American Journal of Emergency Medicine 35 (2017) 112–116

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Original Contribution

Orbital blowout fractures: a novel CT measurement that can predict the likelihood of surgical management☆,☆☆,★

Tamer N. Mansour, MD[a,*], Megan Rudolph, MS IV[b], Derek Brown, MS[c], Natalie Mansour, MD[d], M. Reza Taheri, MD, PhD[e]

[a] Department of Ophthalmology, Division of Oculoplastic and Reconstructive Surgery, The George Washington University, Washington, DC
[b] George Washington University School of Medicine, Washington, DC
[c] The George Washington University, Washington, DC
[d] The Cleveland Clinic, Cleveland, OH
[e] Department of Radiology, Division of Neuroradiology, Program Director, The George Washington University, Washington, DC

ARTICLE INFO

Article history:
Received 7 September 2016
Received in revised form 10 October 2016
Accepted 11 October 2016

ABSTRACT

Objective: The purpose of this study is to identify an accurate and reliable computed tomographic (CT) measurement that can identify those patients presenting to the emergency department (ED) with orbital floor fracture (BOF) who require surgical repair to prevent ensuing visually debilitating diplopia and/or enophthalmos.
Methods: In this retrospective institutional review board–approved study, we reviewed 99 patients older than 18 years with orbital fractures treated in a level I trauma center from 2011 through 2015. Thirty-three patients met the inclusion criteria of having an isolated BOFs with or without a minimally displaced medial wall fracture. The maxillofacial CT of these patients, which included axial, coronal, and sagittal reconstruction of the face in both soft tissue and bone algorithm, were independently reviewed by a neuroradiologist and an oculoplastic surgeon. Each reviewer analyzed the images to answer the following 3 questions: (1) extent of the fracture fragment; greater than or less than 50%? (2) involvement of the inframedial strut (IMS)? and (3) cranial-caudal discrepancy of the orbits. This novel measurement was defined as the difference between the cranial-caudal dimension (CCD), measured just posterior to the globe, of the fractured orbit minus the CCD of the normal side. Electronic medical record was reviewed to determine the course of recovery, ophthalmologist assessment of the globe, motility, diplopia, and the need for operative repair. Statistical analysis was performed to determine the accuracy of the measured CT parameters for the prediction of those who would ultimately require surgical repair.
Results: Of the 33 patients included in the study, 8 patients required surgical correction of their BOFs. Others were managed conservatively. The accuracy of BOF > 50% for predicting those requiring surgical repair was 48%. The accuracy of IMS involvement was 74%. Using a threshold CCD value of 0.8 cm, the accuracy of CCD was 94%. Cranial-caudal discrepancy had a sensitivity of 100% and specificity of 92%. κ Agreement between the 2 readers evaluating the CT images was 0.93.
Conclusion: Initial maxillofacial CT studies obtained in the ED for those with BOF is used to predict which patients may need urgent surgical repair. In this report, we introduce a new CT measurement, called CCD. Cranial-caudal discrepancy greater than 0.8 cm is predictive of the development of diplopia and/or enophthalmos that will require surgical correction. Orbital floor fracture greater than 50% and IMS involvement were much less accurate in making similar predictions. Cranial-caudal discrepancy should be used by the ED physicians to identify those patients who should be referred sooner than later to an oculoplastic surgeon for surgical evaluation and intervention. Correct and timely triaging can prevent the complications of delayed correction including scarring, difficult surgical repair, and/or poor functional and aesthetic outcomes.
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1. Introduction

Patients with orbital fractures make up a significant percentage of those evaluated in the emergency department for facial trauma. All these patients require ophthalmic consultation but some more urgently than others. In our experience, only a fraction of these patients will likely require immediate ophthalmological consultation

☆ Meeting presentation: Not applicable.
☆☆ Financial support: None to disclose.
★ Proprietary interest statement: None of the authors have any financial interest related to the manuscript in any manner.

* Corresponding author at: Department of Ophthalmology, Division of Oculoplastic and Reconstructive Surgery, The George Washington University, Washington, DC 20052. Tel.: +1 202 256 3361 (Mobile); fax: +1 703 875 9215.
E-mail address: tmansour@mfa.gwu.edu (T.N. Mansour).

http://dx.doi.org/10.1016/j.ajem.2016.10.030
0735-6757/Published by Elsevier Inc.

for possible surgical correction. Most patients can be observed without any surgical intervention with follow-up to an orbital trauma specialist within 7 to 10 days. Those requiring surgical correction typically present with some or all of the following symptoms: persistent diplopia within 30° of center vision, functional or aesthetically significant enophthalmos, and orbital muscle/tissue entrapment with or without bradycardia and constitutional symptoms such as nausea and dizziness. Decreasing time elapsed between patient presentation and surgical intervention can improve the long-term outcome as scarring has yet to fully develop, which would make surgery more difficult [1-3].

Computed tomographic (CT) findings suggestive of orbital floor fractures (BOFs) spanning greater than 50% of the orbital floor (BOF > 50%) is considered the most predictive imaging sign that could help identify those patients whom surgical correction is required in the adult population group [1]. Clinically, many patients with the CT finding of BOF > 50% do not have a clinical presentation that would require them to undergo surgical correction. This observation has led us to question the accuracy and reliability of the current imaging guidelines as a predictor of severity of the orbital fracture and the need for earlier surgical repair.

In surgical patients, we observed that the portion of the orbital floor at the midlevel of the inferior rectus (IR) muscle is invariably involved. This observation led us to the hypothesis that a simplified means of identifying those fractures primarily involving this portion of the floor will help us predict symptomatic patients that will most likely require surgical correction. In other words, the location of the floor fracture along with the degree of displacement of the BOF (resulting in greater volume expansion) determines how much instability within the orbital cone ensues after trauma. In this report, we define a reproducible and simple measurement that can predict long-term outcome in patients with BOF. We tested the hypothesis that the difference in the cranial-caudal dimension (CCD) of the fractured side as compared with the noninjured side at the level of the orbit just posterior to the globe can provide a reasonable approach to identifying patients in need of surgical intervention.

2. Methods

In this institutional review board–approved retrospective study, patients who presented to a level I trauma center between 2011 and 2015 with an acute unilateral BOF with or without a small medial wall fracture were included. Patients were excluded if they had CT signs of bilateral orbital fractures, large medial wall fracture, complex facial fractures, or muscular entrapment. In addition, those patients with inadequate follow-up with an ophthalmologist were also excluded.

Two reviewers, a neuroradiologist and an oculoplastic surgeon, who were blinded to the patients' outcomes, were asked to evaluate the BOF using 3 techniques. Orbital floor fracture greater than 50% was defined as a BOF that measured greater than 50% of the size of the orbital floor in either axial, coronal, or sagittal plane. The inferomedial strut (IMS) was noted to be either involved or not involved in the fracture. Any rotation along the *z*-axis of the coronal plane of the CT scan was noted as positive involvement of the IMS. To calculate CCD, the reviewers were asked to follow the instructions outlined in Fig. 1. These steps guided the reviewers to measure the CCD of the orbit at a site in which the position of the globe would most likely be altered by the displaced BOF fragment (area where the IR is thickest in vertical diameter). We predicted that such alteration, if significant enough, would destabilize the orbit enough to necessitate surgical intervention.

The electronic medical record of the patient's first encounter with an ophthalmologist, an oculoplastic surgeon in most cases, after his/her initial visit to the emergency department was reviewed. The patient's ocular status at the time of this first visit (usually within 5-14 days of the trauma) was noted for any symptoms such as ocular pain, nausea or vomiting, and any signs such as periocular swelling, enophthalmos, diplopia, and/or limitation of ocular motility. If this information was not available, the patient was excluded from the study. Whether or not the patient underwent surgery was also noted but blinded from the authors at the time of their calculations of the CCD. Patients with clinically significant diplopia and/or aesthetically disturbing enophthalmos were chosen for surgical repair. Statistical analysis was performed using SAS 9.3 (SAS Institute, Cary, NC). Line plots were drawn using Excel (Microsoft, Redmond, WA).

3. Results

Thirty-three patients fit our inclusion criteria. There were 21 men and 12 women. Twenty-six patients suffered from an isolated BOF, whereas 7 patients had a concomitant minor medial wall fracture.

Of the 33 patients, 25 had BOF > 50%, 7 with fractures less than 50% and 1 patient with a fracture of about 50%. No patients with fractures of 50% or less underwent any surgery. Eight patients of the 25 with BOF > 50% ultimately underwent surgery. In other words, approximately one-third of those with BOF > 50% had surgery. Based on size of BOF, sensitivity was noted at 100%, whereas specificity was only 32%. The negative predictive value (NPV) was 100%, whereas positive predictive value (PPV) was noted at 32% (Fig. 2).

Twelve patients were found to have IMS involvement. Of those 12 patients, 6 ultimately underwent surgery. Sensitivity and specificity were noted to be 75% and 74%, respectively. Positive predictive value was 50% and NPV was 89% (Fig. 3).

Using average CCD, a cutoff of 0.8 cm was defined as threshold measurement differentiating between the group of patients requiring timely surgery and those that do not require surgical intervention. It was found that all 23 patients who had a calculated CCD of 0.8 cm or less did not ultimately require surgery. This resulted in a sensitivity of 100% and a NPV of 100%. Of the patients with a CCD of greater than

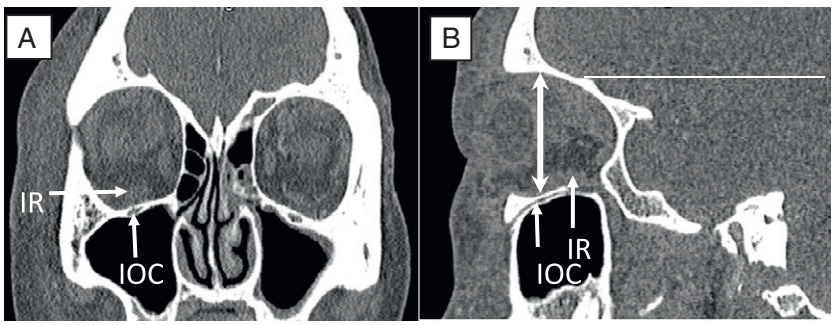

Fig. 1. Cranial-caudal dimension of the orbit. Computed tomographic scan of the orbit in bone algorithm in coronal view (A) at the posterior aspect of the globe defines the level at which the caudal cranial dimension of the globe is measured in the sagittal plane (B). Arrow labeled IOC points to the inferior orbital canal. Arrow labeled IR point to the IR muscle. B, CT scan of the orbit in bone algorithm in sagittal view bisecting the segment of the IR shown in panel A shows the belly of the IR and the course of the IOC. In this view, a globe line is drawn perpendicular to the axis of the globe (thin white line). A line perpendicular to globe line is drawn such that it intersects the posterior aspect of the globe (thick white arrow). The difference between this CCD of the orbit with an acute floor fracture from the normal side CCD is calculated. In patients with BOFs requiring surgical repair, the CCD measures greater than 0.8 cm.