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Major clinical and surgical approaches to treating orbitozygomatic and zygomatic maxillary complex fractures: a systematic review

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Abstract

Introduction: In the scenario of orbitozygomatic fractures, facial and head injuries account for half of deaths due to trauma, and thousands are left with long-term or permanent injuries. Fractures of the zygomatic-maxillary complex (ZMC) and zygomatic arch are common athletic injuries. Operative treatment is indicated in cases of significant displacement or functional disturbance. Technology such as virtual surgical planning, intraoperative navigation, and intraoperative imaging has the potential to improve the accuracy of treatment of challenging fractures. **Objective:** It was to develop a systematic review of the main clinical and surgical approaches to the treatment of orbitozygomatic and zygomatic maxillary complex fractures. **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from October 2023 to January 2024 in the Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 102 articles were found, 26 articles were evaluated in full and 25 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 14 studies with a high risk of bias and 12 studies that did not meet GRADE and AMSTAR-2. Most studies did not show homogeneity in their results, with X^2=57.9%>50%. A single-piece fracture of the fronto-orbito-zygomatic-maxillary bone connected to a temporoparietal bone may require additional osteotomy to achieve successful results in an acute setting. Orbital volume analysis offers a valid modality for objectively evaluating the efficiency of the management of orbitozygomatic complex fractures. The success rate of the fixation procedure at 1 point of the zygomaticomaxillary complex is high, with minimal complications. Intraoperative CT/three-dimensional imaging should be used in the treatment of ZMC fractures requiring orbital floor reconstruction, where adjacent fractures require fixation and/or when ≥ 2 axes are displaced ≥ 5 mm.

Keywords: Orbitozygomatic fractures. Zygomatic maxillary complex. Surgeries. Treatments. Clinical Studies. Meta-analysis.

Introduction

In the scenario of orbitozygomatic fractures, facial and head injuries account for half of deaths due to trauma, and thousands are left with sequelae for long periods or permanently [1-5]. Facial fractures are considered a public health problem in several countries such as the United States of America, Europe, and Asia and studies carried out in Brazil report various types of trauma and facial fractures [6-11] and their etiology and diverse mechanisms such as aggression or accidents that can affect people of any age group or social level [12-14].

In this context, fractures of the zygomatic-maxillary complex (ZMC) and zygomatic arch are common athletic injuries. Displacement of the fracture can lead to retrusion and widening of the midface, causing noticeable deformity. Associated signs and symptoms include hypoesthesia of the infraorbital nerve distribution, trismus, and subjective malocclusion. Operative treatment is indicated in cases of significant displacement or functional disturbance. Technology, such as virtual surgical planning, intraoperative

navigation, and intraoperative imaging, has the potential to improve the accuracy of treatment of challenging fractures [15].

Furthermore, the management of orbitozygomatic fractures depends on a complete preoperative physical examination, with attention to ophthalmological evaluation. Coronal and axial computed tomography (CT) is essential to identify the extent of the fracture and orbital involvement. Adequate exposure and mobilization of the fractured segments are essential for the success of anatomical reduction. Failure to perform effective fixation can lead to subsequent complications, such as enophthalmos and diplopia [1,16].

In this sense, orbital blow-out fractures are those that exclusively affect the floor and/or the medial wall of the orbit. The diagnosis of these fractures is based on physical examination and imaging tests [17,18]. On physical examination, signs and symptoms, such as periorbital ecchymosis, limitation of eye movements, diplopia, and enophthalmos, may be present. Computed tomography is the most efficient exam for diagnosing these fractures. Treatment must be carried out by reconstructing the fractured orbital walls with autogenous, homogeneous, heterogeneous biomaterials or alloplastic materials. Thus, titanium meshes proved to be efficient, presenting good results about the ability to reconstruct the orbital floor and support the contents of the eyeball [18].

The most commonly accepted theories to explain the etiology of these fractures are the theory of hydraulic pressure within the orbit and direct impact. Orbital trauma is frequently observed in facial trauma and can cause a wide range of functional problems such as enophthalmos and diplopia, as well as aesthetic deformities [19].

The diagnosis of orbital fractures is made by combining clinical and imaging findings. The signs and symptoms most frequently associated with these fractures are periorbital and/or subconjunctival ecchymosis, enophthalmos, orbital pain, infraorbital nerve paresthesia, and diplopia. Conventional radiographic images have little sensitivity and specificity in diagnosing these fractures. Computed tomography scans play a fundamental role in diagnosing and evaluating the extent of these fractures. The need for surgical treatment of these fractures is quite controversial. Some orbital blow-out fractures have no sequelae if not treated surgically, while others can result in aesthetically unacceptable enophthalmos and/or disabling diplopia. The main issue, therefore, is the identification of those patients who require surgical intervention, the timing of surgery, and the surgical technique involved [19].

Therefore, the present study developed a systematic review of the main clinical and surgical approaches to treating orbitozygomatic and zygomatic maxillary complex fractures.

Methods

Study Design

The present study followed the international systematic review model, following the rules of PRISMA (preferred reporting items for systematic reviews and meta-analysis). Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed on: 08/14/2023. The methodological quality standards of AMSTAR-2 (Assessing the methodological quality of systematic reviews) were also followed. Available at: https://amstar.ca/. Accessed on: 08/14/2023.

Data Sources and Research Strategy

The literary search process was carried out from October 2023 to January 2024 and was developed based on Scopus, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various eras to the present. The descriptors (MeSH Terms) were used: *"Orbitozygomatic fractures. Zygomatic maxillary complex. Surgeries. Treatments. Clinical Studies. Meta-analysis"*, and using the Boolean "and" between the MeSH terms and "or" between historical discoveries.

Study Quality and Risk of Bias

Quality was classified as high, moderate, low, or very low in terms of risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analyses of randomized clinical trials, followed by randomized clinical trials. The low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using the Cohen test (d).

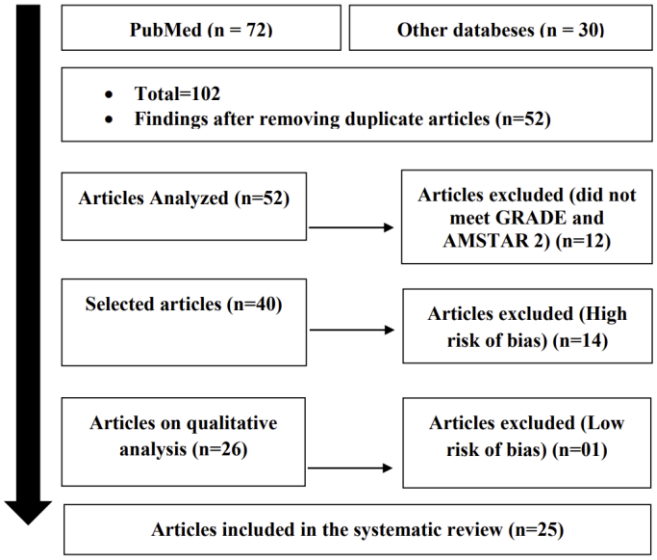
Results and Discussion

Summary of Findings

A total of 102 articles were found that were subjected to eligibility analysis, with 25 final studies being selected to compose the results of this systematic review. The studies listed were of medium to high quality (Figure 1), considering the level of scientific evidence of studies such as meta-analysis, consensus, randomized clinical, prospective, and observational. The biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies showed homogeneity in their results, with

X^2=57.9%>50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 14 studies with a high risk of bias and 12 studies that did not meet GRADE and AMSTAR-2.

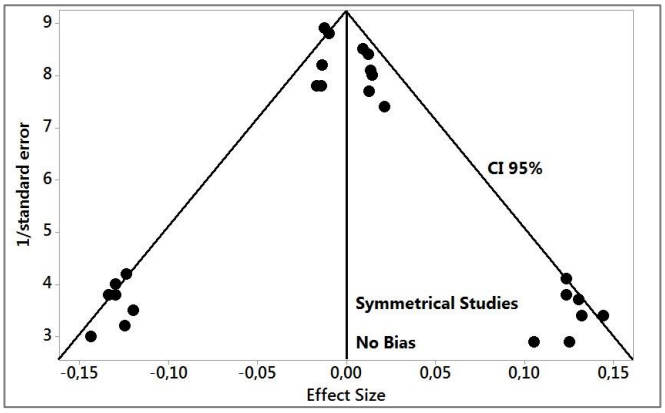
Figure 1. Article selection and exclusion process.



Source: Own authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using the Cohen Test (d). Precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). This graph had a symmetrical behavior, not suggesting a significant risk of bias, both between studies with a small sample size (lower precision) that are shown at the bottom of the graph and in studies with a large sample size that are presented at the top.

Figure 2. The symmetric funnel plot suggests no risk of bias among the small sample size studies that are shown at the bottom of the graph. High confidence and high recommendation studies are shown above the graph (n=25 studies).



Source: Own authorship.

Major Clinical Outcomes

After literary analysis, orbitozygomatic fractures are one of the most frequent maxillofacial injuries. A retrospective study investigated the management and complications of orbitozygomatic fractures. A total of 160 patients with orbitozygomatic fractures were treated with three complications. A total of 85 (53.1%) cases were treated surgically and 155 (97.5%) cases had follow-up up to 6 weeks postoperatively. Twenty-six surgical cases (16.3%) were treated via elevation without fixation. Another 26 surgical cases (16.3%) were treated with one point of fixation, 19 cases (11.9%) with two points of fixation, 12 cases (7.5%) with three points of fixation, and 2 cases (1.3%) were treated with four fixation points. The three complications (1.9%) returned for surgical correction without major consequences; two were due to inadequate cosmesis and one was due to exposure of the fixation plate. No early postoperative infections were observed [20].

In this sense, the frontoorbitozygomaticomaxillary fracture (quadruped fracture) is a type of facial fracture involving several bones in the midface region. This includes the frontal bone (forehead), the orbitozygomatic complex (which includes the zygomatic bone or cheekbone and the orbital bones around the eye), and the maxillary bone (upper jaw). These complex midface fractures associated with temporoparietal bone fractures can occur in clinical practice. A clinical case study evaluated a 44-year-old male patient with a significant frontoorbitozygomaxillary fracture associated with a temporoparietal bone fracture combined with an epidural hematoma on the superior surface of the unilateral frontoparietotemporal convexity. Surgical treatment was performed 3 weeks after the traumatic event. Despite craniotomy of the parietal bone fragment, reduction was not possible. The facial bone reduction was finally achieved after an additional single osteotomy in unilateral zygomaticomaxillary support. Follow-up CT scan performed immediately and 3 weeks after surgery showed successful realignment of the craniofacial bone fracture [21].

Furthermore, a retrospective observational study analyzed orbital volume as an objective assessment modality to assess the accuracy of unilateral fixation of orbitozygomatic complex fractures, comparing postoperative values with the contralateral normal side and pre-treated values. A retrospective radiographic chart review was performed to investigate the primary outcome of objectively quantifying the accuracy of orbitozygomatic complex fracture reduction using orbital volume analysis. A total of 17 records met the inclusion

criteria. Although a statistically significant difference was found between the preoperative orbital volume values of the affected side and the normal unaffected side, a statistically insignificant difference was found between the postoperative values and the control side. An average fall percentage of 6.1% was reported in postoperative records when compared to preoperative records, with a statistically significant difference [22].

After adequate reduction of the zygomatic-maxillary complex (ZMC), it is important to maintain stability and rigid fixation to avoid functional impairment and aesthetic sequelae. A meta-analysis study carried out by authors Neto, Zotarelli-Filho, and Ribeiro da Silva (2023) analyzed the success rates of ZMC fracture stability, the incidence of complications, and aesthetic satisfaction after 1-point fixation. The results of these studies generally showed that the use of 1-point fixation with open reduction presented good results in the short, medium, and long term, showing fracture stability. Complication rates were low and patient satisfaction with aesthetics was considerable [23].

Added to this, the anatomical alteration caused by the zygomatic fracture requires intervention to establish facial symmetry. One study evaluated the effectiveness of 2-point fixation in zygomaticomaxillary complex (ZMC) fractures. A total of 20 patients with established ZMC fractures were operated with a two-point fixation method and followed up for up to 3 months. 2-point fixation revealed satisfactory functional and aesthetic results, offering an efficient result compared to other modalities of management of ZMC [24].

A retrospective study characterized the use of the intraoperative CT scanner for ZMC fracture surgery and analyzed the impact of the intraoperative CT scanner on fracture treatment. We sought to propose an algorithm to guide the appropriate use of intraoperative three-dimensional images in ZMC fracture surgery. A total of 71 patients were identified with intraoperative facial CT and surgery for ZMC fractures during the study period. There was a CT-directed revision rate of 23.9% (17/71). There was a significantly increased likelihood of CT-directed revision for fractures with adjacent fractures requiring fixation and those with ≥ 2 axes displaced ≥ 5 mm [25].

The treatment of blow-out orbital fractures and the ideal time to repair these fractures have been controversial in the literature. The advent of computed tomography has made it possible to easily define the extent of the trauma and the fracture pattern, helping to clarify the need for early treatment. Many patients require surgery, and early repair (up to two weeks) of these fractures is recommended by several surgeons. However, others believe that some patients' signs/symptoms improve spontaneously and prefer to wait for 4-6 months before undergoing surgery [17,18].

In this scenario, surgery is recommended for selected patients, including those with extensive fractures of one or more walls of the orbital cavity, involving more than half of its length, particularly when associated with fracture of the medial wall, evidence of orbital tissue entrapment, enophthalmos of more than 2 mm in the first two weeks after trauma, diplopia and limitation of motility. Patients with minimal or rapidly improving diplopia, good ocular motility, minimal enophthalmos, and a small blow-out fracture, without obvious entrapment of orbital tissues, do not require surgery [18].

In this sense, the convenience, stability, lack of morbidity at the donor site, and reduced anesthetic and operating time have convinced many surgeons to use alloplastic materials for the reconstruction of blow-out fractures, including titanium mesh. Among the reasons for the preference using titanium meshes are: thin materials, easy to contour, easily stabilized, maintain their shape, and have the ability to compensate for volume when properly contoured, without the potential for reabsorption [18,19].

Added to this, a study aimed to implement orbital volume as an objective assessment modality to evaluate the accuracy of unilateral fixation of orbitozygomatic complex fracture, comparing postoperative values with the contralateral normal side and pre-treated values. Therefore, a retrospective radiographic chart review was performed to investigate the primary outcome of objective quantification of the accuracy of orbitozygomatic complex fracture reduction using orbital volume analysis. The comparison of postoperative orbital volume values with preoperative and contralateral normal values was defined as a secondary outcome of the study, together with the percentage of changes in orbital volume of patients treated with unilateral Orbitozygomatic complex fracture. Data reliability was determined by the interclass correlation coefficient and statistical significance was established at the 5% level. Seventeen records met the inclusion criteria. Although a statistically significant difference was found between preoperative orbital volume values on the affected side and the normal unaffected side, a statistically insignificant difference was found between postoperative values and the control side. An average drop percentage of 6.1%. was reported in postoperative records when compared to preoperative records, with a statistically significant difference. The study reported high inter-observer and intra-observer reliability. Orbital volume analysis offers a valid modality for objective assessment of the efficiency of management of orbitozygomatic complex fractures [22].

Conclusion

It was concluded that a single-piece fracture of the frontoorbito-zygomaticmaxillary bone connected to a temporoparietal bone may require additional osteotomy to achieve successful results in an acute setting. Orbital volume analysis offers a valid modality for objectively evaluating the efficiency of the management of orbitozygomatic complex fractures. The success rate of the fixation procedure at 1 point of the zygomaticomaxillary complex is high, with minimal complications. Intraoperative CT/three-dimensional imaging should be used in the treatment of ZMC fractures requiring orbital floor reconstruction, where adjacent fractures require fixation and/or when ≥ 2 axes are displaced ≥ 5 mm.

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Ethical Approval

Not applicable.

Informed consent

Not applicable.

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Data sharing statement

No additional data are available.

Conflict of interest

The authors declare no conflict of interest.

Similarity check

It was applied by Ithenticate[@].

Peer Review Process

It was performed.

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