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Original research

The predictive factors of diplopia and extraocular movement limitations in isolated pure blow-out fracture

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Abstract:

Purpose: To evaluate the predictive factors for development of diplopia and extraocular muscle movement (EOM) limitations in the patients with isolated pure blow-out fracture.

Methods: One hundred thirty-two patients with isolated pure blow-out fracture were included. The diagnosis was done with computed tomography scan. Possible predictive factors were analyzed with logistic regression. The cases that underwent surgery were assigned in the surgical group, and other cases were assigned in the non-surgical group. Receiver operating characteristic (ROC) curve analysis was used in the surgical group to evaluate the power of time interval from trauma to the surgery to predict persistence of 6 months postoperative diplopia and EOM limitation.

Results: At the first visit, 45 of 60 cases (75%) in the surgical group and 15 of 72 cases (20.8%) in the nonsurgical group had diplopia. After 6 months follow-up, 7 cases (11.7%) in the surgical group and 1 case (1.4%) in the nonsurgical group had persistent diplopia. Type of fracture was significantly associated with first visit diplopia ($P = 0.01$) and EOM limitations ($P = 0.06$). In the surgical group, type of fracture ($P = 0.02$ for both) and time interval from trauma to the surgery ($P = 0.006$ and 0.004, respectively) were significantly associated with 1 month diplopia and EOM limitations. Only time interval from trauma to the surgery ($P = 0.04$) was significantly associated with 3 months EOM limitation. In the ROC curve analysis, if the surgery was done before 4.5 (sensitivity = 87.5% and specificity = 61.3%) and 7.5 (sensitivity = 87.5% and specificity = 66.9%) days, risk of 6 months postoperative diplopia and EOM limitation was reduced, respectively.

Conclusions: In the early postoperative period, a higher rate of diplopia was observed in the patients with combined inferior and medial wall fractures and longer time intervals from trauma to the surgery. The best time for blow-out fracture surgery was within 4.5 days after the trauma.

Keywords: Blow-out fracture; Isolated pure blow-out fracture; Diplopia; Extraocular movement limitations

Introduction

Amongst complications of the blow-out fracture, diplopia and extraocular muscle movement (EOM) limitations are common symptoms and signs that may persist even after successful fracture surgery.[1] These complications may be due to entrapment of the muscle or perimuscular soft tissue in the fracture, direct injury to the muscle, hemorrhage in muscle or orbit, muscle edema, and ocular motor nerve palsies.[1,2]

Isolated pure blow-out fracture was defined as the "fracture of one or more orbital walls without the fracture of orbital rim or other facial bones".[1] Many studies evaluated the factors influencing the incidence rate of diplopia and EOM limitations in blow-out fracture cases with different inclusion criteria and different results.[1–14] For example, Parks and colleagues evaluated the relationship between type of fracture and postoperative diplopia and found that diplopia was more commonly observed in inferior and inferomedial wall

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fractures.[1] On the other hand, Ceylan and colleagues compared cases with early and delayed fracture repair and found no difference in the incidence of postoperative diplopia between the two groups.[2] In this study, the effect of multiple factors on diplopia and EOM limitations in the patients with isolated pure blow-out fracture was investigated in a prospective study.

Methods

In a prospective interventional and observational case series approved by the Institutional Review Board of the Farabi Eye Research Center, 142 consecutive patients with isolated pure blow-out fracture between February 2011 and December 2013 in the Oculoplastics clinic of Farabi Eye Hospital were included. The patients with zygomaticomaxillary or orbital rim fracture, history of strabismus or diplopia before trauma, history of previous strabismus surgery, traumatic intraocular damage, and those who did not return for follow-up were excluded from the study. The study and data collection were compliant with the principles of the Declaration of Helsinki. Informed consent was obtained from all patients.

In the history taking, age, gender, type of trauma (assault, motor vehicle accident, falling), time interval from the trauma to the first visit, and time interval from the trauma to the surgery were noted. All patients were asked about binocular diplopia in primary position, up or down gaze, and right or left gaze. The presence of binocular diplopia was also objectively evaluated by the examiner with the question: Do you see this pen as two? If the diplopia was eliminated after closing one eye, the diagnosis of binocular diplopia was confirmed. The cases with binocular diplopia in primary position (far or near) or 30° up, down, right or left gaze were analyzed in the diplopia category. Infraorbital hypoesthesia was checked in all patients with clinical examination. The degree of enophthalmos was assessed in all patients with a Hertel exophthalmometer. The far (6 m) and near (33 cm) deviations in primary position and down gaze were measured with prism and alternate cover test while the prism was placed in the front of the injured eye. In the cases with poor visual acuity in one eye or severe limitation, the deviations were measured with Krimsky method. For analysis, far deviation + near deviation/2 was used as the patient's deviation. Limitation of ductions in horizontal and vertical gazes was measured using a 5-point scale (0 to −4), with 0 representing no limitation and −4 representing no movement beyond midline. All deviation measurements were done by one trained orthoptist that was blinded to the purpose of the study. Complete ophthalmologic examinations were also done for all patients.

The orbital computed tomography (CT) scan was done in all cases to confirm the diagnosis. According to the CT scan findings, the fractures were classified into: isolated medial wall fracture, isolated inferior wall fracture, and combined inferior and medial wall fracture.

The indications of surgery in this study were: 1- enophthalmos >2 mm; 2- extensive fracture involving more than half of the inferior wall in the orbital CT scan; 3- persistent diplopia in primary position or 30° up- or down gaze; 4- evidence of the entrapment of extraocular muscle in the fracture in orbital CT scan; 5- unresolving oculocardiac reflex (necessitating immediate surgery). The cases with one of these signs underwent surgery. All surgeries were done within 2 weeks from the first visit.

All surgeries were done by one of the two authors of this presentation (A.K. and B.E) by transconjunctival approach. Forced duction testing was done in the beginning and the end of the operation under general anesthesia. The implant used in all patients was porous polyethylene (Medpore, Porex Surgical Products, Newnan, GA). The dimensions of the Medpore were selected according to the size of fracture and degree of enophthalmos.

The patients were followed in 1 month, 3 months, and 6 months after the first visit. Similar to the first visit, the cases with diplopia in primary position or 30° up, down, right, or left gaze were analyzed in the diplopia category. Deviations in the primary position and down gaze were also measured in each visit.

Statistical analysis was performed with SPSS version 20 (SPSS Inc., Chicago, IL). The Chi-square test was used to assess the differences in the incidence of diplopia between subgroups. Multivariate logistic regression models were used to model diplopia and EOM limitation as a function of age, gender, type of trauma, type of fracture, enophthalmos >2 mm, infraorbital hypoesthesia, time interval from the trauma to the first visit, and time interval from the trauma to the surgery. In the 1, 3, and 6 months visits, the logistic regression was separately performed for the surgical and non-surgical subgroups. Receiver operating characteristic (ROC) curve analysis was used in the surgical group to evaluate the power of time interval from the trauma to the surgery to predict 6 months postoperative diplopia and EOM limitation. The level of significance was 0.05 for chi-square and ROC curve and 0.1 for logistic regression.

Results

From 142 cases, 10 cases did not return for follow-up and were excluded. Therefore, 132 patients were used for analysis. The preoperative characteristics of the patients are summarized in Table 1. The mean age of the patients was 30.49 ± 11.68 years. The mean time interval from trauma to the surgery was 18.57 ± 28.05 days. Sixty cases (45.5%) required surgery for fracture repair. The findings of diplopia and EOM limitations are shown in Table 2. The pre- and postoperative number (percentages) of the patients with each type of deviation and the mean and standard deviation of horizontal and vertical deviations are presented in Table 3. The frequencies of the first visit and 1, 3, and 6 months visits diplopia in the surgical and non-surgical groups are shown in Table 4.

The surgical complications of visual loss, infection, or exposure of the Medpore, mydriasis and lid malposition did not occur in any patient that underwent surgery. The enophthalmos was eliminated in all patients that underwent surgery due to this problem.

Table 1
The preoperative characteristics of the patients included in the study. The frequencies of variable subgroups are shown as number (percentages).

Variable		
Sex	Male	102 (77.3%)
	Female	30 (22.7%)
Age	mean ± SD (years)	30.49 ± 11.68
	Range (years)	10−60
Type of trauma	Assault	84 (63.6%)
	Motor vehicle accident	42 (31.8%)
	falling	6 (4.5%)
Time interval from the trauma to the first visit	mean ± SD (days)	7.46 ± 18.30
	Range (days)	1−180
Time interval from the trauma to the surgery (in the patients that underwent surgery)	mean ± SD (days)	18.57 ± 28.05
	Range (days)	1−196
Type of fracture	Medial wall only	50 (37.9%)
	Inferior wall only	48 (36.4%)
	Medial and inferior walls	34 (25.8%)
Infraorbital hypoesthesia	Yes	73 (55.3%)
	no	59 (44.7%)
Surgery for blow-out fracture	Yes	60 (45.5%)
	no	72 (54.5%)
Enophthalmos> 2 mm	Yes	30 (22.7%)
	no	102 (77.3%)

SD: Standard deviation.

Table 2
The frequency of the first visit and 1, 3, and 6 months visits diplopia and extraocular movement limitations. The frequencies of the variables subgroups are shown as number (percentages). The cases with binocular diplopia in primary position (far or near) or 30° up, down, right, or left gaze were analyzed in the diplopia category.

Variable	Subgroup	Number (percentages)
First visit diplopia	Yes	60 (45.5%)
	no	72 (54.5%)
1 month visit diplopia	Yes	41 (31.1%)
	no	91 (68.9%)
3 month visit diplopia	Yes	13 (9.8%)
	no	119 (90.2%)
6 month visit diplopia	Yes	8 (6.1%)
	no	124 (93.9%)
First visit EOM limitations	Full extraocular movements	74 (56.1%)
	Limitation in elevation	41 (31.1%)
	Limitation in depression	2 (1.5%)
	Limitation in abduction	4 (3.0%)
	Limitation in elevation and depression	6 (4.5%)
	Limitation in elevation and abduction	5 (3.8%)
1 month visit EOM limitations	Full extraocular movements	89 (67.4%)
	Limitation in elevation	32 (24.2%)
	Limitation in depression	10 (7.6%)
	Limitation in abduction	1 (0.8%)
3 month visit EOM limitations	Full extraocular movements	107 (81.1%)
	Limitation in elevation	14 (10.6%)
	Limitation in depression	11 (8.3%)
6 month visit EOM limitations	Full extraocular movements	124 (93.9%)
	Limitation in depression	8 (6.1%)

EOM: Extraocular movement.

After 6 months follow-up, only 8 of 132 patients had persistent diplopia and EOM limitations. The diplopia in these 8 cases was in the primary position and/or down gaze (Table 2). In these 8 patients, 2 patients had inferior wall fractures, and the others had combined inferior and medial wall fractures. All of them (except one case, Table 4) had undergone surgery for blow-out fracture. All 8 patients underwent strabismus surgery for inferior rectus paresis at least 6 months after the trauma.

Patients with the combined inferior and medial wall fracture underwent surgery more than other types of fractures. 94.1% of combined inferior and medial wall fractures, 54.2% of inferior wall fractures, and 4% of medial wall fractures underwent surgery ($P < 0.001$). Similarly, combined inferior and medial wall fractures had the highest incidence rate, and isolated medial wall fractures had the lowest incidence rate of diplopia and EOM limitations at the baseline visit and 1, 3, and 6 months visits ($P < 0.001$, <0.001, 0.002, and 0.02, respectively for diplopia, and $P < 0.001$, $P < 0.001$, $P < 0.001$, and 0.003, respectively for EOM limitations).

In the logistic regression, only type of fracture was significantly associated with the first visit diplopia ($P = 0.01$) and EOM limitations ($P = 0.06$) for all cases. In the surgical group, type of fracture ($P = 0.02$ for both) and time-interval from the trauma to the surgery ($P = 0.006$ and $P = 0.004$, respectively) were significantly associated with 1 month visit diplopia and EOM limitations. In addition, in the surgical group, only time interval from the trauma to the surgery ($P = 0.04$) was significantly associated with 3 months visit EOM limitation. However, none of the variables were significantly associated with 1, 3, and 6 months visit diplopia and EOM limitations in the non-surgical group and 3 and 6 months visits diplopia and 6 months visit EOM limitation in the surgical group.

The ROC curve analysis was performed in the surgical group to assess the predictive power of time interval from the trauma to the surgery for 6 months postoperative diplopia and EOM limitation. For 6 months postoperative diplopia, the area under the curve (AUC) was 0.73 ($P = 0.025$, 95% CI = 0.57−0.90). The best cut-off point was at the time interval of 4.5 days, with a sensitivity of 87.5% and specificity of 61.3%. Therefore, if the surgery was done before 4.5 days, risk of 6 months postoperative diplopia would be reduced. For 6 months postoperative EOM limitation, the AUC was 0.81 ($P = 0.003$, 95%CI = 0.70−0.91). The best cut-off point was at the time interval of 7.5 days, with a sensitivity of 87.5% and specificity of 66.9%. Therefore, if the surgery was done before 7.5 days, the risk of 6 months postoperative EOM limitation would be reduced.

Discussion

The baseline characteristics of the patients in this study had some similarities and some differences with other studies.[1−14] Like other studies, most blow-out fractures occurred in the male patients.[1,2] Assault was the most common type of trauma

Table 3
The number (percentages) of the patients with each type of deviation and the mean and standard deviation of the horizontal and vertical deviations in the first visit and 1, 3, and 6 months visits. To calculate mean deviations, hypertropia and exotropia were used with positive signs, and hypotropia and esotropia were used with negative signs.

Variable	Type of deviation	Number (percentages)	Mean ± SD (PD)	Range (PD)
First visit primary position vertical deviation	Hypotropia	36 (27.2%)	−1.63 ± 4.84	−15 to 18
	Hypertropia	5 (3.8%)		
	No vertical deviation	91 (69.0%)		
1 month visit primary position vertical deviation	Hypotropia	8 (6.1%)	+1.05 ± 4.66	−6 to 25
	Hypertropia	11 (8.3%)		
	No vertical deviation	113 (85.6%)		
3 months visit primary position vertical deviation	Hypotropia	1 (0.8%)	+1.24 ± 4.46	−4 to 25
	Hypertropia	11 (8.3%)		
	No vertical deviation	120 (90.9%)		
6 months visit primary position vertical deviation	Hypotropia	0 (0%)	+0.89 ± 3.80	0 to 25
	Hypertropia	8 (6.1%)		
	No vertical deviation	124 (93.9%)		
First visit primary position horizontal deviation	Exotropia	24 (18.1%)	+0.48 ± 1.80	−8 to 8
	Esotropia	3 (2.4%)		
	No horizontal deviation	105 (79.5%)		
1 month visit primary position horizontal deviation	Exotropia	24 (18.1%)	+0.51 ± 1.16	0 to 5
	Esotropia	0 (0%)		
	No horizontal deviation	108 (81.9%)		
3 months visit primary position horizontal deviation	Exotropia	24 (18.1%)	+0.50 ± 1.14	0 to 5
	Esotropia	0 (0%)		
	No horizontal deviation	108 (81.9%)		
6 months visit primary position horizontal deviation	Exotropia	24 (18.1%)	+0.47 ± 1.07	0 to 4
	Esotropia	0 (0%)		
	No horizontal deviation	108 (81.9%)		

SD: Standard deviation.
PD: Prism diopters.

Table 4
The frequencies of the first visit and 1, 3, and 6 month visits diplopia in the surgical and non-surgical groups.The frequencies of the variables subgroups are shown as number (percentages).

Visit	Surgical group		Non-surgical group	
	Diplopia	No diplopia	Diplopia	No diplopia
First visit	45 (75%)	15 (25%)	15 (20.8%)	57 (79.2%)
1 month visit	38 (63.3%)	22 (36.7%)	3 (4.2%)	69 (95.8%)
3 months visit	12 (20%)	48 (80%)	1 (1.4%)	71 (98.6%)
6 months visit	7 (11.7%)	53 (88.3%)	1 (1.4%)	71 (98.6%)

in our patients. In the study of Ceylan and colleagues, motor vehicle accidents were the most common type of trauma in blow-out fracture cases.[2]

In this study, the proportion of enophthalmos >2 mm (22.7%) was more than that of the Park and colleagues'[1] and Ceylan and colleagues'[2] studies. In addition, the mean time from the trauma to the surgery in this study was higher than Ceylan and colleagues' study.[2] These relatively high numbers and high rate of surgery (45.5%) might reflect that our sample was derived from a referral center.

The incidence rate of first-visit diplopia varied widely (36–86%) between different studies on blow-out fracture patients.[2–4] The incidence rate was 45.5% in our study. Furthermore, the proportion of the patients that required strabismus surgery (6.1%) was lower than some other studies. This proportion was 17.8% in the Ceylan and colleagues' study.[2] These differences between studies might be due to different inclusion and exclusion criteria. For example, in the Ceylan et al study, in contrast to our study, asymptomatic patients with small fractures were excluded from the study.[2] This may therefore explain the lower rate of strabismus surgery in our study.

The findings about type of fractures were compatible in some parts with Park and colleagues',[1] Burm and colleagues',[5] Eun and colleagues',[6] and Higashino and colleagues'[7]studies. Like these studies, medial wall fracture was the most common fracture, and combined inferior and medial wall fractures had the highest proportion of diplopia.[1,5–7] However, like Park et al's study,[1] and in contrast with Burm et al's[5] and Eun and colleague's[6] studies, combined inferior and medial wall fractures had the highest proportion of EOM limitation. A higher proportion of diplopia and EOM limitations in combined inferior and medial wall fractures can be due to more severe insult in this type of fracture and more severe trauma to the extraocular muscles. Regardless, the type of the fracture was one of the most important indicators of the first visit and early postoperative diplopia and EOM limitations.

In our study, the time interval from trauma to surgery had significant associations with 1 month visit diplopia and 1 and 3 months visits EOM limitations, but there were no significant associations between this variable and 6 months visit diplopia or EOM limitations. This lack of association might be due to the low incidence rate of diplopia and EOM limitations in 6 months visit. As another explanation, the longer time between trauma and surgery might only increase the muscle edema and consequently affect the early postoperative diplopia and EOM limitations. After resolution of this edema, the incidence rate of diplopia and EOM limitations might be unrelated to the time of surgery.

The recommendations about timing of the blow-out fracture surgery and its effect on the postoperative diplopia were different between various studies.[1–14] The earlier reports by Converse and colleagues[8] and Whyte[9] recommended earlier surgery. Matteini and colleagues suggested surgical repair within 3 days from the trauma in children and within 7 days in adults.[10] Burnstine recommended blow-out fracture surgery within 2 weeks from the trauma to prevent scarring and fat atrophy.[11] On the other hand, Dal canto and Linberg found no significant difference in the postoperative diplopia between early fracture repair (within 14 days after trauma) and late fracture repair (within 29 days after trauma).[12,13] Likewise, Simon et al found no significant difference in the postoperative outcomes between early repair (within 14 days after trauma) and late repair (1 month–3.5 years after trauma).[14] In our study, the time interval of more than 4.5 days between trauma and surgery was associated with higher risk of long-term (6 months) postoperative diplopia, and the time interval of more than 7.5 days between trauma and surgery was associated with higher risk of long-term (6 months) postoperative EOM limitation, with relatively high sensitivities. Therefore, in order to avoid diplopia and EOM limitations, blow-out fracture surgery should be performed within 4.5 days after the trauma.

The limitations of this study were selecting patients from a referral center, a relatively low sample size, and a relatively low incidence of diplopia and EOM limitation in the 6 months visit. Multicenter studies might better determine the predictive factors of diplopia and EOM limitations. With the larger sample sizes, the incidence of the diplopia and EOM limitations in 6 months might be enough to evaluate predictive factors.

In conclusion, in this series of the patients with isolated pure blow-out fracture, risk factors were evaluated with more accurate analysis methods, such as logistic regression and ROC curve. The most powerful factor affecting the first visit diplopia and EOM limitations was type of the fracture. In the surgical group, the most powerful factors affecting early postoperative diplopia and EOM limitations were time interval from the trauma to the surgery and type of the fracture. Thus, the surgeon should expect a higher rate of diplopia in the early postoperative period in patients with combined inferior and medial wall fractures or with longer time intervals from the trauma to the surgery and should warn the patients about these problems. In addition, the best time for blow-out fracture surgery was within 4.5 days after the trauma to prevent diplopia and EOM limitations.

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