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Predictive factors for residual diplopia after surgical repair in pediatric patients with orbital blowout fracture

Yun Su, Qin Shen, Ming Lin, Xianqun Fan*

Department of Ophthalmology, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University, School of Medicine, China

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ABSTRACT

Purpose: This study aimed to evaluate the clinical prognosis of diplopia and identify factors that are potentially predictive of residual diplopia postoperatively in pediatric patients with orbital blowout fracture.

Material and methods: This was a retrospective study of clinical data from 135 children and adolescents less than 18 years of age who were diagnosed with orbital blowout fractures between January 2008 and June 2014 in the Department of Ophthalmology. A Kaplan–Meier curve and log-rank statistics were used to identify the recovery status from diplopia. Univariate and multivariate Cox proportional hazards analyses were conducted to identify the characteristics associated with residual diplopia.

Results: Recovery from diplopia was rapid and obvious within 1 year after surgical repair; nearly 80% of the patients were cured of diplopia at that time point, according to the curve. Approximately 85% of the patients would completely recover from diplopia over time, and the remaining patients would most likely have residual diplopia. Multivariate analysis demonstrated that patient age ($p < 0.001$), the time interval between injury and surgery ($p < 0.001$) and preoperative muscle swelling ($p = 0.028$) were factors predictive of residual diplopia.

Conclusion: Early intervention in pediatric patients with orbital blowout fracture is recommended to reduce the rate of residual diplopia. Swelling of the ocular muscle and younger age may result in a prolonged recovery time and a lower recovery rate from diplopia after surgery. The recovery from diplopia in pediatric patients appears to be stable 1 year after surgical repair. Therefore, a follow-up time of at least 1 year is recommended for an overall evaluation of residual diplopia in children.

1. Introduction

Orbital blowout fractures in the pediatric population have been widely discussed in the literature (Grant et al., 2002; Afrooz et al., 2012; Hammond et al., 2013; MacIsaac et al., 2013). Surgeons have reached a consensus on the diagnosis and treatment of pediatric blowout fractures, including specific subtypes such as “trapdoor fracture” or “white-eyed fracture.” However, diplopia remains a difficult complication after surgical repair, particularly in children.

Diplopia is a common complication of blowout fractures. The primary causes of diplopia include injury to the ocular muscles or nerve and entrapment of the muscle or soft tissues (Smith et al., 1984; Burnstine, 2002; Tahiri et al., 2010). The greater elasticity of the orbital bones in children makes entrapment more common, most likely resulting in edema, hemorrhage, or necrosis of the ocular muscle or connective tissues. Therefore, diplopia is a challenging issue for surgeons. Diplopia persists in up to 30% of patients even after proper surgical intervention and long-term follow-up (Harris et al., 2000). Residual diplopia is generally defined as no recovery from diplopia at the last follow-up for 6 months (Harris et al., 2000).

Our previous study discussed the possible factors associated with preoperative diplopia in cases of orbital blowout fractures in children, and briefly analyzed possible causes of residual diplopia (Su et al., 2015). The present study focused on assessment of the clinical prognosis of diplopia and the further identification of risk factors for residual diplopia in pediatric patients.

* Corresponding author. Department of Ophthalmology, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University, School of Medicine, No. 639 Zhizaoju Road, Shanghai, 200011, China. Tel.: +86 21 63135606; fax: +86 21 63134218.
E-mail address: fanxq@sh163.net (X. Fan).

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2. Material and methods

This study followed the tenets of the Declaration of Helsinki and was accepted by the Ethics Committee. Informed consents were obtained. Two of the authors retrospectively reviewed the medical records of patients who were diagnosed with blowout fractures at the Department of Ophthalmology from Jan 2008 to June 2014.

The following principal inclusion criteria for this study were used: 1) less than 18 years of age; 2) unilateral blowout fracture, confirmed using computed tomography; 3) diplopia preoperatively; and 4) surgical repair with a minimum follow-up of 1 year. Patients who had undergone previous surgical repair of an orbital or facial fracture, presented without diplopia preoperatively, exhibited visual loss, anophthalmos, or visual impairment, or presented with complex orbital fractures or bilateral blowout fractures were excluded. The medical records of 425 pediatric patients were reviewed; 135 pediatric patients met the inclusion criteria and were enrolled in this study.

The following information was collected for each patient: clinical data, including demographics, time interval between injury and surgery, fracture locations, clinical presentation, muscle swelling on preoperative CT, surgical procedures, and follow-up information. Muscle swelling was defined as an increase of more than 50% compared to the uninjured side, as estimated on the CT scan. Diplopia was examined using a synoptophore or Hess screen; it was defined as double vision in primary or reading gaze, which had an obvious effect on daily life. Recovery from diplopia was defined as no double vision.

The same surgical team performed all surgical procedures. Nonabsorbable materials, including Medpor® (Porex Surgical, Fairburn, GA, USA) and hydroxyapatite (YHJ Science and Trade Co., Beijing, China), and absorbable materials, including RapidSorb® (Synthes, West Chester, PA, USA), were used as implants.

The recovery curve for postoperative diplopia was analyzed using the Kaplan–Meier method. Cox proportional hazards analysis was performed to determine the factors predictive of residual diplopia. Factors associated with $p < 0.05$ in the univariate analysis were considered for the multivariate model. All statistical analyses were performed using SPSS v19.0 (IBM, Somers, NY, USA), and a two-tailed p-value <0.05 was considered statistically significant.

3. Results

A total of 135 patients were included in this study. Of these, 113 (83.7%) patients recovered from diplopia in a mean follow-up time of 13.7 months. The remaining 24 patients still exhibited diplopia in the primary or any other gaze direction. Seven of these patients presented with diplopia that affected their daily life. Two of these patients were given a prism to correct diplopia, two patients underwent strabismus surgery, and the remaining three patients were closely followed up.

Table 1 displays the clinical characteristics of patients subdivided by trapdoor and non-trapdoor fractures. Of the 135 patients, 23 (17.0%) were diagnosed with trapdoor fractures with entrapment of the extraocular muscle or soft tissues on CT scan and forced duction testing. Cox proportional hazards analysis revealed that age ($p = 0.045$) and muscle swelling ($p = 0.011$) were related to residual diplopia after surgery in patients with trapdoor fractures (Table 2). Twelve of these 23 (52.2%) patients exhibited extraocular muscle swelling before surgery, and 6 of these patients (54.5%) had residual diplopia after long-term follow-up. Only two (16.7%) patients without muscle swelling exhibited residual diplopia.

Fig. 1A shows the recovery curve for postoperative diplopia in 112/135 (83.0%) patients with non-trapdoor fractures. The recovery from diplopia was rapid and obvious within 1 year after surgical repair; nearly 80% of patients were cured of diplopia at that time point according to the curve. Approximately 85% of patients would completely recover from diplopia over time, and the remaining patients would most likely have residual diplopia.

Table 1
Clinical characteristics of pediatric patients with orbital blowout fracture.

Variable	Trapdoor fracture	Non-trapdoor fracture
Patients, n (%)	23 (17.0)	112 (83.0)
Sex, n (%)		
Male	12 (52.2)	85 (75.9)
Female	11 (47.8)	27 (24.1)
Age (y), Mean ± SD	7.35 ± 3.21	12.86 ± 4.67
Cause of injury, n (%)		
Motor vehicle accident	10 (43.5)	26 (23.2)
Activities of daily life	11 (47.8)	43 (38.4)
Sports	2 (8.7)	21 (18.8)
Assaults	0 (0)	22 (19.6)
Interval time (days), median	15	20
Fracture locations, n (%)		
Medial wall	3 (13.0)	23 (20.5)
Floor	18 (78.3)	50 (44.6)
Medial + floor	2 (8.7)	39 (34.8)
Ocular motility restriction, n (%)	20 (87.0)	92 (82.1)
Enophthalmos, n (%)	3 (13.0)	60 (53.6)
Muscle swelling, n (%)	12 (52.2)	23 (20.5)
Implant materials, n (%)		
Absorbable	4 (17.4)	4 (3.6)
Nonabsorbable	19 (82.6)	108 (96.4)
Operation time (min), median	60	85
Blood loss (mL), median	25	22.5
Residual diplopia, n (%)	8 (34.8)	16 (14.3)

Table 3 shows the predictive univariate factors for residual diplopia during the entire follow-up period in non-trapdoor fracture patients. Univariate analysis revealed that patient age, cause of injury, time interval between injury and surgery, and preoperative muscle swelling were significant ($p < 0.05$). Multivariate analysis revealed that patient age, time interval between injury and surgery and preoperative muscle swelling were the factors predictive for residual diplopia.

We subdivided these patients into three age groups based on the growth characteristics of their facial and orbital skeleton and their daily activities (Su et al., 2015): 0–6, 7–12, and 13–18 years of age (Table 4). Residual diplopia occurred most frequently in the 0–6 year age group, with a proportion of 21.1%. The average recovery time declined with age, with the longest time of 12.0 months in the 0–6 year age group and the shortest time of 3.8 months in the 13–18 year group. Fig. 1B illustrates a further analysis of residual diplopia and these subgroups using a Kaplan–Meier curve. Fig. 1B shows that the 13–18 year age group exhibited better outcomes than the other two age groups, but the curve of the youngest group was relatively flat and slowly rising, which indicates a longer recovery time from diplopia in younger patients.

The interval time between injury and surgery was subdivided into two periods according to the length of time that is generally discussed in the literature: ≤14 and >14 days. An interval of 14 days was highly significant with regard to residual diplopia. The proportion of residual diplopia in patients who were treated after 14 days was twice that of patients treated within 14 days (Table 4). Fig. 1C provides a concise illustration of the outcome and recovery from diplopia within and after 14 days. Non-trapdoor fracture patients who were treated after 14 days exhibited a worse outcome and longer recovery time from diplopia compared to patients who were treated within 14 days.

Multivariate analysis demonstrated that extraocular muscle swelling before surgical intervention was another predictive factor