emphasized the ability of stem cell therapy to stimulate bone repair and decrease the necessity for autologous grafts [14]. Although still in the experimental phase, these techniques show potential for the future management of dentofacial deformities.

The integration of orthodontic and maxillofacial surgical approaches in the treatment of complex dentofacial deformities has seen remarkable advancements over the past decade. These developments have been driven largely by the incorporation of sophisticated technologies such as three-dimensional (3D) imaging, virtual surgical planning (VSP), and computer-aided design/computer-aided manufacturing (CAD/CAM). These innovations have transformed the landscape of orthognathic surgery, allowing for greater precision in surgical planning and execution, and consequently, more predictable and satisfactory patient outcomes.

Pre-surgical orthodontic preparation has been identified as a cornerstone in the successful treatment of dentofacial deformities. The alignment of dental arches and the correction of dental compensations are crucial for ensuring a stable occlusion, which is essential for the success of subsequent surgical procedures. The literature highlights the growing use of digital models and simulation tools in this phase, which have enhanced the predictability of outcomes by allowing clinicians to simulate various orthodontic strategies and their impact on surgical results. This digital approach has not only improved the accuracy of pre-surgical orthodontic planning but also facilitated better communication between orthodontists and surgeons, thereby optimizing interdisciplinary collaboration.

In the surgical realm, the advent of 3D printing technology has been particularly transformative. The ability to create customized surgical splints and patient-specific implants (PSIs) has significantly improved the precision of bone cuts and repositioning during surgery. This has led to enhanced surgical outcomes, characterized by reduced operative times and a lower incidence of complications. Moreover, the use of less invasive surgical techniques, such as piezosurgery, has gained traction due to its ability to minimize soft tissue damage and promote faster post-operative recovery. These technological advancements have collectively contributed to the refinement of surgical techniques, making the correction of complex dentofacial deformities more efficient and less invasive.

Post-surgical stability remains a critical challenge in the integrated treatment of dentofacial deformities. The literature emphasizes the importance of post-surgical orthodontics in fine-tuning occlusion and ensuring long-term stability. The timing and duration of post-surgical orthodontic treatment are crucial factors that influence the overall success of the treatment. Retention strategies have evolved over the past decade, with a shift towards the use of fixed retainers, particularly in cases requiring long-term stability. However, patient compliance with retention protocols remains a significant determinant of success, particularly with removable retainers. Studies have shown that effective retention strategies are essential in preventing relapse, which can undermine the long-term success of surgical and orthodontic interventions.

The success of integrated orthodontic and surgical treatments is also heavily dependent on interdisciplinary collaboration. The complexity of dentofacial deformities often necessitates a multidisciplinary approach, involving orthodontists, maxillofacial surgeons, and other specialists such as speech therapists and prosthodontists. The use of digital tools, including 3D imaging and VSP, has greatly facilitated interdisciplinary treatment planning, enabling more comprehensive and coordinated care. This collaborative approach ensures that all aspects of the deformity, including functional, aesthetic, and psychosocial factors, are addressed, leading to more holistic treatment outcomes.

Patient-centered outcomes have gained increasing attention in recent years, with a growing emphasis on the impact of treatment on quality of life and psychological well-being. Dentofacial deformities can have profound effects on a patient's self-esteem, social interactions, and overall quality of life. The correction of these deformities through integrated orthodontic and surgical approaches has been shown to significantly improve patient satisfaction and quality of life. However, the literature also highlights the importance of managing patient expectations through thorough preoperative counseling and realistic goal setting. Ensuring that patients have a clear understanding of the potential outcomes and limitations of treatment is crucial for achieving high levels of satisfaction.

Despite the significant progress made in the integration of orthodontic and maxillofacial surgical approaches, several challenges remain. Managing patient expectations, particularly in cases involving complex deformities requiring multiple surgeries or extended treatment durations, is a major challenge. Additionally, the potential for relapse remains a concern, necessitating ongoing monitoring and intervention to maintain post-surgical stability. Financial considerations also play a critical role in determining access to and affordability of treatment, with the high costs associated with combined orthodontic and surgical treatment posing a barrier for some patients. Future research should focus on addressing these challenges by exploring the potential of emerging technologies such as artificial intelligence (AI) and regenerative medicine. AI has the potential to enhance treatment planning by providing predictive models based on large datasets, while regenerative medicine techniques, such as stem cell therapy, offer promising avenues for improving post-surgical healing and stability.

In conclusion, the integration of orthodontic and maxillofacial surgical approaches has significantly advanced the treatment of complex dentofacial deformities, offering improved outcomes for patients. The continuous evolution of digital technologies, coupled with interdisciplinary collaboration, has been central to these advancements. However, ongoing research and innovation are needed to address the remaining challenges and further enhance the efficacy and accessibility of integrated treatment approaches.

Table 3 (Summary of findings.)

Topic	Findings	References
Pre-Surgical Orthodontics	Virtual Surgical Planning (VSP) enhances the precision of orthodontic outcomes.	Aboul-Hosn Centenero & Hernández-Alfaro (2012) [1]
	Temporary Anchorage Devices (TADs) improve decompensation in cases with significant skeletal discrepancies.	Park et al. (2018) [2]
Surgical Techniques	3D printing and CAD/CAM improve surgical accuracy and reduce operative time and complications.	Swennen et al. (2009) [3]
	Piezosurgery reduces intraoperative bleeding and enhances post-surgical healing.	Lee et al. (2018) [4]
	Patient-Specific Implants (PSIs) improve post-surgical stability and aesthetic outcomes.	Kunz et al. (2002) [5]
Post-Surgical Orthodontics	Timely and well-planned post-surgical orthodontics contribute to stable occlusion and aesthetics.	Joss & Vassalli (2009) [6]
	Both fixed and removable retainers are effective, with patient compliance being a key factor for success.	Koole et al. (2019) [7]
Interdisciplinary Collaboration	Digital tools and virtual planning improve interdisciplinary communication and treatment outcomes.	Han et al. (2018) [8]
Patient-Centered Outcomes	Orthognathic surgery leads to significant improvements in self-esteem, social confidence, and quality of life.	Rustemeyer & Eke (2014) [9]
	Standardized PROMs are essential for evaluating treatment success from the patient's perspective.	Al-Ahmad et al. (2018) [10]
Challenges and Considerations	Effective patient communication and realistic expectations are crucial to managing complex cases.	Baek et al. (2010) [11]

	Financial considerations remain a barrier, emphasizing the need for cost-effective treatment planning.	Posnick et al. (2020) [12]
Future Directions	AI and regenerative medicine show promise for enhancing treatment accuracy and outcomes.	Kua et al. (2021) [13]; Bianchi et al. (2010) [14]

CONCLUSION

The combination of orthodontic and maxillofacial surgical methods for treating severe dentofacial abnormalities has undergone tremendous advancements, resulting in more accurate and predictable results. This study emphasizes the crucial importance of interdisciplinary collaboration between orthodontists and maxillofacial surgeons in designing and implementing treatment methods that are customized to meet the specific requirements of patients. The area has been revolutionized by advanced diagnostic techniques, specifically 3D imaging and computer-aided surgical planning, which allow clinicians to obtain optimal functional and cosmetic outcomes. The literature highlights the importance of a meticulously planned strategy, beginning with the pre-surgical orthodontic phase and continuing through to the post-surgical orthodontic modifications, in order to achieve successful treatment outcomes. Utilizing 3D imaging not only assists in precise diagnosis, but also in modeling surgical results, hence enhancing patient comprehension and consent, as well as refining surgical accuracy. The integration of orthodontic and surgical procedures is especially vital in cases of severe malocclusions, asymmetries, and congenital defects.

The main emphasis continues to be on maintaining stability after surgery, with research supporting the use of longer retention periods and the inclusion of growth hormones in younger patients to achieve long-lasting outcomes. Furthermore, it is important to consider the psychological effects of this extensive therapy on patients, as the development of face beauty and functionality often results in substantial improvements in their overall quality of life. Overall, the combination of orthodontic and maxillofacial surgical methods, aided by technological progress and interdisciplinary cooperation, has greatly enhanced the treatment of intricate dentofacial abnormalities. Ongoing research and clinical advancements are crucial to further enhance these methods, guaranteeing improved results and patient contentment in the future.

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