Clinical correlation between ocular injuries and the characteristics of orbital wall fractures

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Clinical correlation between ocular injuries and the characteristics of orbital wall fractures

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Seong-Hee Min

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Abstract

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Purpose: To assess the clinical association of traumatically induced ocular injuries and characteristics of blowout fractures.

Methods: Retrospective review of medical records and orbital computed tomography (CT) of 183 patients from January 2004 to May 2007.

Results: The number of vision threatening ocular injuries and associated facial bone fractures increase in larger blowout fractures.

Conclusion: The incidence of vision threatening ocular injuries increase as the size of the blowout fractures increases. This may indicate that direct impact on the globe may result blowout fractures which favors the hydraulic theory.

Key words: blowout fracture, computed tomography, ocular injury

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I. INTRODUCTION

Orbital blowout fractures commonly occur in blunt facial trauma. Thinnest areas of the bony orbit, inferior and medial wall, are frequently involved. The most common clinical presentation is pure blowout fracture where edges of the orbit remain undamaged.[1,2]

Because it occurs behind the orbital rim, the exact mechanism of orbital blowout fractures has been the subject of debate for many years. The two most accepted theories in the mechanism of blowout fractures are the buckling and hydraulic theory.[3-8]

The concept of the buckling theory was first introduced by Le Fort[3] in 1901, proposing that a traumatic force is conducted through orbital rim to cause blowout fracture of orbital wall. Several clinical and experimental studies have been reported to support the buckling mechanisms.[8-12] The hydraulic theory, postulated by Pfeiffer in 1943, assumes that direct injury on the globe, not the orbital rim, is transferred to orbital walls.[6] Several Subsequent experimental studies consistently supported this theory.[6,713,14] Recent experimental studies suggest both of mechanisms may contribute in the blowout fractures.[15,16]

There also have been numerous attempts to describe the association between ocular injuries and the mechanism of blowout fractures.[7,17-27] The incidence varies widely, and no study has reported the clinical association between vision threatening ocular injuries in relation with the size of blowout fractures.

This study was performed to evaluate the exact incidence of ocular injuries and assess the clinical correlation between vision threatening ocular injuries and the size of blowout fractures.

II. MATERIALS AND METHODS

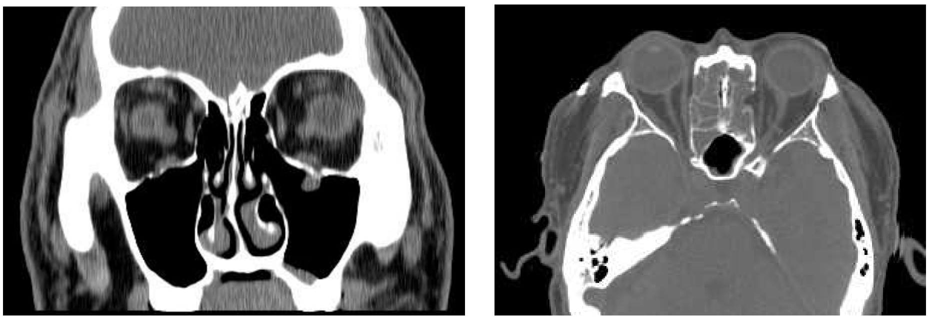
1. Subjects

Medical records of 689 consecutive patients with diagnosis of orbital wall fracture by blunt orbital trauma in the Severance Hospital Emergency department or Department of Ophthalmology from January 2004 through May 2007 were retrospectively reviewed. 183 non-consecutive patients were included in this study. Patients with the following conditions were included: (1) patients with pure blowout fracture(s) of inferior, medial, or inferomedial walls, (2) positive computed tomography (CT) findings, and (3) a full ophthalmologic examination within 4 days of injury. The medical records were reviewed for the following information: age, gender, side and vector of the injury, date to presentation to the hospital, and ophthalmologic examination with gross inspection, ocular motility evaluation including forced duction test, exophthalmometry, slit lamp examination, and retinal biomicroscopy.

2. The grading of orbital wall fractures

To identify clinical levels of blowout fractures, the CT axial and coronal images with 3-mm slices were obtained within 4 days of injury.

Blowout fractures were classified in three grades according to the degree of orbital volume expansion. The coronal CT images in the evaluation of inferior wall fractures, and the axial CT images in the evaluation of medial wall fractures were used. Grade 1 blowout fracture was defined as minimal orbital expansion with soft tissue prolapse (Figure 1); grade 2 as moderate expansion with soft tissue prolapse (Figure 2); and grade 3 as significant expansion with soft tissue prolapse (Figure 3).



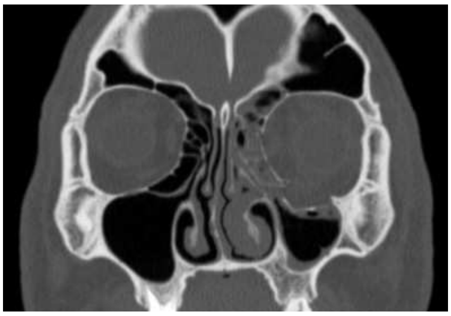
(a) (b)

Figure 1. Grade I blowout fractures. (a) Minimal inferior wall fracture with soft tissue entrapment in the coronal CT image. (b) Minimal medial wall fracture in the axial CT image.

(a) (b)

Figure 2. Grade II blowout fractures. (a) Moderate inferior wall fracture with soft tissue prolapse in the coronal CT image. (b) Moderate medial wall fracture with soft tissue prolapse in the axial CT image.

(a) (b)



(c)

Figure 3. Grade III blowout fractures. (a) Significant inferior wall fracture with soft tissue prolapse in the coronal CT image. (b) Significant medial wall fracture with soft tissue prolapse in the axial CT image. (c) Significant inferomedial wall fracture with soft tissue prolapse in the axial CT image.

3. The statistical analysis

For the statistical analysis of the number of vision threatening injuries, and the grading of blowout fractures, Pearson chi-square test was used. One-way analysis of variance (ANOVA) was used to compare age in three groups of blowout fractures. The association between vision, presence of vision threatening ocular injuries, associated facial bone fractures and grade was assessed using linear by linear association.

Statistical calculations were performed using the SPSS version 13.0 (SPSS Inc., Chicago, IL) for Windows program. The level of statistical significance was set at $P<0.05$.

III. RESULTS

1. Patient characteristics

Patient's age ranged from 6 to 90 years, with a mean age of 32.4 years; 143 (78.1%) were male and 40 (21.9%) were female (Table 1). Table 2 provides a summary of patient characteristics. There are no differences in gender, age, and laterality in three blowout fracture groups ($p>0.05$). Table 3 shows vector of injuries. Violence is the leading cause of blowout fractures including 109 patients (45.9%).

Table 1. Age and sex distribution.

Age (years)	Number of patients (%)		
	Male (%)	Female (%)	Total (%)
0-9	5 (2.7)	2 (1.1)	7 (3.8)
10-19	35 (19.1)	4 (2.2)	39 (21.3)
20-29	47 (25.7)	4 (2.2)	51 (27.9)
30-39	30 (16.4)	5 (2.7)	35 (19.1)
40-49	17 (9.3)	6 (3.3)	23 (12.6)
50-59	5 (2.7)	8 (4.4)	13 (7.1)
>60	4 (2.2)	11 (6.0)	15 (8.2)
Total	143 (78.1)	40 (21.9)	183 (100)

Table 2. Patients' characteristics.

	Grade I fracture (n=71)	Grade II fracture (n=50)	Grade III fracture (n=62)	*P*-value
Gender				
Male	54 (29.5%)	40 (21.9%)	49 (26.8%)	0.856*
Female	17 (9.3%)	10 (5.5%)	13 (7.1%)	
Age[1]	33.1±20.7	29.1±18.4	34.5±14.6	0.272†
Laterality				
Right	30 (16.4%)	25 (13.7%)	22 (12.0%)	0.302*
Left	41 (22.4%)	25 (13.7%)	40 (21.9%)	

*Pearson chi-square.

†One-way analysis of variance (ANOVA).

[1]Age in years, mean ± standard deviation.

Table 3. Vector of injuries.

Vector		Number of patients (%)	
Violence		85 (46.4)	
	Fist		68 (37.2)
	Foot		4 (2.2)
	Others		13 (7.0)
Slip down			39 (21.3)
Sports injury			26 (14.2)
Traffic accidents			21 (11.5)
	Incar		13 (7.1)
	Outcar		3 (1.6)
	Motorcycle		5 (2.7)
Falling down			3 (3.3)
Industrial injury			3 (1.6)
Unknown[1]			3 (1.6)
Total			183 (100)

[1] Drunken status and decreased mental status are included.

2. Grading of blowout fractures

183 patients with blow out fractures were classified in three groups according to the degree of orbital volume expansion and soft tissue prolapse in orbital CT findings (table 3). The patients were evenly distributed in three groups.

Table 4. Grading of blowout fractures.

Grade*	Number of patients (%)
I[1]	71 (38.8)
II[2]	50 (27.3)
III[3]	62 (33.9)
Total	183 (100)

*Coronal and axial CT images were evaluated.

[1]Minimal orbital expansion and soft tissue prolapse.

[2]Moderate orbital expansion and soft tissue prolapse.

[3]Significant orbital expansion and soft tissue prolapse.

3. Correlation of ocular injuries and the size of blowout fractures

Associated intraocular and extraocular injuries are listed in table 5 and 6. Hyphema is the most common and commotion retina is the second most common intraocular injury. Vision threatening ocular injuries are defined as those injuries that could result the best corrected visual acuity (BCVA) less than 20/100 in snellen chart: globe rupture, hyphema, lens dislocation, traumatic cataract, commotio retina, retinal and subretinal hemorrhage, retinal tear, vitreous hemorrhage, retinal detachment, choroidal rupture, macular hole, intraorbital hemorrhage, and traumatic optic neuropathy (table 7). The number of vision threatening ocular injuries increase as the size of blow out fracture increases (p=0.001). Most vision threatening injuries are intraocular injuries. The incidence of associated facial bone fractures increases in higher grade of blowout fractures (p=0.003).

Table 5. Intraocular injuries associated with blowout fractures.

Intraocular injuries	Number of patients (%)
Hyphema	68 (37.2)
Gross	8 (4.4)
Microscopic	60 (32.8)
Commotio retina	53 (29.0)
Iritis	33 (18.0)
Retinal/subretinal hemorrhage	11 (6.0)
Choroidal rupture	6 (3.3)
Lens dislocation	6 (3.3)
Vitreous hemorrhage	5 (2.7)
Retinal tear	4 (2.2)
Traumatic cataract	4 (2.2)
Macular hole	3 (1.6)
Globe rupture	3 (1.6)
Retinal detachment	1 (0.4)
Total number of patients with intraocular injuries[1]	118 (64.5)

[1]The total number of patients is less than the sum of intraocular injuries because a patient with multiple injuries is counted as one in total.

Table 6. Extraocular injuries associated with blowout fractures.

Extraocular injuries	Number of patients (%)
Eyelid laceration	43 (23.5)
Facial bone fracture	39 (21.3)
Intraorbital hemorrhage	19 (10.4)
Canalicular laceration	7 (3.8)
Facial laceration	4 (1.7)
Traumatic optic neuropathy	7 (3.8)
Total number of patients with extraocular injuries[1]	65 (35.5)

[1]The total number of patients is less than the sum of extraocular injuries because a patient with multiple injuries is counted as one in total.

Table 7. Assessment of injuries.

	Grade I (n=71)	Grade II (n=50)	Grade III (n=62)	*P*-value*
Visual acuity[1]				
≤ 20/100	7 (3.8%)	8 (4.4%)	15 (8.2%)	0.027
≥ 30/100	64 (35.0%)	42 (23.0%)	47 (25.7%)	
Vision threatening ocular injuries[2]				0.002
None	35 (19.5%)	27 (14.8%)	14 (7.7%)	
Present	36 (19.7%)	23 (12.6%)	48 (26.2%)	
Associated facial bone fracture[3]				0.003
None	62 (33.9%)	41 (22.4%)	41 (22.4%)	
Present	9 (4.9%)	9 (4.9%)	21 (11.5%)	

*Chi-square test with linear by linear association.

[1]Best corrected visual acuity at the first visit.

[2]Globe rupture, hyphema, lens dislocation, traumatic cataract, commotio retina, retinal and subretinal hemorrhage, retinal tear, vitreous hemorrhage, retinal detachment, choroidal rupture, macular hole, intraorbital hemorrhage, and traumatic optic neuropathy.

[3]Nasal , zygomaticomaxilla complex and mandible fractures.

IV. DISCUSSION

Theoretically, more serious trauma related ocular injuries are expected with the hydraulic theory because the force is directly delivered to the globe, and less serious ocular injuries are anticipated in the buckling theory because the force is applied to the rim, not the globe.

Clinically, most ocular injuries in majority of blowout fracture patients are transient and do not compromise vision. From this clinical impression, we had previous assumption of favoring the buckling theory when we first started this study. We assumed that if the traumatic force is distributed to the globe, periorbital tissue, and orbital wall, the globe could be protected from serious ocular injuries. But when we analyzed the association of ocular injuries with respect to the size of blowout fractures, the incidence of vision threatening ocular injuries increased as the size of blowout fractures increase. This positive clinical association between ocular injuries and the size of the orbital wall fractures favors the hydraulic theory.

Various documentations on ocular injuries have been reported. But there is no consensus on the incidence of ocular injuries because each observer used different method and extent of evaluation. Due to the characteristic transient nature of trauma population, many previous reports failed to include early formal ophthalmic examinations. Several reports have analyzed ocular injuries in cases of periorbital trauma.[17-27] Early studies presented symptoms of blowout fractures without numerical analysis.[17,18] Later works presented data of ocular injuries with numerical analysis.[19-24] But the incidence of ocular injuries widely varies from 4% to 67%.[19,20] Most reports regarded both intraocular and extraocular injuries including subconjunctival hemorrhage, iritis, canalicular, lid, and facial lacerations which do not cause subsequent visual decrement and often do not resulted from direct globe injuries. Some reports included symptoms of blowout fractures, such as diplopia, enophthalmos, and exophthalmos. Recent reports describe more detailed incidence of intraocular and extraocular injuries.[25-27] He et al defined ocular injuries that could be related to the direct injury to the globe, including traumatic mydriasis, traumatic iritis, hyphema, lens dislocation, commotio retina, subretinal hemorrhage, retinal detachment, choroidal rupture, eyeball rupture, and traumatic optic neuropathy.[27] He reported 22% of blowout fracture related ocular injuries. This wide range of previously reported ocular injuries occurred because each study used different method and extend of evaluation. The characteristic transient nature of ocular trauma and inconsistent timing of ocular examination from the onset of ocular injury also draw concern on the possibility of nondetected ocular injuries especially in early post-trauma period.

In this study, we included ocular findings which could result visual decrement from the direct ocular trauma. For the purpose of this study, “vision threatening” ocular injuries were defined as those with potential of visual decrement. To do so, cases with initial BCVA of less than 20/100 from the ocular trauma were reviewed and injuries which could result such visual decrement were included as “vision threatening” ocular injuries.

Results of this study showed that 58.5% (107 patients) of blowout fracture patients were associated with positive findings of ‘vision threatening’ ocular injuries.

This incidence is high, but it is still similar to some of previous reports despite they included different spectrum of ocular injuries.[20,26]

Although not all 107 patients with vision threatening ocular injuries showed initial BCVA less than 20/100, statistically significant increase in the number of patients with BCVA less than 20/100 was noted in larger blowout fractures (p=0.027).

The most common ocular injury was hyphema (37.2%, 68 patients). This is higher than previous reports. He at al reported only 3.75%[27] and Lee at al reported 13.5%[25] in their studies of blowout fractures. Most traumatic hyphema are microscopic hyphema and resolve within a week. The significantly high incidence of hyphema in this study resulted probably because we included only cases which had undergone a full ophthalmic examination within 4 days from injury. Previous studies could not include such cases.

The number of patients with hyphema increased in larger blowout fractures (p=0.000, Pearson chi-square test with linear by linear association). Most patients showed microscopic hyphema which do not compromise vision whereas the presence of gross hyphema (8 patients) significantly affected their vision. The magnitude of force varies in clinical situation. Increased incidence of hyphema and the size of blowout fractures would result in patients struck by stronger traumatic force.

The commotio retina (53 patients, 29%), the second most common ocular injury, did not show statistically significant positive relationship with the size of blowout fractures (p=0.856, Pearson chi-square test) in this study. The incidence agrees with previous reports which ranged from 9%[27] to 36.8%.[26] Some injuries included in grade 3 patients, such as gross hyphema, vitreous hemorrhage, and subretinal hemorrhage, could have obstructed clear evaluation of posterior segments. However, when we consider the relationship between the presence of vision threatening ocular injuries and the size of blowout fractures, the number of patients with vision threatening ocular injuries increased as the size of blowout fractures become larger (p=0.002).

The mechanism of blowout fractures has been debated for many years. Two principal mechanisms are the buckling and the hydraulic theories concerning the traumatic force to the orbital rim and the globe, respectively. The buckling theory was originally proposed by Le Fort[3] in 1901 from his clinical experiences. It was subsequently investigated by Fujino et al[8] by placing impacts onto infraorbital rim of dried human skull. Phalen et al[12] experimentally repeated Fujino's study by delivering impacts to the infraorbital rims of dry skulls and human cadaver specimens. These studies demonstrated that blowout fractures could be produced by impact on the orbital rims without direct impact to the globe. The concept of the buckling theory was challenged by Pfeiffer in 1943 for the first time.[6] He postulated the hydraulic theory after his observation of 24 orbital blowout fractures. Experimental study using a human cadaver by Smith and Regan showed that the hydraulic force was necessary for blowout fractures.[7] This conclusion was further supported by Green et al and Rhee et al in their experimental studies.[13,14] Recent experimental studies were able to produce blowout fractures by both mechanisms under the same experimental conditions.[15,16] However, in clinical situations, vectors of trauma are enormously variable and cannot be classified. The high incidence of hyphema, a common manifestation of blunt ocular trauma in this study, supports the hydraulic theory, direct globe to wall contact. Also, the consistent positive relationship between the number of patients with BCVA less than 20/100, vision threatening ocular injuries, and the size of blowout fractures favor the hydraulic theory. With more force applied, more ocular injuries, as well as larger blowout fractures could occur.

V. CONCLUSION

The incidence of ocular injuries in blowout fractures is high in early post-trauma period. But most ocular injuries do not compromise vision. Fron this study, clinical associations of high incidence of ocular injuries, and the relationship between vision threatening ocular injuries and the size of blowout fractures favor the hydraulic theory of the blowout fracture mechanism.

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Abstract (In Korean)

안손상과 안와골절 양상의 임상적 상관관계

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민 성 희

목적: 외상에 의한 안손상과 안와골절 양상간의 임상적 연관성을 알아보고자 하였다.

방법: 2004년 1월부터 2007년 5월까지 안와파열골절로 진단받은 환자 183명의 임상기록과 안와 전산화 단층촬영 결과를 후향적으로 분석하였다.

결과: 시력에 심각한 영향을 미칠 수 있는 안손상의 빈도 및 동반된 안면골 손상은 안와골절의 크기가 커짐에 따라 증가하는 것으로 나타났다.

결론: 시력에 심각한 영향을 줄 수 있는 안외상의 빈도는 안와골절의

크기가 증가함에 비례하며 이는 안구에 직접 충격이 전해지는 "hydraulic"이론을 뒷받침하는 것으로 보인다.

핵심되는 말: 안와파열골절, 전산화 단층촬영, 안손상