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Orbital floor fracture (blow out) and its repercussions on eye movement: a systematic review

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Abstract
The aim of this systematic review was to investigate the relationship between fractures of the floor of the orbit (blow outs) and their repercussions on eye movement, based on the available scientific literature. In order to obtain more reliable results, we opted for a methodology that could answer the guiding question of this research. To this end, a systematic review of the literature was carried out, using a rigorous methodological approach. The risk of bias was assessed using version 2 of the Cochrane tool for the risk of bias in randomized trials (RoB 2). This systematic review was carried out according to a systematic review protocol previously registered on the PROSPERO platform. The searches were carried out in the PubMed (National Library of Medicine), Scopus, ScienceDirect, SciELO, Web of Science, Cochrane Library and Embase databases, initially resulting in 553 studies. After removing duplicates, 515 articles remained, 7 were considered eligible, of which 3 were selected for detailed analysis. However, the results of the included studies did not provide conclusive evidence of a direct relationship between orbital floor fractures and eye movement.

Keywords Orbital fractures, Oculomotor nerve trauma, Orbit and ocular motility disorders

Introduction
The anatomy of the orbit is a complex and vital structure, made up of seven distinct bones that define its boundaries [1]. Within this pyramid-shaped bone cavity, a variety of essential elements are present, including the eyeball, fat, extraocular muscles, nerves, blood vessels, lacrimal sac and lacrimal gland [2]. Its lateral and medial walls are outlined by a combination of bones, most notably the greater wing of the sphenoid bone and the zygomatic bone in the lateral wall, and the lacrimal bone, ethmoid bone, maxilla and lesser wing of the sphenoid in the medial wall [3, 4]. The orbital floor, formed mainly by the maxilla and the zygomatic bone, plays a fundamental role in maintaining the normal structure and function of the orbit. Its delicate curvature, which extends smoothly from the inferior orbital rim to the superior orbital

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fissure, is important in preventing complications such as enophthalmos in cases of orbital fractures [5, 6].

Orbital fractures are injuries to the bones surrounding the orbit and represent the third most common type of facial fracture in adults and children [7, 8]. They are generally classified based on their anatomical location, including fractures of the orbital floor, orbital roof, lateral wall and medial wall [9, 10]. Blunt trauma to the ocular region is the main mechanism of injury, often resulting in fracture of the thin bones of the orbit, especially the floor and medial wall [11, 12]. These injuries occur due to the transmission of kinetic energy from the bones around the eye or due to increased pressure when the eyeball presses on the orbit. They are also known as blow-out fractures, as they tend to move away from the orbit [6, 13].

Thus, the etiology of orbital floor fractures, as well as other types of maxillofacial trauma, includes traffic accidents, assaults, falls, sports injuries, firearm injuries and other incidents [14]. In addition, industrial accidents have also been identified as a source of trauma [15]. In developing countries, such as India, traffic accidents are one of the main causes of trauma, while in studies carried out elsewhere, assaults are often cited as the main cause. Worldwide, men are significantly more affected by maxillofacial trauma than women, accounting for approximately 85% of cases [16, 17].

In addition, the diagnosis of these fractures is based on physical examination and imaging tests. On physical examination, signs and symptoms such as periorbital ecchymosis, limited eye movement, diplopia and enophthalmos may be present [18]. Computed tomography is the most efficient test for diagnosing these fractures. Treatment should be carried out by reconstructing the fractured orbital walls with autogenous, homogenous, heterogenous or alloplastic biomaterials [18–20].

Therefore, the aim of this systematic review was to determine, based on the available scientific literature, the relationship between the fracture of the floor of the orbit (known as blow out) and its consequences for eye movement.

Materials and methods

In order to obtain more reliable results, we opted for a methodology that could answer the guiding question of this research. To this end, a systematic review of the literature], to assess the relationship between orbital floor fracture (blow out) and the repercussions on the ocular. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was used to write the study [21]. The process followed criteria predefined by a Systematic Review Protocol registered with PROSPERO [22], guiding the selection and analysis of articles to provide a comprehensive overview of current knowledge on the subject. The methodological analysis included a clear protocol for selecting studies, extracting data and assessing methodological quality, maintaining transparency and rigor to guarantee the validity of the results. Strategies were adopted to evaluate and mitigate errors, including standardized training, initial testing, consensus meetings between evaluators and continuous monitoring. A double-blind review was carried out at all stages. When there was a small conflict regarding the exclusion of an article, a third independent reviewer was asked to resolve the disagreement, ensuring clear and consistent criteria. Once this conflict was resolved, the third reviewer excluded the paper, as did the first, as the study did not answer the research question.

Development and registration of the systematic review protocol

A meticulous protocol, covering all the essential elements of the methodology of a systematic review, was drawn up and submitted for approval on the PROSPERO (Prospective Register of Systematic Reviews) [22] platform prior to the start of this study. This protocol covered several aspects in detail, including defining the start and end date of the study, formulating the research question, the databases searched, structuring the acronym PICO (patient, intervention, comparison, outcome), designing a precise search strategy, stipulating inclusion and exclusion criteria for the study, determining outcome measures, screening methods, data extraction and analysis, as well as the approach to data synthesis. The prior registration of this protocol in the International Prospective Register of Systematic Reviews (PROSPERO) [22] was carried out in order to guarantee the transparency, integrity and methodological quality of this systematic review.

This systematic review was conducted in accordance with a systematic review protocol previously registered on the PROSPERO platform, identified by the number CRD42024497638.

PICO question

The use of the PICO components (Patient, Intervention, Comparison and Outcome) played a crucial role in defining the search strategy for evidence and the subsequent analysis of this systematic review. This specific approach was key to locating relevant studies and played a vital role in ensuring objectivity during the assessment of this work. Patient (P): Individuals diagnosed with an orbital floor fracture; Intervention (I): Exposure to orbital floor fracture; Comparison (C): Individuals without an orbital floor fracture; Outcome (O): The repercussions on eye movement, including changes in motility, diplopia and other related changes.

Guiding research question

The research question was formulated as follows: What is the relationship between orbital floor fracture (blow out) and repercussions on eye movement?

Search strategy and selection of articles

The electronic bibliographic searches were carried out through systematic searches in the PubMed (National Library of Medicine), Scopus, ScienceDirect, SciELO, Web of Science, Cochrane Library and Embase databases. Search terms and Boolean operators (AND and OR) were combined to better perform the searches in the databases, and the following search strategy was formulated:: Fractures AND Ocular Motility Disorders) OR (Oculomotor Nerve Injuries AND Ocular Motility AND Orbital Fractures AND Facial Trauma) OR (Ocular Trauma OR Orbital Fractures AND Ocular Motility AND Muscle Damage) Portuguese strategy: (Relation AND Orbital Fractures AND Ocular Motility Disorders) OR (Oculomotor Nerve Injuries AND Ocular Motility AND Orbital Fractures AND facial trauma) OR (Ocular trauma AND Orbital Fractures AND Ocular Motility AND muscle damage).

The methodological quality of the articles chosen was assessed by two independent researchers, considering both the title and the abstract (when available). The aim was to check whether these articles met the inclusion criteria; when the information in the abstract was insufficient to determine the inclusion of the study, the full text was read. After individual assessments, the researchers reached a consensus on the inclusion of studies for full text analysis.

Criteria for selection, inclusion and exclusion of studies

We included studies in English, Spanish, Japanese, Chinese, German and Portuguese which were randomized clinical trials, systematic reviews, cohort studies, case–control studies, cross-sectional studies, detailed case reports, with a sample made up of patients of all ages and both sexes who had suffered a fracture of the floor of the orbit. All studies that did not meet the inclusion criteria for this study, such as patients with medical conditions that could significantly interfere with the association between orbital floor fracture and eye movement, were excluded.

Results

Selection of studies

The database search resulted in the initial identification of 553 studies. After removing duplicates using Rayyan© software [23], 515 articles remained, as shown in Fig. 1. Of these, 7 were considered eligible according to the inclusion criteria and were selected for a more detailed analysis. After a thorough evaluation, taking into account the inclusion and exclusion criteria, 3 studies were identified as particularly relevant and included in this systematic review.

Risk of bias

In this study, the risk of bias assessment was carried out using version 2 of the Cochrane tool for risk of bias in randomized trials (RoB 2). When examining each included study individually, it was observed that all three included studies raised concerns regarding the risk of bias, as illustrated in Fig. 2:

Given the nature of the intervention in the treatment of orbital floor fractures (blow out), improving the risk of bias is impossible. Orbital floor fractures have complex implications for eye movement, and the variability in surgical techniques, surgeon experience and individual patient characteristics contributes to the possibility of bias in the results of these studies. Therefore, it will not be possible to establish a totally reliable conclusion from this systematic review. The presence of bias can distort the findings and compromise the validity of the conclusions drawn from this analysis. This highlights the importance of adequately addressing and mitigating bias in future studies to ensure an accurate and reliable understanding of the topic in question.

Discussion

This study critically analyzed the existing literature on the relationship between orbital floor fractures and their consequences for eye movement. The results obtained from the included studies did not provide conclusive evidence establishing a direct relationship between orbital floor fractures and eye movement. Although in the current literature some studies have suggested a possible association, the lack of consensus and the heterogeneity of the results highlight the need for further research to clarify this complex relationship. This review highlights the importance of multidisciplinary approaches and high-quality studies for a more comprehensive understanding of the repercussions of orbital floor fractures on ocular function.

Some studies suggest that blow-out fractures are associated with limited ocular motility and can therefore result in ocular pathologies [24]. When a fracture occurs in the floor of the orbit, possibly longitudinal rupture of the rectus muscle, vertical diplopia, muscle contusion, scarring within and around the orbital fibrous sheath network, nerve contusion and incarceration within fractures and fibrosis or incarceration involving the muscular fascial network can be common repercussions of trauma [25]. These complications not only affect visual function,

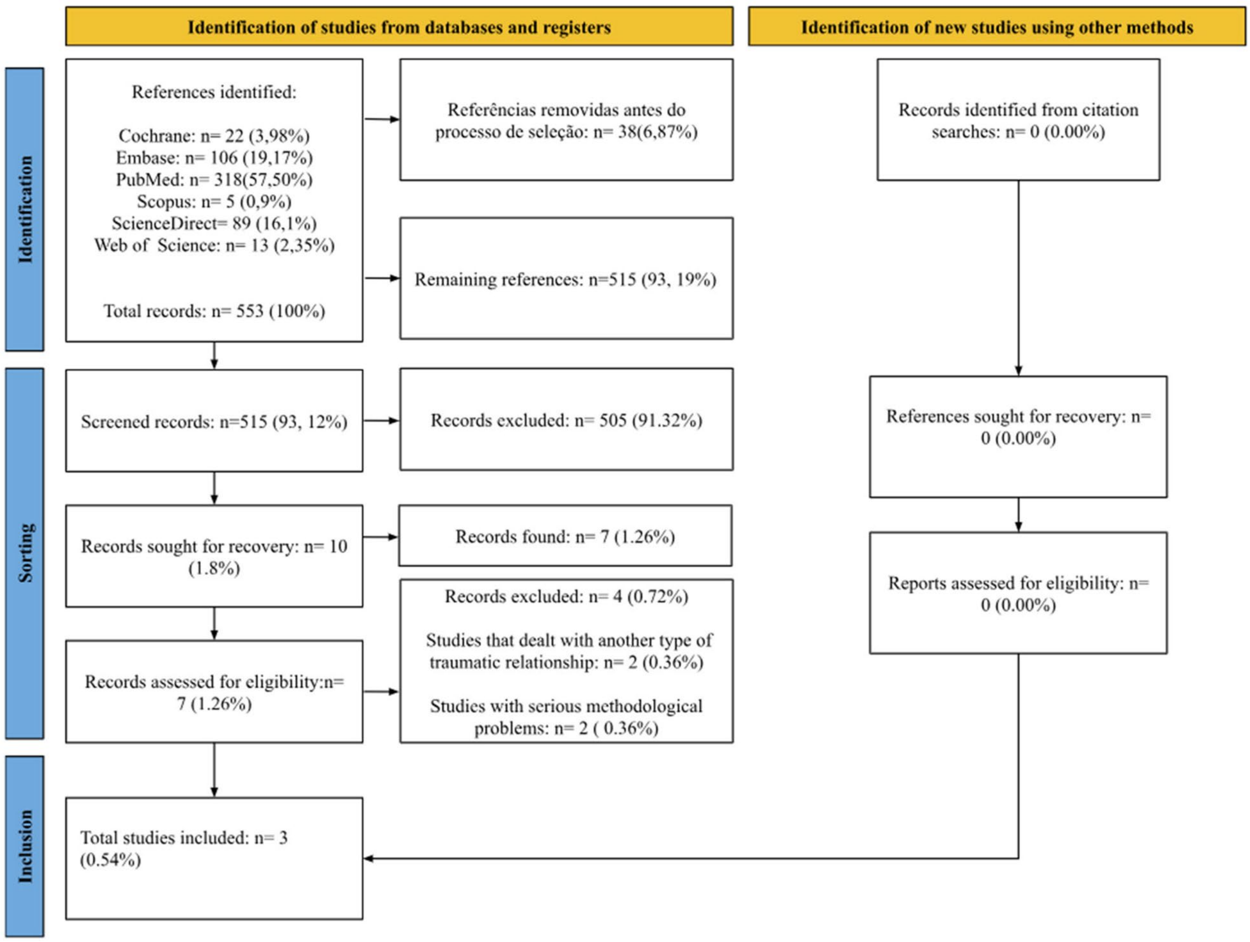

Fig. 1 Bibliographic search flowchart, adapted from PRISMA 2020. Source: authors (2024), adapted from PRISMA [22]

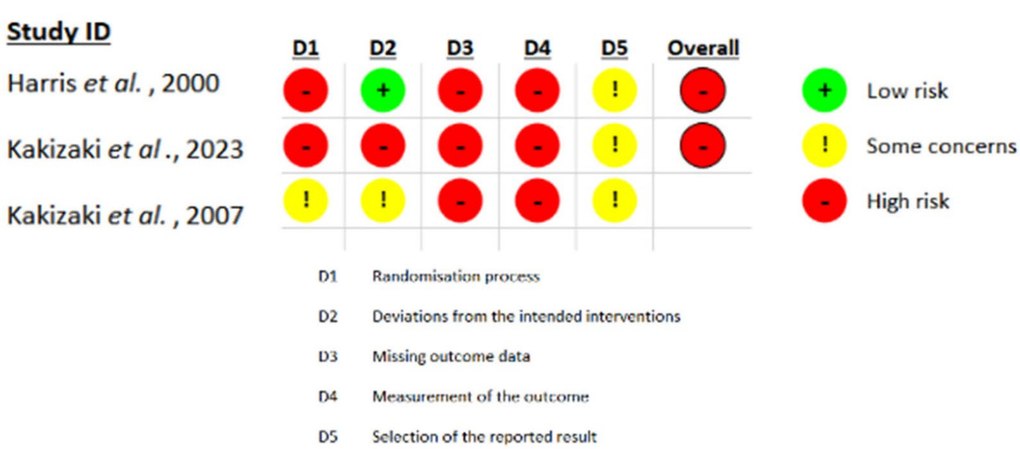

Fig. 2 Individual analysis of bias for each included study. Source: Authors (2024), adapted from the ROB-2 Tool

but can also have a significant impact on the patient's quality of life. However, it is necessary to check the methodologies used in such research extensively, so that there are no inconsistencies in the results presented [26–29].

In the context of trapdoor fractures of the orbital floor, those that do not involve muscle incarceration generally have a more favorable prognosis in terms of eye movements. However, when muscle incarceration occurs in trapdoor fractures, paralysis of the inferior oblique muscle can contribute to disturbances in ocular motility, in addition to the disturbances caused by connective tissue septa [30]. Most experts believe that the restriction of motility after blow-out fractures is caused by soft tissue edema and hemorrhage, or by damage to the muscles that control eye movements, such as the inferior rectus, inferior oblique and medial rectus, or even a combination of both, due to the bony fixation of the muscles and fascia [31]. However, the results of this review revealed a lack of robust evidence to support this claim. The limited methodology of the included studies raises concerns about the reliability of the results. Thus, late motility problems after orbital fractures with or without repair remain poorly understood and challenging to treat, as they resemble other eye movement restrictions, regardless of the underlying cause [32–35].

Imaging tests such as Computed Tomography (CT) can be used to analyze the relationship between fractures and ocular motility before surgery in cases of blow-out orbital fractures. Although the use of CT is a relevant way of assessing this type of trauma, there is a bias in its ability to predict the recovery of post-operative motility. Thus, the interactions between bone fragments and soft tissues may not be fully represented by CT images, which can lead to inaccurate inferences about the results of post-surgical ocular motility. Furthermore, the classification of injuries as burst fractures based on CT can be subjective and may not fully reflect the extent of tissue damage or the severity of subsequent fibrosis. Therefore, the relationship between the degree of soft tissue incarceration or displacement and motility outcomes may be more complex than this approach suggests [36–39].

In short, there is no concrete evidence that blow out fractures alone can affect the motor function of the ocular nerve, since other factors such as trauma and the surgical intervention itself can also result in neurogenic diplopia. In addition, syndromes can also have an influence on this process. As a result, diplopia can be significantly affected by a number of factors [40–43].

Conclusion

After a systematic analysis of the literature and with the results found to compose this systematic review, it is limited to establish a direct relationship between the fracture of the floor of the orbit and repercussions on eye movement.

Author contributions

Conception and planning of the study: Elio Hitoshi Shinohara; Data collection and analysis: Ilan Santana, Mayara Viana, Julliana Pallhano-Dias; Interpretation of results: All the authors contributed to the interpretation of the results obtained from the data analysis, collaborating in the discussion of the findings and the drawing up of well-founded conclusions. Writing the manuscript: Ilan Hudson Gomes de Santana was responsible for the initial writing of the manuscript, while all the co-authors contributed to the writing of the materials and methods, results, discussion and conclusions, ensuring the clarity and cohesion of the text. Critical revision of the content: All the authors carried out critical revisions of the content of the manuscript, incorporating feedback and suggestions from the co-authors and making the necessary adjustments to improve the quality and accuracy of the text. Approval of the final version: All the authors contributed to the review and approval of the final version of the manuscript submitted for publication, ensuring its compliance with the ethical and scientific standards required by the journal.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

As this is a systematic review, it was not necessary to obtain approval from the research ethics committee to carry out this study.

Competing interests

The authors declare no competing interests.

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