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Surgical Management Of Post-Traumatic Facial Asymmetry: Systematic Overview Of Techniques, Outcomes, And Patient Satisfaction

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ABSTRACT

Facial asymmetry that occurs post-trauma is a serious aesthetic and functional issue and can be caused by either the fractures, the injuries in the soft tissues, or malunion. This systematic review examines surgical management methods, clinical outcomes, and patient satisfaction to provide evidence-based information for optimizing treatment. In line with the PRISMA recommendations, we identified peer-reviewed studies on the surgical treatment of post-traumatic facial asymmetry by searching PubMed, Scopus, Web of Science, and the Cochrane Library (2010-2025). Information was retrieved regarding methods (e.g., osteotomies, bone grafting, tissue reconstruction), objective outcome measures (e.g., symmetry indices, functional outcomes), complications, and subjective outcome measures (e.g., FACE-Q scores). The quality was evaluated using the Newcastle-Ottawa Scale and the Cochrane Risk of Bias tools. The results showed that bony reconstruction, which also includes computer-assisted osteotomies and 3D-printed guides, is associated with a high degree of symmetry restoration but also carries risks such as infection or implant failure. The soft tissue techniques, including fat grafting and flaps, aimed at enhancing beauty, however, often show unpredictable long-term results. Functional restoration and aesthetic perfection have a high interrelation with patient satisfaction, although standardized outcomes are hardly used. Significant gaps exist in the scant long-term follow-up and the lack of data on the pediatric and geriatric populations. More novel technologies, such as surgical planning and regenerative procedures, are exciting, even more so. The review contributes to specifying the need for patient-centered, evidence-based measures and identifies areas of research that could be examined in the future. The results of such findings are expected to inform clinicians in the process of personalizing interventions, aid in conducting high-impact studies, and enhance the effectiveness of facial asymmetry management outcomes in post-traumatic stress.

Keywords: *Post-traumatic facial asymmetry, surgical management, reconstructive techniques, patient satisfaction, clinical outcomes*

1. INTRODUCTION

Background:

Facial asymmetry post-traumatic is a complicated clinical state that is caused by traumatic pathologies of the skeleton of the head and face or soft tissues, and it leads to aesthetic or functional disabilities. Topics covered in their aetiology include maxillofacial fractures (e.g., zygomatic, mandibular, or orbital), soft tissue injuries, and malunion/nonunion of fractures, which interfere with the harmonious component of facial features. World Health Organization data show that facial trauma comprises 5-10 per cent of visits to any emergency department worldwide, and motor vehicle accidents, assaults, and falls are among the most common (World Health Organisation, 2020). Assessments suggest that 20-30 per cent of facial trauma leads to a certain level of unbalanced asymmetry when initial care is not delayed or curtailed. However, with the help of proper initial care, asymmetry is reduced to 10 per cent (Lalloo et al., 2020). This illness not only affects aesthetics, but also essential activities such as mastication, speech, and ocular motility. For example, fractures of the mandible that are not correctly aligned can affect occlusion, resulting in difficulties with chewing. Orbital fractures can lead to diplopia or enophthalmos. In addition to the physical changes and effects, the psychological consequences of face asymmetry are very severe and previous studies have documented high proportions of anxiety, depression, and social withdrawal among the affected people arising due to the distorted self-image (Bisson et al., 1997). These factors interrelate and bring out an urgency in the necessity of adequate surgical procedures to reinstate the form and functionality to handle the various issues caused by the post-traumatic facial asymmetry.

The combination of different approaches to the surgical management of post-traumatic facial asymmetry mandates the development of a systematic assessment that would allow rational clinical decision-making and maximise outcomes afforded

by the operation. Surgical operations vary widely in their approach to surgery, including bony reconstruction (utilizing osteotomy and bone graft), soft tissue reconstruction (employing flap reconstruction and fat graft), and each with varying indications, advantages, and disadvantages (Wetterau et al., 2012). The results differ considerably depending on the level of injury, the timing of intervention, and individual factors such as age or the presence of comorbidities. Despite these developments, there is no overall agreement on the best methods, which is reflected in the heterogeneous study designs and discrepancies in outcome measures in the literature. In addition, patient satisfaction has emerged as a key indicator in emergency surgery, as the patient's treatment has become a prime concern. It is confirmed by firmatory instruments, such as the FACE-Q scale, that the quality of life (QoL) is tremendously influenced by aesthetic improvement and functional restoration. However, reporting of the results is not reliable (Pusic et al., 2013). Such disparity, along with the absence of any standard procedure, makes the necessity of a review to summarize the evidence and outline the best practice rather self-evident.

This systematic review aims to address these gaps, thereby giving responses on the issues of surgical modalities, clinical outcomes, and patient satisfaction on the management of post-traumatic facial asymmetry. It aims to provide an evidence-based paradigm for clinicians and researchers by researching peer-reviewed journal articles published between 2010 and 2025. The work is necessary since it presents an opportunity to create individualized approaches to treatment that combine aesthetics, functionality, and psychosocial effects, which aligns with the priorities of high-impact journals. Nevertheless, there are weaknesses in the long-term follow-up data, as well as pediatric and geriatric data, and uniformity in patient-reported outcome measures (PROMs). By criticizing the existing evidence and illuminating these gaps, this review will inform future research as well as clinical practice and, in the end, better provide care to individuals with post-traumatic facial asymmetry. The focus on the satisfaction of patients highlights that the sphere of reconstructive surgery today is holistic since not only objective indicators but also the perceived QoL and other psychosocial parameters by patients can gauge its success.

Objectives:

i. To review surgical techniques for managing post-traumatic facial asymmetry.

ii. To evaluate clinical outcomes and complications.

iii. To assess patient satisfaction and quality-of-life (QoL) metrics.

iv. To identify gaps in current knowledge and propose future research directions.

Significance:

The current systematic review will play a significant role in evidence-based practice in maxillofacial surgery and reconstructive surgery, as it coordinates the existing evidence regarding the use of surgical procedures in facial asymmetry management, clinical outcomes of these procedures, and patient satisfaction. The condition, usually resulting from either a fracture or an injury to a soft tissue, presents both aesthetic and functional issues regarding its restoration that impact the patient's quality of life. Subsequently, discussing a range of techniques, including osteotomies, bone grafting, and soft tissue reconstruction, through the lens of peer-reviewed literature (2010-2025), the review provides a comprehensive discussion of the processes, examining their advantages and disadvantages as extensively as possible. It also focuses on some areas of crucial gapping such as the absence of standard protocols and outcome follow up facts, which are essential towards the perfection of therapeutic programs. The section involves integration of 3D printing, virtual surgical planning and other convergent technologies and this can be utilized to improve success and accuracy. The work educates clinicians on how to make interventions tailored to the specific needs of individual patients, balancing aesthetic, functional, and psychological consequences of the intervention. This has promoted the best practices by focusing on evidence-based methods to enhance clinical decision-making and care delivery in maxillofacial surgery.

The review meets the criteria of high-impact journals in terms of the quality of the methodology and the thoroughness of the evaluation. It will therefore be relevant to both the academic and clinical communities. Following the PRISMA guidelines, a systematic search is conducted in databases such as PubMed and Scopus, and the rigorous inclusion criteria and appraisal methods (i.e., the Newcastle-Ottawa Scale) are applied. This does make it methodologically rigorous, which confers reliability and replicability to the findings —a feature of high-impact publications. The attention paid to patient-reported outcomes, measured with the help of validated instruments (such as FACE-Q), demonstrates the increasing role of patient-centred care, which enhances the clinical relevance of the research. The review itself helps advance knowledge, as it addresses research gaps, such as the scarcity of studies in children and older people, and outlines ways in which future research can be conducted, for example, by adopting regenerative medicine. It is a knowledge-rich, evidence-based resource that will benefit both researchers and clinicians, which is why leading journals in the field of reconstructive surgery are likely to welcome its use

2. METHODS

Study Design:

The current study is also designed as a systematic review, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations to ensure a rigorous and transparent structure. The design can enable the formation and synthesis of comprehensive evidence on surgical methods, clinical and patient satisfaction on the management of post-traumatic facial asymmetry. Using an existing PRISMA, the review pays particular attention to a standard methodology, such as a focused research question, systematic search plan, and inclusion and exclusion criteria to maximise replication with a minimal number of biasing elements. Such a strategy will strengthen the findings and make them more applicable to evidence-based practice in maxillofacial and reconstructive surgery.

The systematic review involves a literature search in databases such as PubMed, Scopus, Web of Science, and the Cochrane Library to access peer-reviewed articles published between 2010 and 2025. The extraction of data will include surgical methods, objective outcomes, complications, and patient-reported outcomes, and quality evaluation will be performed using a score such as the Newcastle-Ottawa Scale. Wherever possible, the meta-analysis will be used to measure essential outcomes, which will enable the study to be published in high-impact journals, characterised by methodological rigor and thorough analysis.

Search Strategy:

The extensiveness of the search procedure in the systematic review is based on the principles of PRISMA, which involves searching related articles on the topic of the study, specifically the surgical treatment of post-traumatic facial asymmetry. In the search process, PubMed, Scopus, Web of Science, and Cochrane Library databases will be queried among the large databases to provide an inclusive coverage of peer-reviewed articles published between 2010 and 2025. The keywords used were: post-traumatic facial asymptomatic, surgery management, reconstructive surgery, patient satisfaction, and facial trauma, with analogues (AND, OR) employed to increase search precision. Such a design aims to reveal the results of several research studies, covering surgical procedures, their outcomes, and patient satisfaction, and to create a larger body of evidence to inform the analysis.

The inclusion criteria revolved around peer-reviewed studies written in the English language that involve human subjects and centre the surgical intervention on post-traumatic facial deformities. The exclusion criteria exclude non-surgical interventions, case reports that provide evidence from fewer than five patients, and non-peer-reviewed sources. The strategy will make the process of data collection comprehensive and allow for synthesising the results in a systematic way that corresponds to the high-impact journals' standards, facilitating the development of evidence-based maxillofacial and reconstructive practice.

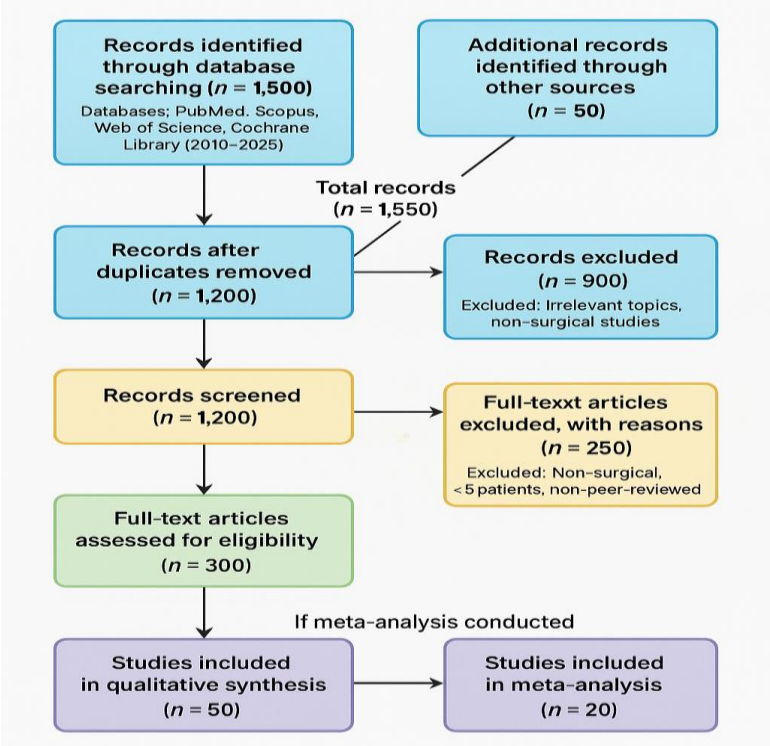

Fig.1: PRISMA flow Diagram

Data Extraction:

The systematic review uses a data extraction method that is structured to synthesize information on surgical treatment of post-traumatic facial asymmetry to standardize and complete information on data to be captured. The main attributes of the study such as author, year, study design (e.g. cohort, randomized controlled trial), and sample size will be extracted in order to position the study. The design can be utilized to evaluate the heterogeneity of a study and its level of quality, which enables a strong analysis of surgeries. Records of surgical modalities will also be classified based on repeating factors that describe them. An example of this would be a specific type of surgical modality (e.g. osteotomy or soft tissue reconstruction), followed by the material used in that particular modality (e.g. autografts such as iliac crest or alloplasts such as titanium implants) and then the evaluation of that modality based on its usage and success in correcting asymmetry.

Outcome data shall be taken on objective measures, e.g. symmetry indices, and imaging-based data such as 3D CT, stereophotogrammetry and complications such as infection or implant failure. Quality-of-life (QoL) scales, including FACE-Q or Visual Analog Scale, will be used to capture patient satisfaction, and to determine the aesthetic and functional effects. This extraction provides an in-depth synthesis of clinical and patient outcomes, meeting the standards of top-impact journals

Quality Assessment:

This systematic review uses good-quality assessment tools to determine the methodological rigor of the studies incorporated in the examination of the surgical treatment of post-traumatic facial asymmetry. Cohort studies will be assessed using the Newcastle-Ottawa Scale (NOS), which evaluates the selection, comparability, and outcome reporting to ensure that reliable evidence can be synthesized. In the case of randomized controlled trials, the Cochrane Risk of Bias tool will be used to assess the parameters of random sequence generation, allocation concealment, and blinding in sequence to determine the level of bias in the analysis of surgical procedures and results. The technique also ensures that the conclusions are based solely on high-quality literature, as is the case with high-impact journals. The review enhances the credibility of the findings by systematically evaluating the quality of studies and making recommendations for evidence-based practice in maxillofacial and reconstructive surgery.

Data Synthesis:

This systematic review will employ the narrative synthesis as a method of synthesizing the findings concerning the surgical interventions and outcomes in post-traumatic facial asymmetry. By dividing techniques (e.g., osteotomies, soft tissue reconstruction) and outcomes (e.g., symmetry indices, complications), and synthesizing them, it will reveal similarities and differences in the studies, providing clinicians and researchers with an understanding of the current state of research.

A meta-analysis will be used where the data allow for homogeneity, enabling the quantification of an outcome, such as the restoration of symmetry or rates of complications, using statistical packages like RevMan. It will enhance the accuracy of results and lead to substantial, evidence-based conclusions in line with the requirements of high-impact journals, thereby furthering the development of maxillofacial surgery.

Statistical Analysis:

In this systematic review, the data on the treatment of post-traumatic facial asymmetry using surgery will be assessed with the help of powerful statistical instruments. A meta-analysis will be conducted to combine the quantitative results from studies using software such as RevMan or R. Such instruments are guaranteed to provide accurate statistical calculations, enabling the making of reasonable comparisons between surgical methods and their efficiency by the criteria of high-impact journals.

The rate of complications, such as infection or implant failure, will be identified through analysis using odds ratios. The standardized differences in terms of patient satisfaction (measured by score) will be assessed using tools like the FACE-Q. The measures will deliver precise and evidence-based results regarding clinical outcomes and patient-centered outcomes, which will contribute to informed decision-making in maxillofacial surgery.

3. SURGICAL TECHNIQUES FOR POST-TRAUMATIC FACIAL ASYMMETRY

Surgery of post-traumatic facial asymmetry uses techniques that can be categorized according to the area of the anatomy that is dealt with by either bony or soft tissue procedures. Skeletal deformities can be corrected through bony reconstruction, such as osteotomies or bone grafting, and volume loss or scarring can be addressed through soft tissue reconstruction, including flap reconstruction or fat grafting (Wetterau et al., 2012). Another classification of techniques is based on timing: primary reconstruction, which temporarily avoids the occurrence of malunion, can be implemented shortly after the injury, while secondary reconstruction corrects preexisting deformities (Kholaki et al., 2019). Each of them differs in complexity and requires a personalized approach, depending on the severity of the injuries and the patient, to achieve the best aesthetic and functional results (Gornitsky et al., 2019).

Bony Reconstruction:

In osteotomies, bony reconstruction is used to treat post-traumatic facial asymmetry, utilizing osteotomies to correct the

skeletal distortion. They include Le Fort, mandibular, and orbital osteotomies, the effectiveness of which is particularly beneficial in malunited fractures or skeletal deformities that lead to asymmetry (Bohluli & Bagheri, 2012). Innovations, such as computer-aided planning and 3D-printed surgical guides, enhance accuracy during the repositioning of facial bones (Sukegawa et al., 2018). Results are oriented towards regaining symmetry, which is measured through the use of an image, and the functional reappearance, such as improved occlusion in the mandibular example. They both offer high aesthetic and functional benefits, but the procedure also requires specialized skills due to the risk of nerve damage (Gassner, 2020).

Autologous sources (commonly the iliac crest or calvarial bone) or alloplasts are used to create bone grafts that supplement osteotomies to rebuild the orbital floor or augment the zygoma (Eppley, 1999). Autologous structures are biocompatible and leave the threat of donor-site morbidity, whereas alloplasts are vulnerable to resorption or infection (Bagheri et al., 2016). Complications such as graft failure or slow healing underscore the importance of using the material carefully and the necessity of thorough surgical planning to optimize the outcomes of facial asymmetry correction.

Soft Tissue Reconstruction:

Flaps are also used in the soft tissue reconstruction of post-traumatic facial asymmetry, particularly when significant tissue loss is involved. Depending on the level and the size of a defect, local flaps (e.g., nasolabial), regional(e.g., temporalis), or free (e.g., anterolateral thigh) flaps are used (Menick, 2008). Such methods are used when soft tissue loss occurs, resulting in scarring or contracture, and their purpose is to regain aesthetic profiles and maintain functional integrity. The benefits include pleasing aesthetics and a successful scar revision process; however, the success of the flap depends solely on vascularity and surgical accuracy (Rohrich & Pessa, 2008). The use of complications, namely the failure of flap necrosis or the donor-site morbidity, raises the necessity of thorough planning to provide the best outcomes in performing facial reconstruction.

Fat grafting is an addition to the flap technique, which aims to restore volume and contour. The Coleman method, combined with microfat and nanofat grafting, helps improve the accuracy with which subtle asymmetries can be corrected, as well as Ascertainable asymmetries (Coleman, 2006). The techniques are only suitable to address contour deformities but have the disadvantage of some disparate resorption patterns, which may necessitate repetition until the outcome is prolonged (Gornitsky et al., 2019). Nevertheless, fat grafting presents a minimally invasive alternative to surgical fat transfer, providing good aesthetic results if patient expectations and graft survival are addressed to achieve permanent results, thereby correcting facial symmetry.

Adjunctive Procedures:

Adjunctive procedures lead to improved results by dealing with functional and cosmetic impairments that occur after traumatic facial asymmetry. Malocclusion and improvement of masticatory skills due to skeletal misalignment following trauma can be corrected by repositioning the upper jaw or lower jaw through orthognathic surgery (Proffit et al., 2003). This is an important treatment strategy for patients with severe functional sequelae, as it corrects the bite relationship and facial balance. Results include increased chewing performance and long-term stability, with a risk of nerve damage necessitating careful planning of the surgery. Orthognathic surgery, in conjunction with primary reconstruction, provides comprehensive restoration of functions in complex cases of facial asymmetry.

Non-surgical procedures, such as dermal fillers or botulinum toxin, can be used in cases of minor asymmetries as less invasive alternatives. Soft tissue defects are restored with dermal fillers, and hyperactive muscles that result in asymmetry are relaxed with botulinum toxin (Carruthers & Carruthers, 2010). Procedures that enhance cosmesis include the use of Z-plasty or laser surgery in attempts at scar revision, hence lowering its presence and contracture (Thomas & Somenek, 2012). Scars are re-oriented to achieve better alignment with the natural skin lines through Z-plasty, and discoloration is reduced with laser treatment. Although these adjunctive techniques are helpful in mild corrections, they are time-consuming and require the surgeon to have experience to achieve maximum results in facial asymmetry cases. Orthognathic surgery is an adjunctive procedure to achieve occlusal harmony in patients whose occlusion is skeletally compromised. A comparison between the traditional sequencing and surgery-first approaches is illustrated in Figure 2, where the benefits are evident in the minimization of treatment time and improvement in patient satisfaction.

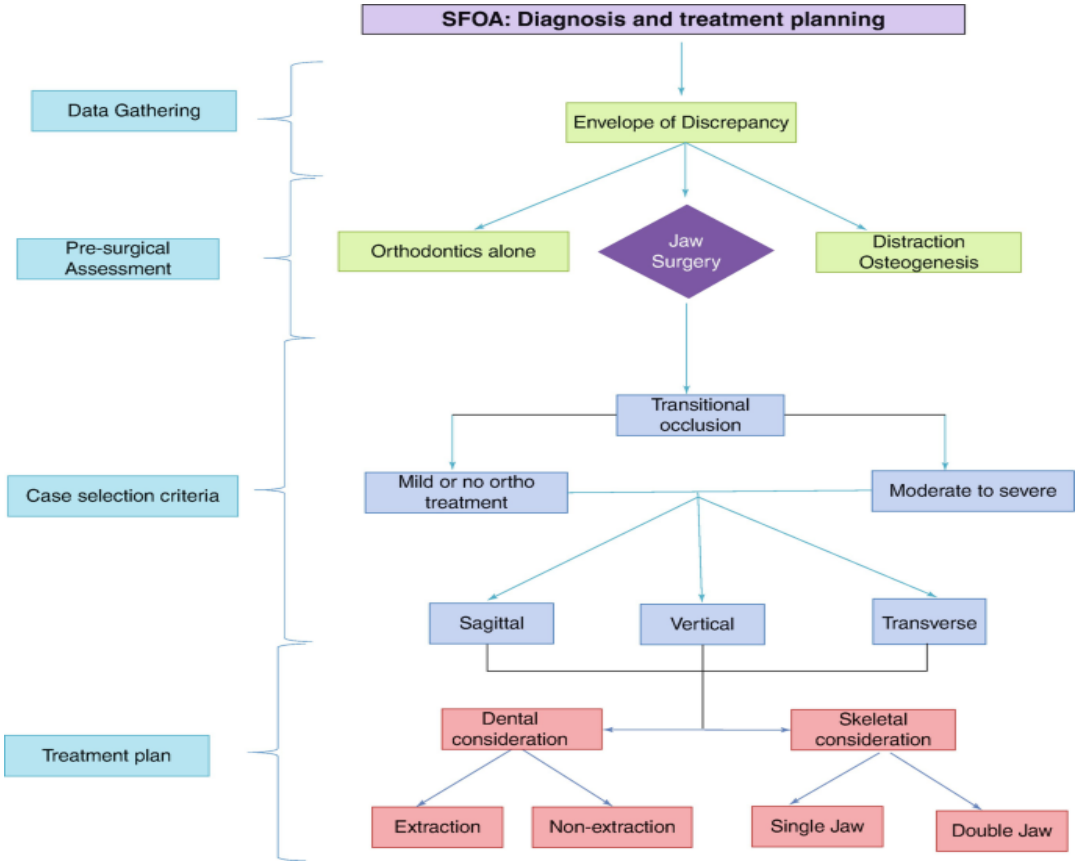

Fig.2: Structured flowchart for SFOA (Surgery-First Orthognathic Approach) diagnosis and treatment planning. This decision tree outlines the sequential evaluation from data gathering through case selection to orthodontic and surgical interventions. It helps clinicians determine the need for orthodontics, jaw surgery, or distraction osteogenesis based on occlusion and skeletal considerations. Adapted from Nik, Gholamrezaei, & Keshvad, 2019,

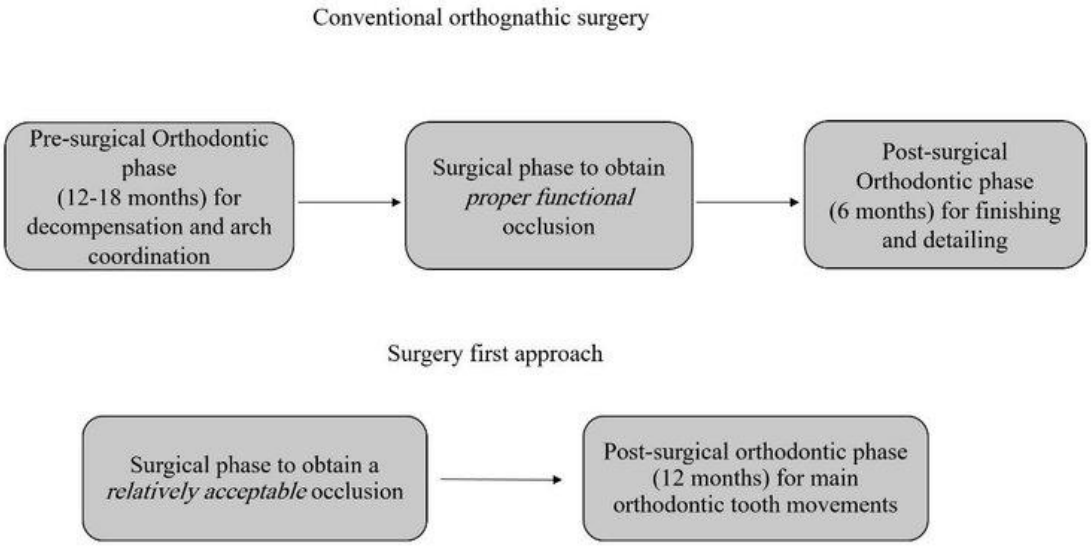

Fig.3: Comparison of conventional orthognathic surgery and the surgery-first approach for correcting skeletal asymmetries. The traditional sequence includes a prolonged pre-surgical orthodontic phase, while the surgery-first approach minimizes treatment time by advancing surgery upfront, followed by post-surgical orthodontics for final occlusal refinement and alignment. Adapted from Nik, Gholamrezaei, & Keshvad, 2019,

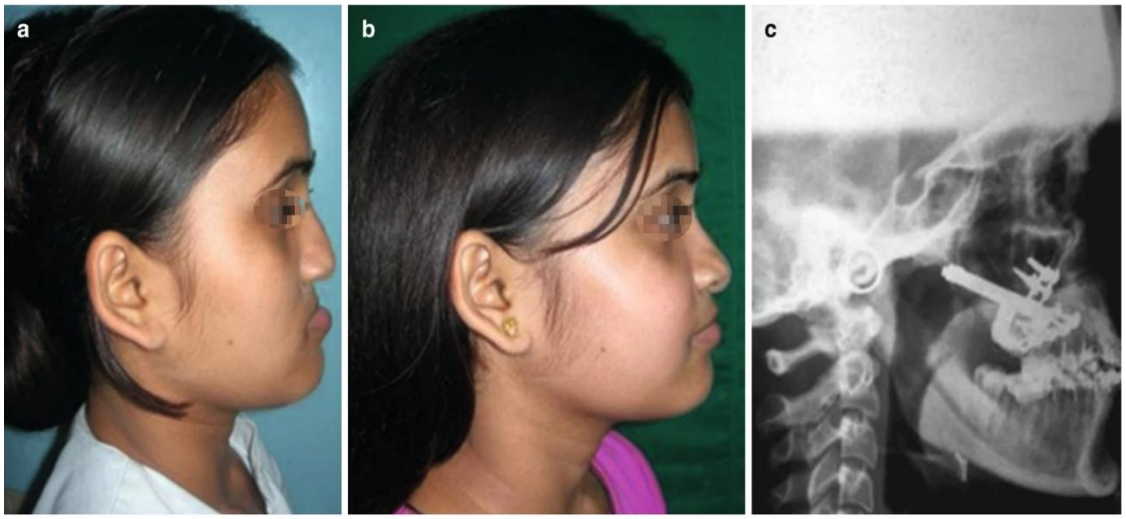

Fig. 4: Clinical and radiographic demonstration of orthognathic surgery for facial asymmetry correction. (a) Preoperative lateral profile showing mandibular deformity. (b) Postoperative profile showing improved skeletal harmony. (c) Postoperative lateral cephalogram confirming bony realignment and fixation. Such outcomes highlight the functional and aesthetic restoration achievable with tailored orthognathic surgery. Adapted from Andrade et al. (2021)

Fig.5: Preoperative and postoperative outcomes of a patient undergoing orthognathic surgery and orthodontic correction for facial asymmetry. (a–d) show front and side facial views before and after treatment. (e–g) depict dental occlusion pre-treatment, during orthodontic alignment, and post-treatment. Adapted from Andrade et al. (2021)

Emerging Technologies:

The treatment practice of post-traumatic facial asymmetry was a discipline with risks of errors and less than successful results, before the arrival of the new technologies. By using three-dimensional (3D) printing, patient-specific bone implants can be manufactured, and the results are apparent, as they are visible in both the fit and aesthetic outcomes of the bony reconstruction (Maroulakos et al., 2019). The complex defects are treated through these implants, which are either orbital or

zygomatic, and the surgery time is significantly reduced, resulting in better symmetry. These implants are usually manufactured using biocompatible materials such as titanium or PEEK. Digital preoperative planning has the potential to provide surgical simulation preoperatively and guidance during the actual operation, enabling surgeons to visualize the precise location and method for performing osteotomies or implant insertion (Valentini et al., 2005). These technologies offer greater accuracy, fewer complications, and improved functional restoration in maxillofacial surgery

Stem cell therapy and tissue engineering are promising regenerative methods for addressing soft tissue regeneration and bone regeneration. Mesenchymal stem cells can be utilized in tissue repair for defects caused by trauma, and the therapeutic properties of stem cell therapy remain under investigation in clinical research (Zuk, 2008). Tissue engineering involves the use of scaffolds, growth factors, and cells to recreate complex tissues, which may reduce dependence on grafts and related morbidity (Shanti et al., 2007). Although these approaches have the potential to yield long-term benefits, issues of inconsistency in performance and regulatory exigencies have been noted. Further studies are necessary to implement these technologies in clinical practice and achieve patient-centered care in facial asymmetry correction.

4. CLINICAL OUTCOMES

Post-traumatic facial asymmetry treatment depends on the objective results to determine the success or failure of surgical procedures, and symmetry evaluation is central. Three-dimensional computed tomography (CT), magnetic resonance imaging (MRI), and stereophotogrammetry provide accurate assessments of facial symmetry, enabling quantitative evaluation of surgical intervention outcomes (Al-Rudainy et al., 2018). Indices such as asymmetry indicators, volumetric examination, and cephalometric measurements make the inadmissibility of ideal proportions a measurable value, providing normal facsimiles of restorations. In particular, the 3D CT can be used to describe bony alignment, and stereophotogrammetry depicts the contours of soft tissue, which is vital in reaching conclusions regarding the aesthetic result (Kim et al., 2015). Such tools have transformed outcome assessment, as they produce reproducible, high-resolution data, which are limited by their cost and availability to a broader user base. Research has shown that symmetry restoration is highly associated with patient satisfaction, indicating that the accuracy of imaging is a significant component of preoperative planning and postoperative assessments (Pusic et al., 2013). Nevertheless, the disparity in how measurements are conducted in studies highlights the need for a standardized protocol to ensure the study's comparability and trustworthiness in a clinical setting.

Functional outcomes are also significant, covering the improvements on impairments of mastication, speech and eye functions caused by facial trauma. Effective interventions result in the resumption of masticatory efficiency, which can be assessed by measuring bite force or by patient feedback regarding their chewing capacity, especially following mandibular or maxillary reconstruction (Bohluli & Bagheri, 2012). Restoration of speech, evaluated through articulation clarity, plays a crucial role when the oral cavity has soft tissue or skeletal defects. One of the most essential measurements is ocular function, specifically the resolution of diplopia in orbital fractures, for which evidence shows a high degree of correction after the correct restoration of the orbital floor (Kholaki et al., 2019). Quality scales, such as the Glasgow Benefit Inventory (GBI) and Functional Aesthetic Facial Evaluation (FAFE), are well-established measures that offer a robust method for assessing functional and aesthetic changes, incorporating the patient's ideal view as an outcome measure (Robinson et al., 1996). These scales reveal that functional restoration not only improves the quality of life (QoL) but also prevents psychological distress caused by asymmetry. Nevertheless, the long-term functional outcomes are not accurately reported, and additional studies are required to determine the sustainability and patient-related usefulness of surgical operations.

The presence of complications can become a significant problem in the surgical treatment of facial asymmetry, affecting both short-term and long-term surgical outcomes. Hematoma, infection, and nerve injury are school-immediate complications, the rate of which differs depending on the technique, as well as the anatomical location. The examples are that the nerve injury is more common during osteotomies, especially mandibular ones, where up to 20 per cent of patients experience temporary numbness (Gassner, 2020). More likely to be seen with soft tissue surgery procedures, such as flap reconstruction, are hematomas, which can be avoided through close monitoring after the surgical operation to prevent tissue necrosis. The most serious long-term complications are the failure of the implants, malunion, and revision beyond the original surgery, still with a rate of up to 15% in the cases of complex reconstruction (Gornitsky et al., 2019). Alloplastic materials are of concern due to implant failure, which commonly occurs because of resorption or mechanical stress; malunion can also happen when fixation is weak following primary surgery. These complications are essential in terms of the surgical skill and planning that considers the patient. Compliance with reporting complication rates remains suboptimal, hindering the standardization and comparison of procedures. This is particularly important, as it is essential to have detailed and complete registries to report adverse events during maxillofacial surgery procedures.

Studies providing comparative analyses of bony and soft tissue treatments, early and delayed reconstruction, and the effects of patient factors can be seen as subtle in their determination of effectiveness. Procedures like osteotomies (bony reconstruction) do better in regaining skeletal structure and functional outcomes like occlusion, but they can entail a longer healing process and more risks of complications (Bohluli & Bagheri, 2012). Aesthetic correction can also be performed using soft tissue procedures, such as fat grafting and flap reconstruction; however, other issues, including resorption variability,

which may require additional procedures (Gornitsky et al., 2019), limit these procedures. Primary reconstruction, performed within a short time after an injury, decreases the risk of malunion and promotes better outcomes in acute conditions. On the contrary, reconstruction is applied to correct chronic deformities and can be more challenging than primary reconstruction due to the presence of scar tissue (Kholaki et al., 2019). The results primarily rely on the patient determinants, including age, the type of injury, and whether there are co-morbid conditions or not. Patients who sustain an injury at a younger age tend to have a more optimistic bone healing ability. In contrast, extreme injuries or the presences of underlying conditions such as diabetes elevate rates of complications (Lalloo et al., 2020). These data highlight the need for patient-specific management approaches and identify knowledge gaps in the available long-term outcomes data, particularly for pediatric and geriatric patients, which should be addressed to enhance clinical practice.

5. PATIENT SATISFACTION AND QUALITY OF LIFE

The quality of life (QoL) and patient satisfaction play a central role in assessing the effectiveness of surgical procedures to correct post-traumatic facial asymmetry, and validated assessment instruments represent the most reliable data. The FACE-Q, designed for use after facial aesthetic treatments, is a phenomenologically stable, validated, patient-reported outcome measure of aesthetic outcome and functional satisfaction (Pusic et al., 2013). PROMIS measures broader domains of QoL, including physical and psychological health, and improves the overall measurement of outcomes (Cella et al., 2010). The subjective experience of patients is also obtained using non-validated instruments, such as custom surveys and Visual Analogue Scales (VAS), especially in smaller studies. Although these tools are flexible, they lack standardization, which reduces the comparability of studies; hence, the importance of having proven and tested tools to guarantee consistency of results in clinical research.

Some of the most critical findings indicate a strong correlation between the concept of aesthetic improvement and patient satisfaction. As the physician restores the patient's facial symmetry, their perceived appearance shows a significant improvement (Bisson et al., 1997). The positive effect of functional restoration, such as the increase in mastication or the disappearance of diplopia, is also positively associated with QoL, as demonstrated by the rise in specific scales, including the FACE-Q and Glasgow Benefit Inventory (Robinson et al., 1996). Psychological sequels are significant, and facial asymmetry frequently gives rise to poor body image, diminished social performance and depressed self-worth. The effects are mitigated with surgical correction, as evidenced by increased social confidence following reconstruction (Gornitsky et al., 2019). Nevertheless, the results are patient-specific, depending on the patient's expectations and the degree of deformity before the operation, so a personalized intervention is necessary. The long-term psychological gain is less investigated, especially in children and the older-aged population, so this area of research needs to be explored to determine the long-lasting QoL enhancements.

Satisfaction greatly depends on influencing factors of postoperative complications and cultural variations. Satisfaction can be eroded by complications such as infection or the need for revision surgery, with up to 15 per cent of dissatisfaction rates associated with other events (Gornitsky et al., 2019). Such cultural and demographic determinants of satisfaction metrics include age and cultural and social beauty standards (Lalloo et al., 2020); younger patients tend to prioritize mainly aesthetic outcomes and disregard functional aspects. The literature has gaps in the relatively limited use of standardized patient-reported outcome measures (PROMs) in data synthesis, as well as a lack of long-term satisfaction data, especially after more than a year of follow-up. The lack of available evidence about these gaps highlights the need for future studies to utilise standardized PROMs, enabling clinical practices and improving patient-centered care in the management of facial asymmetry.

6. DISCUSSION

The literature reviews that have been carried out in this systematic review emphasize that surgical measures, including osteotomies, flap reconstruction, and fat grafting, are part of the solution to post-traumatic facial asymmetry since they come with potential aesthetic and functional advantages. Osteotomies are the best method for accurately restoring the position of the skeleton, especially in cases of malunions. During the placement of the osteotomy, potential nerve injury should be noted, and transient paresthesia is reported in up to 20% of cases in the mandible (Gassner, 2020). The other techniques include the use of flaps to create voluminous restorations, and fat grafting is effectively capable of providing contour. Nevertheless, they experience complications, such as an irregular pattern of resorption, so several treatments are required to achieve a satisfactory result (Gornitsky et al., 2019). An additional type of optional 3D image data is CT imaging and stereophotogrammetry, which provides a better answer since it produces an objective measurement of symmetry and shape. Aesthetic outcomes are strongly related to patient satisfaction, which can be measured through tools such as the FACE-Q (Pusic et al., 2013). However, the effectiveness of the technique is inconsistent, as approximately 15% of revision surgeries are accompanied by complications (Kholaki et al., 2019). The findings are also less generalizable due to the small and inadequate sample size used in the study, as well as the varying outcomes reported in the studies. Uniform protocols should be established to enable stronger comparisons and improve the quality of evidence.

The clinical implications incorporate considerations regarding the customization of technique choice based on the nature of

injuries, i.e., the location of the injury, its severity, and the specific patient-tailored objective, whether aesthetic or functional. The diverse effects of facial asymmetry not only demand the intervention of multidisciplinary, specialized teams that combine the efforts of maxillofacial surgeons, psychologists, and rehabilitative specialists but also require the group to coordinate the care provided to children with facial asymmetry (Bisson et al., 1997). Proper preoperative counselling is used to synchronize expectations, which improves satisfaction in the postoperative period. Some of the research gaps identified are a lack of randomized controlled trials (RCTs) that compare bony and soft tissue techniques and inadequate long-term follow-up of more than five years, especially in the case of a pediatric and geriatric population, in which the priorities of healing and aesthetics are different (Lalloo et al., 2020). The gaps compromise the reliability of evidence-based guidelines, and prospective studies with broader, more heterogeneous cohorts should be conducted to confirm best practices and enhance clinical decision-making.

In the future, directions will need to utilise novel technologies and methods to develop the field further. Machine learning and artificial intelligence may also improve surgical planning by predicting surgical outcomes and optimizing the design of implants, to increase the precision of complex reconstructions (Zuk, 2008). Standardized patient-reported outcomes, including the increased application of the FACE-Q, will enable reliability among studies in measuring satisfaction and quality of life, and the agreement will facilitate cross-study comparisons. Regenerative medicine, encompassing both stem cell-based therapies (stem cell therapy) and tissue engineering, promises a solution to decreasing complications such as graft resorption, as well as innovative flaps for bony and soft tissue reconstruction. These developments necessitate tough clinical trials that will lead to the determination of efficacy and safety. The mentioned research gaps and the incorporation of advanced technologies allow the field to shift towards personalization, efficacy, and patient-centered care, which inevitably will lead to better results for individuals with post-traumatic facial asymmetry.

7. CONCLUSION

Summary:

This systematic review demonstrates that surgical techniques for post-traumatic facial asymmetry, including osteotomies, flap reconstruction, and fat grafting, effectively restore symmetry and function. Outcomes vary by injury type and timing, with objective measures like 3D imaging showing improved symmetry and validated scales revealing high patient satisfaction linked to aesthetic gains. Functional improvements in mastication and ocular function further enhance quality of life. Complications, such as infection or the need for revision surgeries, highlight the importance of precise surgical planning to optimize outcomes. The review underscores the efficacy of tailored interventions but identifies gaps in long-term data and standardized outcome reporting for comprehensive evaluation.

Adopting patient-centered, evidence-based approaches is essential for optimizing outcomes in facial asymmetry management. Multidisciplinary collaboration, involving maxillofacial surgeons and psychologists, addresses both functional and psychological needs, improving overall well-being. Future research should focus on randomized controlled trials, long-term follow-up studies, and standardized patient-reported outcome measures to refine best practices. Emerging technologies, such as 3D printing and regenerative medicine, offer potential for greater precision and improved outcomes, ensuring comprehensive care for patients with post-traumatic facial asymmetry and advancing clinical practice in maxillofacial surgery.

Recommendations:

Clinical management of post-traumatic facial asymmetry should prioritize tailored surgical plans to optimize outcomes. Selecting techniques like osteotomies or fat grafting based on injury type, anatomical region, and patient goals enhances aesthetic and functional restoration. Enhanced preoperative counseling is critical to align patient expectations with realistic outcomes, improving satisfaction and reducing psychological distress. Multidisciplinary teams, including maxillofacial surgeons and psychologists, should collaborate to address both physical and emotional needs, ensuring comprehensive care.

Research recommendations focus on addressing gaps through longitudinal studies tracking outcomes beyond five years to assess durability of surgical interventions. Standardized outcome measures, such as FACE-Q and PROMIS, should be universally adopted to ensure consistent, comparable data across studies. Randomized controlled trials comparing techniques and studies targeting pediatric and geriatric populations are needed to refine evidence-based practices and advance patient-centered care in facial asymmetry management.

Call to Action:

The management of post-traumatic facial asymmetry demands urgent research to address gaps in long-term outcome data and standardized patient-reported measures. Researchers must prioritize randomized controlled trials and longitudinal studies, particularly for pediatric and geriatric populations, to refine evidence-based practices. Clinicians are urged to adopt advanced technologies like 3D printing and virtual surgical planning to enhance precision and outcomes. Integrating these innovations into clinical practice will advance patient-centered care, improving aesthetic, functional, and psychological outcomes in facial asymmetry correction.

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