Early Versus Late Repair of Orbital Blowout Fractures

Guy J. Ben Simon, MD; Hasan M. Syed, MD; John D. McCann, MD, PhD; Robert A. Goldberg, MD

■ **BACKGROUND AND OBJECTIVE:** To compare early and late surgical repair of orbital blowout floor fractures.

■ **PATIENTS AND METHODS:** A retrospective, comparative interventional case series reviewed medical records of 50 consecutive patients who underwent unilateral orbital floor fracture repair in a 4-year period. Comparative analysis was performed between patients operated on within 2 weeks of injury and those operated on at a later stage.

■ **RESULTS:** Assault, motor vehicle accidents, and sports injuries were the most common causes of injury. Surgery was performed due to inferior rectus muscle entrapment and limitations in up gaze in 20 (40%) patients or to prevent enophthalmos in cases with significant bony orbital expansion in 30 (60%) patients. After surgery, enophthalmos improved an average of 0.8 mm. Limitation in ocular motility improved after surgery but was statistically significant only in up gaze. Patients who underwent early repair (within 2 weeks) achieved less improvement in enophthalmos versus patients who underwent late repair (delta enophthalmos of 0.2 ± 1.1 vs 1.3 ± 1.9 mm, respectively; $P = .02$).

■ **CONCLUSION:** In these patients, postoperative vertical ductions and postoperative enophthalmos improved after fracture repair. Surgery was associated with a low rate of postoperative complications. No apparent difference in surgical outcome was seen between early (within 2 weeks) and late surgical repair.

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INTRODUCTION

Orbital blowout fractures occur in various blunt injuries, with the medial and inferior walls most commonly involved. Approximately half of the cases can develop late enophthalmos depending on the range of orbital tissue expansion into adjacent sinus cavities; approximately one-fourth of the patients develop diplopia due to ischemic muscle injury or restriction associated with displaced or traumatized muscle. Infraorbital nerve hypoesthesia may also occur.[1] Combined medial wall and floor fractures may be associated with ocular trauma in more than half of the cases. In most cases, diplopia resolves spontaneously so that enophthalmos is the most common late sequela of orbital fractures.

From the Jules Stein Eye Institute, Department of Ophthalmology, David Geffen School of Medicine at UCLA, Los Angeles, California.

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Address correspondence to Guy J. Ben Simon, MD, Goldschleger Eye Institute, Sheba Medical Center, Tel Hashomer, Israel 52621.

Orbital roof fractures are more common in children younger than 7 years, and more than two-thirds of the cases occur in boys. This may be a consequence of the lack of frontal sinus pneumatization and the relatively larger cranium in this age group. Multiple wall fractures, especially when the orbital roof is involved, are associated with increased risk of concurrent intracranial injury.[2,3] Computed tomography is the preferred imaging technique for evaluating orbital fractures, with coronal sections being the most sensitive for orbital floor involvement.[4] Saggital sections are more sensitive for demonstrating the anterior and posterior extent of floor fractures.

Current evidence for surgical intervention of orbital fractures includes "white eyed" blowout fractures, nonresolving oculocardiac reflex, and early enophthalmos. In cases of symptomatic diplopia, surgical repair is indicated within 2 weeks of trauma if there are large floor fractures with anticipated late enophthalmos or clinical or radiological evidence of orbital soft tissue entrapment. Surgery at a later stage may be associated with severe scar tissue formation, leading to a higher postoperative complication rate. Some advocate surgery at an even earlier stage in cases of suspected ischemic injury to extraocular muscles.[5]

The purpose of this study is to evaluate functional and aesthetic results of patients with orbital floor fractures who had surgery at an early stage (less than 2 weeks) after injury versus patients who had surgery months to years after injury.

PATIENTS AND METHODS

In our retrospective, comparative interventional case series, 50 consecutive electronic medical records of patients who underwent unilateral orbital floor fracture repair at the Jules Stein Eye Institute in a 4-year period (January 2000 to December 2003) were evaluated. Data regarding visual acuity, intraocular pressure, ocular motility, enophthalmos, associated ocular injuries, surgical reports, and preoperative and postoperative imaging studies were recorded and analyzed. Patients were then divided into two groups: "early repair" included those who underwent orbital surgery during the first 2 weeks after trauma and "late repair" included those who underwent surgery up to 3.5 years after the orbital trauma.

Surgical Technique

Surgery was performed because of inferior rectus muscle entrapment, limitation in up gaze, or anticipated enophthalmos in cases with significant bony orbital expansion. Orbital implants were used to bridge the fracture gap; fixation screws were used when stabilization of the implant could not be achieved. In general, patients with fractures with anticipated enophthalmos of 1 mm or less and no clinical evidence of inferior rectus entrapment were not operated on. The study complied with the policies of the local Institutional Review Board and was compliant with the Health Insurance Portability and Accountability Act.

Statistical Analysis

Statistical analysis was performed using the paired samples t tests to evaluate preoperative and postoperative data such as visual acuity, intraocular pressure, ocular motility, and enophthalmos. The chi-square non-parametric test was used to evaluate the trauma history in different age groups. Pearson bivariate correlation was used to examine the influence of age, time from injury to surgical repair, degree of enophthalmos, number, and cross-sectional area of implants on clinical outcome.

Independent samples t tests were used to examine the difference in enophthalmos correction and motility improvement between early and late repair groups. The Wilcoxon Mann Whitney related samples non-parametric test was used to compare surgical outcomes between patients younger than 18 years and older patients, as well as for a comparison of patients who were operated on within the first year after injury to those who were operated on more than 1 year after the injury. Statistical analysis was performed using Microsoft Excel 2003 (Microsoft Corporation, Redmond, WA) and SPSS version 12.0 (SPSS, Inc., Chicago, IL) programs.

RESULTS

Fifty patients (37 men, 13 women; mean age = 33 years) underwent orbital surgery for blowout fractures during the follow-up period. Demographics of the study population are summarized in Table 1. Isolated orbital floor fractures were the most common pattern with 34 (68%) patients, followed by floor and medial wall fractures with 14 (28%) patients (Table 2). Assault was the most prevalent cause of orbital trauma with 22 (44%) patients, followed by motor vehicle accidents

TABLE 1

Demographics of 50 Consecutive Patients Who Underwent Orbital Blowout Fracture Repair at the Jules Stein Eye Institute in a 4-Year Period

Variable	No. ± SD (range)
No. of patients	50 (37 men, 13 women)
Age (y)	33 ± 18 (range: 6 to 85)
Side of fracture	
Right	21 (42%)
Left	29 (58%)
History	
Assault	22 (44%)
MVA	8 (16%)
Sports/recreation	8 (16%)
Trauma/other	5 (10%)
Fall	5 (10%)
FESS	2 (4%)
Time to surgery	4 ± 8.5 mo. (range: 1 day to 3.5 years)
Follow-up (mo.)	3.6 ± 1.9 (3 to 12)

SD = standard deviation; MVA = motor vehicle accident; FESS = functional endoscopic sinus surgery.

TABLE 2

Orbital Fracture Characteristics and Type of Implant Used in Surgical Repair

Characteristics	No. (%)
Concomitant eye injury	
Globe rupture[a]	2
Cornea laceration	8
No. ocular injury	40
Fracture type[b]	
Floor	34 (68%)
Floor/medial wall	14 (28%)
Floor/lateral wall	2 (4%)
Implant	
No implant	2 (4%)
Medpore	22 (44%)
Lactasorb	12 (24%)
Other	8 (16%)
Bone	4 (8%)
Titanium mesh	2 (4%)
No. of implants	
1	34 (68%)
2	12 (24%)
3	2 (4%)
4	2 (4%)

[a]One patient underwent primary repair but visual acuity remained at no light perception due to optic nerve avulsion or traumatic optic neuropathy; the other patient underwent evisceration with implant along with orbital fracture repair.
[b]Three patients had bilateral orbital fracture but had surgery on just one side.

and sports injuries with 8 (16%) patients in each category. Patients older than 17 years were more likely to sustain orbital fractures as a result of an assault than younger patients ($P < .000$; χ^2 test).

Although concomitant ocular injury was not common, there were two cases of globe rupture, one resulting in evisceration and the other resulting in a final visual acuity of hand motions. Eight additional cases had minor corneal lacerations that resulted in no decrease in visual acuity after primary repair.

Twenty (40%) patients had clinical and radiographic evidence of inferior rectus muscle entrapment (Figs. 1 and 2); they exhibited severe limitations in vertical ductions compared to patients with no entrapment ($P < .001$, independent samples t test). They also achieved better improvement in ocular motility after surgery ($P = .05$) (Table 3; Figs. 3 and 4). Of the 34 (68%) patients who had enophthalmos preoperatively, 20 patients had enophthalmos of 2 mm or greater. Patients with more severe enophthalmos were less likely to have severe limitations in vertical ductions compared to patients without enophthalmos (r = -0.7, $P = .04$, Pearson bivariate correlation).

Surgery was performed because of either inferior rectus muscle entrapment or limitations in up gaze in 20 (40%) patients or anticipated enophthalmos in cases with orbital tissue expansion into the maxillary or ethmoidal sinuses in 30 (60%) patients.

Average time (± standard deviation) elapsed from injury to orbital surgery was 4 months (± 8.5 months) (range = 1 day to 3.5 years), although most patients (27; 54%) were operated on within 2 weeks of orbital trauma. Overall, 40 (80%) patients were operated on within the first year after injury, and the others were operated on up to 3.5 years after the orbital fracture.

Following surgery, visual acuity remained unchanged (mean = 20/25 preoperatively and 20/30 postoperatively). Intraocular pressure increased after surgery but remained within normal limits (Table 4). Enophthalmos markedly improved an average of 0.8 mm (± 1.6 mm) from a preoperative mean of 1.6 mm

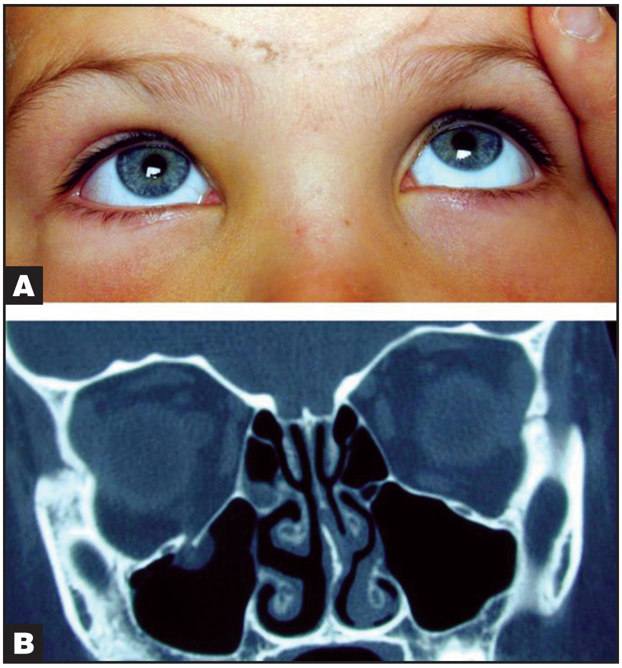

Figure 1. A 6-year-old child after blunt orbital trauma while playing a sport. (A) Clinical and (B) radiographic evidence of right orbital trap door fracture with inferior rectus muscle entrapment.

(± 1.7 mm) to a postoperative mean of 0.8 mm (± 1.4 mm) (P = .002, paired samples t test; Fig. 5). Older age was associated with more severe postoperative enophthalmos (r = .4, P = .03, Pearson correlation). Larger implants were used in patients with more severe enophthalmos (r = .7, P = .001). Positive correlation was found between the number of implants and implant size to the change in enophthalmos (r = .4, P = .007, and r = .5, P = .02, respectively). Surgery at a later stage was associated with a larger number of implants (r = .5, P = .02). Limitations in globe motility improved after surgery, but this was only statistically significant in up gaze (a score of -1.4 preoperatively to -0.7 postoperatively, P < .001) (Fig. 6).

When comparing surgical outcomes among early repair (1 day to 2 weeks after the injury) and late repair (1 month to years after the injury), patients with early repair had less preoperative enophthalmos compared to patients with later repair (1 ± 1 mm vs 2.3 ± 2.1 mm, P = .008, independent samples t test). This is probably because orbital swelling had not resolved completely; therefore, these patients achieved less improvement in enophthalmos (delta enophthalmos of 0.2 ± 1.1 mm vs 1.3 ± 1.9 mm, P = .02, Wilcoxon Mann Whitney independent samples t test). There were similar improvements in supraductions and infraductions post-

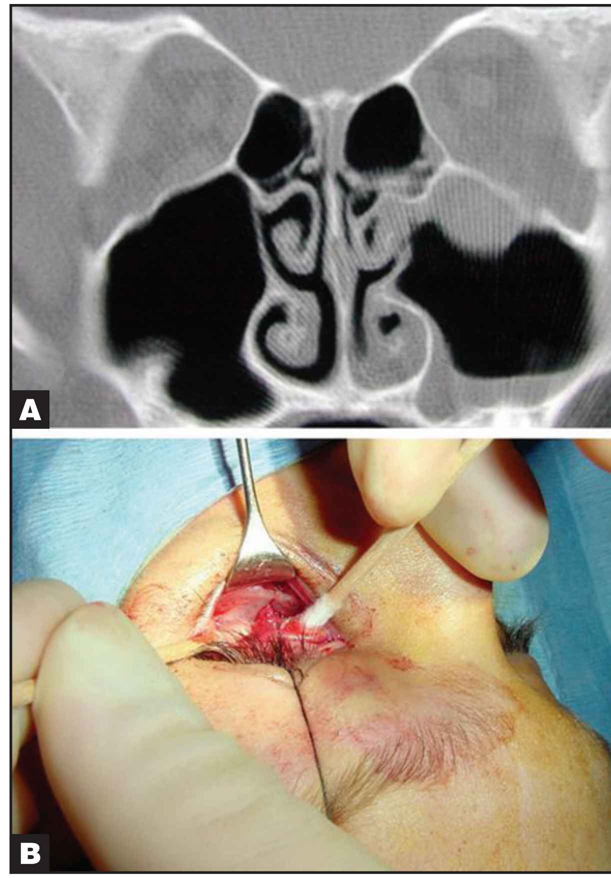

Figure 2. (A) Computed tomography scan of the coronal section of the orbits of an 11-year-old boy with left orbital floor fracture. (B) Intraoperative photograph of inferior rectus muscle entrapment in the orbital floor fracture.

operatively in both groups. Postoperative visual acuity, intraocular pressure, and lateral ocular duction were also similar in both groups (Table 5). Surgical outcome was not different between the various types of implants. However, due to small numbers in each group, a definitive conclusion cannot be made. Clinical outcome was similar in patients younger than 18 years compared to older patients (Wilcoxon Mann Whitney test).

Forty (80%) patients were operated on in the first year after orbital injury. There was no difference in any of the clinical parameters, such as enophthalmos correction, visual acuity, or postoperative limitations of ocular ductions, compared to patients who were operated on at a later stage.

Complications included one case of postoperative optic neuropathy with decreased visual acuity from 20/25 preoperatively to 20/80 with +2 afferent pupillary defect 3 months postoperatively. Of note, this patient sustained a brain concussion and was unconscious

TABLE 3

Preoperative and Postoperative Vertical Ductions in Patients Operated on for Orbital Blowout Fracture at the Jules Stein Eye Institute in a 4-Year Period[a]

	Muscle Entrapment (n = 20)				No Muscle Entrapment (n = 30)			
	Up		Down		Up		Down	
Motility	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop
0	0	10	13	13	16	22	23	24
-1	6	5	2	3	4	4	5	3
-2	8	2	4	2	8	2	2	3
-3	5	2	1	2	2	2	0	0
-4	1	1	0	0	0	0	0	0

Preop = preoperative; Postop = postoperative; 0 = normal motility; -1 = mild restriction; -2 = moderate; -3 = severe; -4 = no motility.
[a]Patients are divided into those with inferior rectus muscle entrapment and those without inferior rectus muscle entrapment (the number of patients in each category is shown in the table). Motility was graded on a scales of 0 to -4 , with 0 indicating normal motility and -4 indicating no motility.

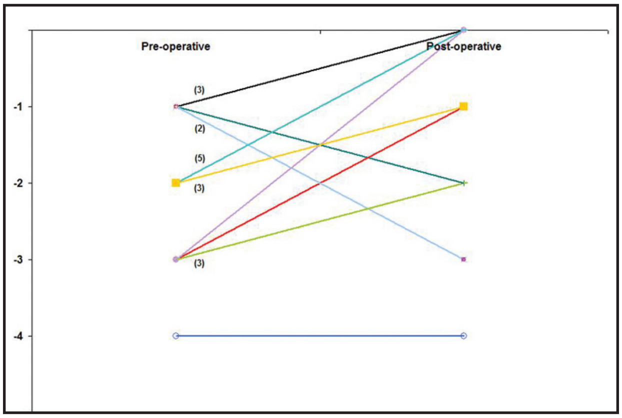

Figure 3. Preoperative and postoperative limitations in up gaze in patients with clinical and radiographic evidence of muscle entrapment. Y axis is motility score (0 to -4), each line is one or more patients.

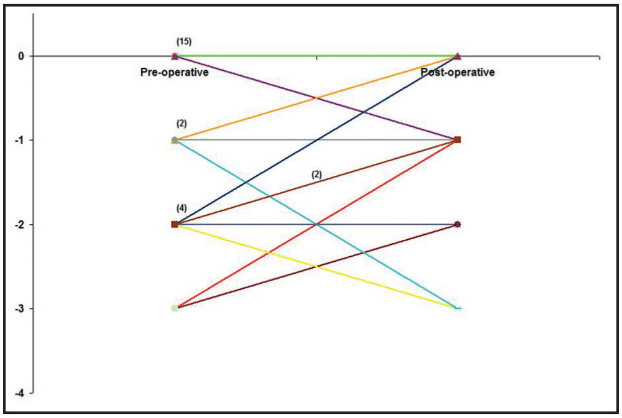

Figure 4. Preoperative and postoperative limitations in up gaze in patients without muscle entrapment. Y axis is motility score (0 to -4), each line is one or more patients.

for 1 week following the head trauma and had preoperative bilateral central scotomas in computerized central 10-2 visual fields. One case of postoperative periorbital cellulitis that resolved with an oral antibiotic and one case of postoperative orbital apex syndrome that resolved spontaneously were observed.

DISCUSSION

In our patients, surgery for orbital blowout fractures resulted in similar outcomes regardless of the timing of the repair. Patients who were operated on at an early stage had similar improvement in enophthalmos and ocular ductions when compared to patients who were operated on later. Assault and interpersonal violence were among the most common causes of orbital floor fracture, although sports and recreational activities were also responsible for a sizable portion of injuries in younger patients, which is similar to previous reports.[6] Surgical timing of orbital fractures remains controversial. Some investigators advocate a conservative approach to blowout fractures,[7-9] especially in cases of floor fractures with intact periorbita,[10] whereas others advocate early repair.[5,6,11-17]

Putterman et al.[7] observed 57 patients with orbital floor fractures without surgery (28 patients were evaluated retrospectively and 29 patients prospectively). At the time of their last examination, almost all patients were free of visually disturbing diplopia in the functional position of gaze, although two-thirds of the patients had primary gaze diplopia and limitation in vertical ductions at the initial examination. Twenty percent of the patients had diplopia in the extreme positions

TABLE 4

Preoperative and Postoperative Data for 50 Patients Undergoing Orbital Blowout Fracture Repair at the Jules Stein Eye Institute in a 4-Year Period

Variable	Preoperative (Mean ± SD)	Postoperative (Mean ± SD)	P^a
Visual acuity	20/25	20/30	NS
Intraocular pressure (mm Hg)	9.1 ± 7.6	13.8 ± 5.5	.036
Enophthalmos (mm)	1.6 ± 1.7	0.8 ± 1.4	.002
Motility[b]			
Up	-1.4 ± 1.2	-0.7 ± 1.1	< .001
Right	-0.4 ± 0.8	-0.3 ± 0.8	NS
Down	-0.4 ± 0.8	-0.4 ± 0.8	NS
Left	-0.3 ± 0.9	-0.3 ± 0.9	NS

SD = standard deviation; NS = not significant.
[a]P was calculated using paired-samples t test.
[b]Ocular duction limitations were evaluated on a scale of 0 to -4, with 0 indicating normal motility and -4 indicating no motility.

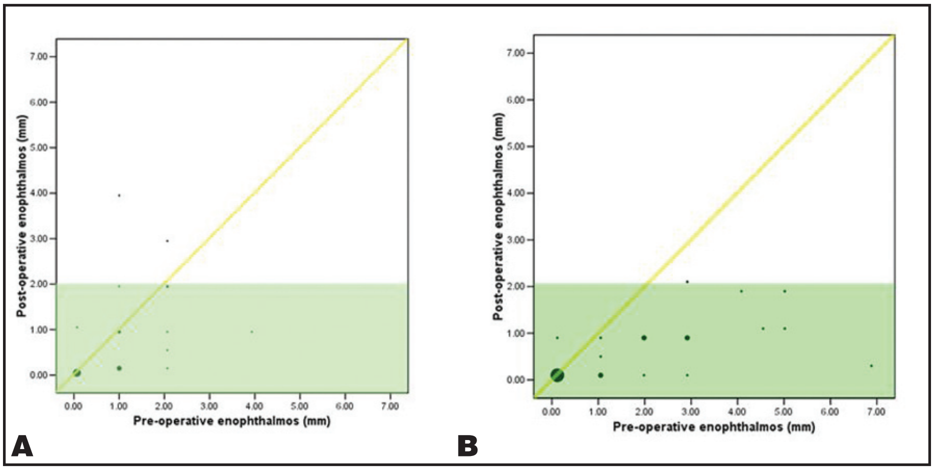

Figure 5. Scattergram of preoperative and postoperative enophthalmos (mm) in 50 patients operated on for orbital blowout fractures at the Jules Stein Eye Institute. Patients were divided according to (A) early repair (within 2 weeks of injury) and (B) late repair. Most of the patients in both groups had less than 2 mm enophthalmos postoperatively (green area). Marker size is a count indicator for number of patients in each point.

of gaze. None of the patients desired surgical correction for enophthalmos. The authors concluded that the basic cause of symptoms is hemorrhagic edema of the orbital fat with or without prolapse into the maxillary sinus and not a trapped inferior rectus muscle. However, at the time of their work, computed tomography of the orbits was not performed and the age distribution of patients was not reported.

Ellis and Reddy[18] published a series on 58 patients who were operated on for zygomaticomaxillary complex (ZMC) fractures without internal orbital reconstruction. They concluded that, in cases of ZMC fractures with minimal or no soft tissue herniation and with minimal distortion of the internal orbit, ZMC reduction is adequate in realigning the orbital fractures, with no postoperative orbital expansion or soft tissue sagging.

Most investigators advocate for early fracture repair, especially in young patients with severely restricted ocular motility. Bansagi et al.[17] found that trap door fractures with clinical evidence of entrapment may be associated with minimal findings on computed tomography scans. It was also shown that early repair is important to reduce the rate of complications and improve ocular motility. Delayed surgery was associated with postoperative diplopia.[15]

Matteini et al.[19] investigated 108 consecutive cases of orbital fractures and recommended early surgery in children and adults with diplopia or in cases of associated injuries such as orbital apex fracture, cerebrospinal fluid leak, and penetrating injuries. Delayed surgery can be performed on orbital wall fractures that do not involve the orbital rim. Other investigators, however, did not find any difference in

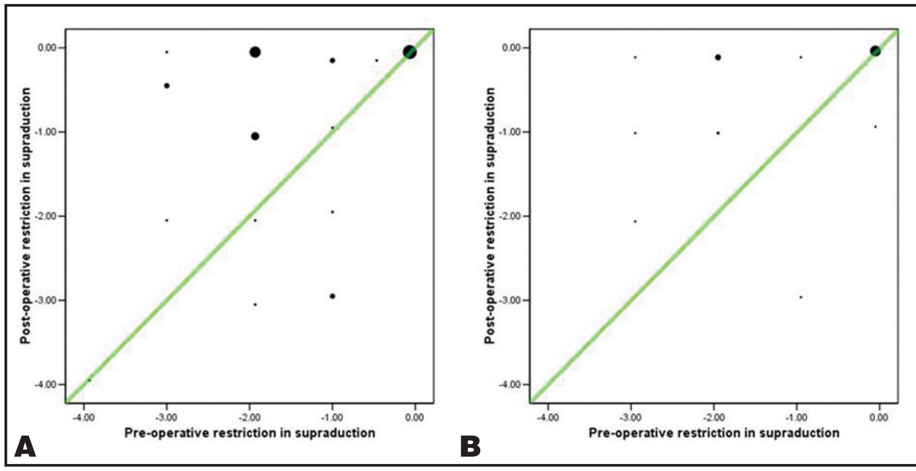

Figure 6. Scattergram of preoperative and postoperative limitations in supraduction in 50 patients operated on for orbital blowout fractures at the Jules Stein Eye Institute. Patients were divided according to (A) early repair (within 2 weeks of injury) or (B) late repair. Limitations in supraduction were graded on a 0 to -4 scale, with 0 indicating normal motility and -4 indicating no motility. Patients in both groups had similar improvement in supraduction postoperatively. Marker size is a count indicator for number of patients in each point.

TABLE 5

Comparison of Early (Within 2 Weeks) Versus Late Repair of Orbital Fracture in 50 Patients Who Were Operated on at the Jules Stein Eye Institute in a 4-Year Period

Variable	Early Repair (n = 27)	Late Repair (n = 23)	*P*
Delta visual acuity[a]	-0.06	-0.03	NS
Delta IOP (mm Hg)[b]	4.3 ± 7.2	5.6 ± 10.7	NS
Delta enophthalmos (mm)[c]	0.2 ± 1.1	1.3 ± 1.9	.02
Delta motility[d]			
Up	0.6 ± 1.3	0.7 ± 1.2	NS
Right	0 ± 1.3	0.2 ± 0.8	NS
Down	-0.4 ± 1.0	0.4 ± 0.6	NS
Left	-0.4 ± 1.0	0.1 ± 0.6	NS

IOP = intraocular pressure; NS = not significant.
[a]Calculated as logarithm of the minimum angle of resolution (postoperative visual acuity) – logarithm of the minimum angle of resolution (preoperative visual acuity).
[b]Calculated as IOP (postoperative) – IOP (preoperative).
[c]Calculated as enophthalmos (postoperative) – enophthalmos (preoperative).
[d]Ocular duction limitations were evaluated on a scale of 0 to -4, with 0 indicating normal motility and -4 indicating no motility.

ophthalmologic findings and ocular motility in cases of isolated orbital floor fractures between patients undergoing surgery and those who did not after 3 months.[20]

In general, immediate intervention is indicated in cases of diplopia with imaging evidence of entrapped muscle or periorbital tissue. Other indications include the "white-eyed blowout fracture" in young patients with marked limitation in extraocular motility, nonresolving oculocardiac reflex, minimal ecchymosis or edema, and imaging evidence of floor fracture with entrapment.[6,21] Early intervention is recommended to avoid difficult repair associated with soft tissue scarring into fracture sites. Most advocate intervention within 2 weeks in patients with symptomatic diplopia and positive forced-duction test with evidence of entrapment or large floor fracture with anticipated latent enophthalmos on computed tomography scans.[21]

Adult patients with restriction in ocular motility after orbital fracture may show gradual improvement over time because restriction is often caused by nerve damage, orbital edema, or hemorrhage rather than true muscle entrapment. However, when there is imaging evidence of inferior rectus muscle entrapment, resolution with conservative treatment and steroids is unlikely and prompt surgery is required.[22,23]

Pitfalls of our study stem from its retrospective design. All patients in the study were operated on, so we cannot decipher the natural history of fracture healing. The mean age of our patients was 33 years; therefore, our conclusions may apply more aptly to young adults and not to the pediatric population.

It is important not to defer surgery in orbital fractures with inferior rectus entrapment, especially if the muscle is tightly entrapped in a small fracture. In young adults, ocular ductions limitations that result from blunt muscle and soft tissue trauma without evidence of frank entrapment may resolve 6 to 9 months following the injury. Late surgery seems to result in similar outcomes as early surgery. In cases with mild orbital volume expansion, especially when the maxillo-ethmoidal strut and the fronto-ethmoidal struts are intact, one may consider deferring surgery to a later stage.

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