Ophthalmologic Findings in Patients with Non-Surgically Treated Blowout Fractures

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Abstract

We evaluated the ocular and visual status in a group of patients with a non-surgically treated blowout fracture. Clinical examination with refraction, test of binocular function, and tear film evaluation was performed in 23 patients. These values were statistically correlated with the orbital volume measurements and ocular finding from the patient records at presentation. About 50% of the study group was symptomatic due to low visual acuity from refractive errors and decompensated phorias as a consequence of the blowout fracture. Several patients displayed changes in tear film production. There was no strong correlation between the measured parameters and orbital volume measurements. Patients with a non-surgically treated blowout fracture often display ocular and visual changes after discharge. A routine visual exam is advocated in all patients after the ocular status has stabilized after a blowout fracture.

Keywords

- blowout fractures
- visual acuity
- astigmatism
- diplopia
- strabismus
- tears

The eye bulb is protected inside the orbital cavity, suspended in a system of fascia, tendons, muscles, and fat. This prevents the bulb from changing position in the orbit and only allows for eye rotations around its geometrical center. A blunt injury to the eye or the orbital rim, however, will push the eye bulb posterior, out of position, in the orbital cavity. If the hit is hard enough, the impact will fracture the orbital bones.¹ Isolated fractures of the orbital floor are often referred to as a “blowout fracture” (BOF). A BOF can lead to a posteriorly translated (i.e., enophthalmos) and a sunken eye bulb position (i.e., hypoglobus),² and the fractured sharp bone edges can become entrapped the musculus rectus inferior, leading to restriction of gaze and diplopia.³

In some cases, the orbital floor fragments are not displaced and the orbital volumes remain roughly unchanged. If no indications for surgery exist like reduced vision, double vision (i.e., diplopia), obvious enophthalmos,⁴ or radiologi-

cal evidence of muscle entrapment, such a fracture can be left without surgical intervention.⁵ All patients with a BOF at Karolinska University Hospital are examined by an ophthalmologist within 2 days, ruling out eye-threatening injuries. The examination includes testing of monocular visual acuity and intraocular inspection looking for retinal engagement, extraocular motility testing, and presence of diplopia and measurement of enophthalmos with Hertel exophthalmometry to evaluate the eye bulb position. In emergency cases with affected vision and/or entrapped extra ocular muscles, the ophthalmologist sees the patient promptly.

The fractured orbital floor heals in its new position by fibrous union, if treated nonsurgically.⁶ It is not well known to what extent the trauma and the changed orbit will affect refraction, visual acuity, and ocular tear film stability. BOF patients normally complain of reduced vision in the acute

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phase,⁷ but in our opinion, based on clinical experience, vision can also be reduced after discharge. This could theoretically be due to changes in refraction, disrupted tear film due to changed tear secretion,⁸ an injured cornea, or visual loss due to retinal damage or trauma to the optic nerve. The impaired vision might manifest itself as fatigue, pain in or around the eyes, blurred vision, headache, and double vision (i.e., eye strain). The aim of this study was to examine the visual status in a group of patients with BOFs that were left untreated and to compare these with the contralateral unaffected eye. The measurements will also be correlated to the findings from the records at presentation.

Methods

Patient Selection

From the patient records of the Ear, Nose, and Throat (ENT) department at Karolinska University Hospital, patients were selected who had an isolated, non-surgically treated unilateral fracture of the orbital floor as diagnosed on a computed tomography (CT) scan. The decision to refrain from surgery of the orbital floor fracture was made on the basis of the volume of the herniated orbital content (less than 1 to 1.5 mL). From March 2003 to April 2007, 89 patients met the criteria mentioned above. They were all contacted by regular mail. In the letter, they were invited to a clinical eye examination at the St. Erik Eye Hospital in Stockholm, Sweden, and 43 patients responded to the letter. Two appeared to have had medial orbital wall fracture instead of orbital floor fracture, and 12 had been scanned with CT slices thicker than 2 mm, which worsened detail resolution in the analysis. Finally, six individuals did not show up for examination. Thus, 23 individuals were included in the study (19 men, 4 women). Informed consent was obtained from all patients, and the study was approved by the Local Ethics Committee at the Karolinska Institutet. Data from orbital volume measurements from the same patient group have been described elsewhere.⁹

Clinical Examination and Data Collection

The clinical examination included measurement of enophthalmos with Hertel exophthalmometry, refractive status of the eyes by a subjective monocular refraction, monocular visual acuity, degree of heterophoria with prism cover test, test of stereovision with Lang stereo test, control of ocular motility, measure of convergence, accommodation, fusion ability, and estimation of tear film quantity by inserting a cotton thread with phenol (i.e., Phenol red thread, ZONE-QUICK, Oasis Medical Inc., Marshfield, MA) and measurement of tear prism height and estimation of tear film quality by measuring the tear breakup time. Ophthalmologic data from the patient records from the time of the injury were reviewed and compared with the measured parameters. On the fractured side, the volume (in milliliters) of the herniation and the volume of the orbit including the herniation were measured. The orbital volume on the nonfractured side was also measured for calculating the relative volume difference.

Data Analysis and Statistics

The data were organized in Microsoft Excel and analyzed with the StatSoft, Inc. (2007), Statistica (data analysis software system), version 8.0 (www.statsoft.com). A correlation analysis was performed on the orbit measurements and the ophthalmologic data. The data were analyzed with a dependent *t* test ($\alpha = 0.05$).

Results

General

The ophthalmologic investigation was performed 6 to 23 months after the trauma. All patients had a retinal inspection by an ophthalmologist at the time for the injury, and no one displayed retinal hemorrhages or retinal detachments.

Orbital Volumes and Enophthalmos

The relative volume difference between the fractured and the nonfractured orbit was on average 8.6% (between 0% and 17.2%). The affected side was always larger. The average herniated volume (soft tissue pushed into the underlying sinus) was 1.00 mL (± 0.62 standard deviation). The examination of the patient group revealed enophthalmos (≥ 2 mm) in 5 of the 23 patients (22%), which varied between 2 and 4 mm. The enophthalmos was always found on the affected side.

Orthoptic Status

All patients had normal ocular motility except for one patient (No. 19) who had an overfunction of musculus oblique inferior, which was due to a known strabismus (present before the BOF) with intermittent diplopia resulting in a larger near exophoria with an intermittent vertical diplopia. This patient also had a 4-mm enophthalmos, which according to the earlier optometry records and the patient himself was not present before the BOF; he was sent back to the ENT department for management. Sixteen patients had no or only minor (i.e., physiological) near exophoria (< 6 prism diopter (pD)), and six patients displayed larger exophoria (> 6 pD). Intermittent diplopia could be found in eight patients in total; four of those could be related to the orbital floor fracture, as the diplopia developed first after the trauma and the strabismus varied with gaze angle (noncomitant). In the other four subjects, there was a history of intermittent diplopia prior to the trauma, and the heterophoria had the same angle in all gaze directions (i.e., comitant), which is not the case if the action of the extraocular muscles are restricted due to an orbital trauma. All patients except one had stereovision (< 550 arc seconds). This patient (No. 11) had noncompensated heterophoria leading to esotropia with diplopia, which was not correlated to the orbital fracture. The heterophoria was comitant and with a similar angle at distance and near (basic esophoria). The angle of heterophoria was not related to any kind of refractive error or accommodative discrepancies. The diplopia was also known to occur prior to the trauma by the patient.

All patients had normal near point of accommodation in relation to age and normal near point of convergence. For

Table 1 Summary of Clinical Findings at Emergency and During Follow-up

Patient	Emergency (at Presentation)				Follow-Up		
	Hematoma (Eye Lids)	Hypoesthesia (Infr. Orb.)	Sub. Conj. Bleeding	Diplopia	Diplopia	Enophthalmus (mm)	Affected Tear Film
1	Y	Y	N	N	N	N	Excess
2	Y	Y	N	N	N	1	N
3	Y	—	N	Y	N	N	Decrease
4	Y	Y	—	N	N	N	Decrease
5	—	—	—	N	N	N	N
6	Y	—	Y	Y	Y	2	Excess
7	Y	Y	Y	N	N	N	Decrease
8	Y	N	Y	Y	N	1	N
9	Y	—	Y	N	Y	2	N
10	—	—	N	Y	N	N	N
11	Y	Y	—	N	Y	N	N
12	Y	—	—	N	N	N	N
13	Y	Y	Y	Y	Y	1	Decrease
14	N	—	N	N	N	2	N
15	N	N	N	Y	N	2	N
16	—	—	—	—	N	N	N
17	—	—	—	—	N	N	Decrease
18	Y	—	Y	N	N	N	Decrease
19	Y	—	Y	N	Y	4	N
20	—	—	Y	Y	Y	N	N
21	Y	Y	—	N	Y	N	Decrease
22	Y	N	N	Y	N	1	N
23	Y	Y	N	Y	Y	N	Decrease

Y, present; N, not present; sub. conj. bleeding, subconjunctival bleeding; infr. orb., infraorbitalis.

details, see ► **Table 1**. No correlation was found between the prism cover test, near point of convergence, or accommodation to the volume measurements of the orbit ($r^2 < 0.3$).

Visual Examination

A monocular refraction of both eyes was performed and a significantly larger astigmatism was found on the affected side ($-0.97 \text{ D} \pm 0.84$) compared with the nonaffected side ($-0.49 \text{ D} \pm 0.38$; $p = 0.027$). The larger astigmatism ($\geq 0.50 \text{ D}$) on the affected side was found in 12 subjects, and two subjects displayed a larger astigmatism in the nonaffected eye. The nine other patients had no or less than 0.50 D astigmatism. No preponderance to a specific astigmatic axis position could be found, but one observation was the large difference in axis position between the two eyes. No difference in spherical ametropia was found ($p = 0.71$). The best corrected visual acuity was slightly better on the nonaffected side (decimal acuity 1.0) compared with the affected side (decimal acuity 0.8; $p = 0.20$). Pinhole test did not enhance visual acuity. The data from the visual examination did not

correlate strongly ($r^2 < 0.3$) to the volume measurements of the orbit nor the calculated difference between the orbit volumes.

Cornea Inspection and Tear Film Evaluation

Cornea inspection was performed in slit lamp microscopy. All subjects had a clear cornea with normally injected corneal limbus. No indication of corneal damage could be found, which was in accordance with the medical records (no symptoms like corneal pain, blepharospasm, light sensitivity, etc.). The precorneal tear film was evaluated in terms of quantity and quality. The quantity measurement revealed on average a slightly lower amount of tear film in the affected eye compared with the unaffected. Tear meniscus height (tear prism on the lower eye lid) was on average 0.17 mm on the affected eye compared with 0.19 mm ($p = 0.49$) on the nonaffected eye. The phenol red thread test (comparable to the Schirmer's test) revealed a value of 15.9 mm on the affected eye compared with 19.0 mm on the nonaffected eye ($p = 0.034$). The affected side had a shorter breakup time

(12.0 seconds) compared with the nonaffected side (13.8 seconds; $p = 0.22$). A breakup time less than 10 seconds is regarded as low. The data from tear film evaluation did not correlate strongly ($r^2 < 0.3$) to the volume measurements of the orbit nor the calculated difference between the orbit volumes.

Discussion

The aim of this study was to evaluate the ocular and visual status in a group of patients with untreated BOF. Unfortunately, only 23 patients were included in the study group from a selection of 89 from the patient records. The low response to the invitations (48%) and the technical requirements of the CT images were the main reasons for the relatively small study group (26%).

A blunt injury to the eye will most often cause ecchymosis and edema of the eyelids and in the periorbital region.¹⁰ A massive edema can block vision in the affected eye, and this makes examination of the eye and vision more difficult. Sometimes the patient lacks normally worn corrective spectacles or contact lenses on one or both eyes, which gives unreliable measures of the visual status. Another obstacle when examining those patients is the altered mental status due to the head injury and if the patient suffers from shock. Many of the BOF patients are also affected by drugs or alcohol. In these cases, an intraocular inspection by an ophthalmologist is crucial to rule out an incorrectly taken visual status from pathological causes such as hemorrhages in the eye and in more severe cases of eye bulb rupture and severe visual loss.^{11,12} The affected eye usually displays poorer vision in the acute phase, possibly due to changes in refraction, disrupted tear film due to changed tear secretion,⁸ or an injured cornea. An injured cornea is very painful and accompanied by a blepharospasm (i.e., involuntary closure of the eye lids). These changes often normalize after a couple of days and the visual status improves.

Motility defects are a common finding in the acute phase after a BOF.¹³ This is either due to soft tissue edema or hemorrhage¹⁴ or a direct restriction in the action of the extraocular muscles due to the fracture.^{15,16} Gosse et al reported that approximately one-third of BOF patients recovered spontaneously within 2 weeks, and recovery continued in those patients who did not have orbital surgery.¹⁷ Motility defects that recovered spontaneously were thought to be caused by hemorrhage or edema. Motility defects will inherently lead to diplopia, but small deviations might be difficult even for the patient to reveal. Two different methods to diagnose diplopia were used at presentation and follow-up: anamnestic question at presentation and visual testing at follow-up. The Maddox dark red glass dissociates the eyes and makes it easier to distinguish small deviations. This might be one reason for the odd finding of diplopia present at follow-up but not at presentation. It is possible that the prevalence of diplopia at presentation could be higher if the clinicians used the Maddox dark red glass and dissociated the eyes more effectively.

At least 4 of the 23 patients (17%) had problems with intermittent diplopia at follow-up. This prevalence is higher than expected for a normal population, at least based on our clinical experience. We can only find one article reporting a 3.1% prevalence of intermittent diplopia in a group of university students.¹⁸ As can be seen in ►Table 1, five patients had enophthalmos (≥ 2 mm). Three of those had problems with intermittent diplopia, and only one had deficient ocular motility. Therefore, neither the motility test nor the presence of enophthalmos can be regarded as specific enough to identify patients with binocular disturbances in need of care.

All patients had full refraction. Half of the group had larger astigmatism on the affected eye. Interestingly, several patients had been informed about a manifest visual loss due to the BOF. In eight cases, the astigmatic correction was not optimal, and after correcting the refractive error, visual acuity was considerably improved. A blunt trauma toward the eye affecting the anterior segment of the eye has been shown to increase astigmatism.¹⁹ Corneal inspection did not support such a mechanism in our study group. One possibility is that the BOF changed the orbital cavity in such way that the supporting tissue surrounding the eye bulb exerts pressure on the bulb. This could lead to changed curvature of the cornea and larger astigmatism. The average visual acuity was slightly lower on the affected eye despite fully corrected astigmatism. Best corrected visual acuity did not rise in response to the pinhole test, which means that the lower acuity most certainly has an origin other than the anterior segment of the eye.

Tear film evaluation revealed subnormal values in 10 of 23 patients (43%). Eight patients displayed a decreased tear production, while two revealed an excess in tear production (epiphora). The phenol red thread test is less invasive compared with the better-known Schirmer's test, but the correlation of the two tests has been criticized to be weak, as have the test results from both tests to dry eye symptoms.²⁰ The scores of the phenol red thread test in this study do not indicate tear film insufficiency because the average value in the affected eye was almost 16 mm. A score of less than 10 mm indicates insufficient tear film production (according to Zone Quick). Tear meniscus height also indicated a lower value on the affected side, and this measurement has been shown to be a strong predictor of tear film insufficiency.²¹ The correlation between the tear meniscus height and the phenol red thread test was $r^2 = 0.60$ in this study, indicating a valid estimation of tear film production.

All patients in this study were excluded from surgical intervention because of lack of several clinical signs such as diplopia, enophthalmos, radiological evidence of muscle entrapment, and so on. This is an accepted clinical praxis.³ Only one patient from the study group was sent back to the ENT department because of severe problems with diplopia and 4-mm enophthalmos. However, the other patients were not free from the sequel of the BOF.

Conclusion

The finding that several patients were symptomatic due to low visual acuity and decompensated phorias underlines the

importance of a routine visual exam in all patients after the ocular status has stabilized after a BOF. This is an inexpensive and adequate examination that will reduce or eliminate ocular and visual symptoms.

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