Journal of Plastic, Reconstructive & Aesthetic Surgery (2016) 69, e238–e244

JPRAS
An International Journal of Surgical Reconstruction
www.JPRASurg.com

Predicting late enophthalmos: Differences between medial and inferior orbital wall fractures

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Received 4 January 2016; accepted 22 August 2016

KEYWORDS
Enophthalmos;
Orbital wall fracture;
Predictor;
Computed tomographic scan

Summary *Introduction:* The purpose of this study was to compare the strength of the relationships between predictors and late-onset enophthalmos in medial and inferior orbital wall fractures and to determine the most significant predictive factor of enophthalmos in medial or inferior orbital wall fracture.
Methods: Sixty-three adult patients with unilateral medial or inferior orbital wall fracture who had been left untreated for more than two months were enrolled in this study. Patients who had accompanying multiple orbital wall fractures and those with orbital-zygomatic fractures were excluded. Orbital defect area and herniated muscle and fat volumes were evaluated using computed tomography. The degree of enophthalmos was measured using a Hertel exophthalmometer.
Results: Herniated muscle and fat volumes were positively correlated with defect area in the medial orbital wall fracture but showed no positive correlation with inferior orbital wall fracture. In the medial orbital wall fracture group, enophthalmos was positively correlated with defect area and herniated muscle and fat volumes. Defect area was more highly related to enophthalmos than other analyzed metrics. The defect area predictive of enophthalmos was 1.98 cm^2. However, enophthalmos was positively correlated only with herniated fat volume in inferior orbital wall fracture. The herniated fat volume predictive of enophthalmos was 343.50 mm^3.

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http://dx.doi.org/10.1016/j.bjps.2016.08.004

Conclusion: Orbital defect area in medial orbital wall fracture and herniated fat volume in inferior orbital wall fracture were the most significant predictors of late-onset enophthalmos.

Introduction

Orbital wall fractures can lead to several complications such as diplopia, enophthalmos, or limited extraocular movement. When noticeable enophthalmos or diplopia caused by incarceration of the extraocular muscle or fine ligament system is observed, surgical intervention should be considered. However, enophthalmos is usually not immediately apparent because of edema of the orbital tissues. Thus, many surgeons have estimated the extent of late enophthalmos based mainly on the size of orbital wall defects calculated using computed tomographic (CT) images. Therefore, there have been many studies on the expected defect size associated with enophthalmos in orbital wall fractures.[1–7] However, defect size varies between papers or locations of fracture, and there has been little research on isolated orbital wall fracture rather than multiple wall orbital fractures.

Several papers have reported that the volume of herniated orbital tissue or morphologic change in extraocular muscles can be a predictor of late enophthalmos in orbital wall fractures.[2–4,8,9] However, to our knowledge, there are no reports comparing the strengths of the relationships between these predictors and late enophthalmos. In medial and inferior orbital wall fractures, orbital tissue herniates into the anatomically distinct ethmoid and maxillary sinuses.[10] Thus, there can be a major difference in predictors of late enophthalmos between medial and inferior orbital wall fractures. Therefore, the purpose of this study is to compare several predictors of late enophthalmos in medial and inferior orbital wall fractures and to determine the most significant predictive factor of enophthalmos in medial or inferior orbital wall fracture.

Materials and methods

This study was a retrospective review of consecutive adult patients who were diagnosed with unilateral medial or inferior orbital wall fracture during a nine-year period from January 2004 to December 2012. No patient underwent reconstruction of orbital wall fracture for more than two months after the original injury. This study was conducted after obtaining approval from the Institutional Review Board of Sungkyunkwan University (2013-SCMC-031-00). Only patients with complete clinical records, CT scans (axial and coronal sections), ophthalmic examination, and a follow-up period longer than two months[11] were included in the study. Patients who had accompanying nasal bone fracture, mandibular fracture, or zygomatic arch fracture, except multiple wall orbital fractures and those associated with orbital-zygomatic fractures, were included. Based on the study of Yano et al.,[12] linear-type fractures, which have little effect on orbital volume change, were not included.[13] The degree of enophthalmos was measured using a Hertel exophthalmometer. The measurement was performed by one ophthalmologist.

CT imaging (LightSpeed VCT; GE Medical Systems, Milwaukee, WI, USA) was performed with 2.5-mm-thick slices. A picture archiving and communication system (PACS; Impax; Agfa, Ridgefield Park, NJ, USA) was used to measure and analyze orbital defect area, herniated muscle and fat volumes, and orbital volume. CT numbers were set in the ranges of −200 to +100 Hounsfield units (HU) for orbital volume, −200 to −30 HU for orbital fat volume, and −30 to +100 HU for orbital muscle volume.[14] To reduce errors, measurements were performed three times by the same investigator (J.S.P).

Evaluation items

In medial orbital wall fracture, measurement items were determined using axial scans; in inferior orbital wall fracture, measurement items were determined using coronal scans.[15] Orbital volume was measured from axial scans regardless of fracture location.

Orbital defect area

Defect width is the shortest horizontal distance between the defect-free margins of the medial or inferior orbital wall (Figure 1, left).[15] The widths were measured in all sections; the results were summed and multiplied by section thickness to obtain the defect area.

Herniated muscle or fat volume

Herniated muscle or fat was morphologically outside of the spontaneous orbital wall arch and prolapsed into the ethmoid or maxillary sinus (Figure 1, center and right). The herniated muscle or fat volume was approximated by summing the manually traced herniated muscle or fat area of each section and multiplying by section thickness. In the case of burst-type fracture of the medial or inferior wall, the spontaneous orbital wall arch was identified as the line connecting the ethmoidomaxillary suture[4] and the superior border of the medial orbital wall or the lateral border of the inferior orbital wall. The herniated muscle or fat volume ratio was obtained by dividing the volume of herniated muscle or fat by orbital volume and then multiplying by 100 and was expressed as a percentage of orbital volume.