



difficulty; high-risk of ectropion; lymphedema due to disturbances in the lymphatic drainage of scalp, forehead and upper eyelid areas. In addition, there is the possibility of poor healing or deformation due to scar formation in the lower eyelid after such incisions [1].

Signs and symptoms of the orbital floor fractures include paresthesia in the pathway of the infraorbital nerve and diplopia in binocular vision, especially at upward and lateral gazes. Forced duction test is carried out in unconscious or sedated patients to evaluate the involvement of ocular muscles. If this test is not carried out correctly, it will not be without any risks to the eye and its supporting structures. In addition, the value of this test in early stages after trauma is under question because if there is edema, ocular hematoma or swelling of extraocular muscles or their sheaths and in patients with atraumatic restrictive myopathies (thyroid orbitopathy) the test might be falsely positive [2].

In an attempt to more accurately diagnose orbital floor fractures and the amount of its displacement, radiographic techniques are very useful. Although use of plain radiographs and magnetic resonance imaging has been recommended, computed tomography (CT) scan has become the technique of choice for the evaluation of orbit subsequent to trauma. Coronal sections are particularly valuable in the diagnosis of orbital floor fractures. Unfortunately, despite the availability of these facilities, diagnosis might be delayed due to the inability to provide such imaging modalities because of the presence of concomitant injuries or inability to transfer the patient. The patient should be properly positioned within the CT scan machine, which might not be possible in unconscious trauma patients or patients with neck injuries [2].

In addition, CT scan images are prone to artifacts due to dental restorations, which might blur the orbit. Delaying the therapeutic procedures might lead to numerous complications, including a change in the position of the eye, trauma to periocular muscles and trauma to the eye and surrounding tissues [3].

Endoscopic technique through the maxillary sinus provides a better view in blow-out fractures, especially in the posterior region during implant placement; in addition, this technique is useful in decreasing periorbital edema after surgery without any need for lower lid incisions [4].

This technique is especially useful when there are hyphema and retraction of the eye globe is not without any hazards. Therefore, this technique can also be used to examine the floor of the orbit during surgery after the reduction procedure [1].

The aim of the present study was to evaluate the efficacy of the safe and repeatable endoscopic technique via maxillary sinus in the diagnosis of fractures of the floor of the orbit, followed by reconstruction.

Results of the present study might lead to the popularity of endoscopic technique in maxillofacial surgeries, and it is hoped that the results of this study will help to improve maxillofacial surgical techniques with the use of new tools,

including the endoscope

## Material and Methods

In this clinical trial, all patients with the orbital floor and zygomatic complex fractures due to motor vehicle accidents (MVA), interpersonal violence and falling, who were referred to the Department of Maxillofacial Surgery, Shariati Hospital, Tehran, Iran, from September 22, 2006, to July 22, 2007, were included. In the first stage, patients were examined by an ophthalmologist in relation to visual acuity, intraocular pressure, diplopia, and other possible traumas to eyes.

A total of 40 patients were eligible to be included in the study. Based on the radiographic evidence, 20 patients who met the protocol of the study underwent treatment with the use of an endoscope and the endoscopic results were compared with radiographic results in relation to sensitivity. The rest of the subjects underwent routine surgical treatment modalities, and the complications were compared with those in endoscope group (Group 1).

All patients had 1-mm axial and coronal CT scan sections as the gold standard. The sections were processed with the advanced IQ View software program (Image Information Systems LTD. /UK), which has some advantages, including the provision of exact dimensions between the two points in one-hundredth of a millimeter, measuring the internal and external angles between objects. In addition, the radiologist recorded the exact location of fractures in terms of the location of infraorbital nerve and the maximum size of the defect in mm on coronal sections based on each patients data on CD using the IQ software program. Patients were referred to one particular imaging center under one particular protocol to eliminate possible bias. Based on the classification presented by strong, fracture patterns were categorized and evaluated as medial trapdoor (MT), medial blow-out (MBO), and lateral blow-out (LBO). Based on this classification, internal fractures are located between the thicker bone at the lower border of lamina papyracea, referred to as a laminar bar, and the infraorbital nerve. External fractures extend from laminar bar to the thicker bone of the external wall of orbit (Figure 1).



Figure 1. Blow out fracture

### *The procedural steps of treatment with the endoscope*

#### *Hemostasis*

Hemostasis during the surgical operation was achieved by injecting 2% lidocaine with 1:80,000 epinephrine into the

buccal vestibule, the buttress area of the zygoma, the fractured lateral rim area, and the incision line of the lateral eyebrow before incision.

#### *Maxillary antrostomy*

At first an incision was made on the buccal mucosa, and a subperiosteal dissection was carried out to gain access to the anterior wall of the sinus, zygomatic buttress, and zygomatic arch. In most cases, the fractures were of the comminuted type due to the thinness of the anterior wall of the sinus and the fractured segments were fallen into the maxillary sinus and there was no need to create an osseous window on the anterior wall of maxillary sinus.

#### *Pulse test and visualization of the orbital floor*

By applying and removing pressure on the eye (pulse test) and visualization from the underneath through the endoscope, the periorbital tissue was clearly observed like a pulse movement. This test revealed the fracture site and its size and the amount of periorbital tissue which had undergone herniation into the maxillary sinus. In addition, the infraorbital nerve was clearly visible as a white line. At this stage, endoscopic findings were compared with 1-mm CT scan sections as the gold standard in relation to sensitivity. Data were recorded in relevant questionnaires.

In cases in which the fracture was comminuted, the small bony fragments which could interfere with the reduction procedure were carefully removed from the sinus using a Freer elevator and a forceps. Large bony fragments which were connected to the periosteum and the mucosa of the area in a hinge form were left in place. Removal of the bony fragments was carried out very carefully to prevent more damage and trauma to periorbital tissues. In cases in which the infraorbital nerve was entangled with bony fragments, these fragments were separated from the nerve. No attempt was made to return periorbital tissues into orbit.

#### *Forced duction test*

Before reducing the fractured bones, forced duction test was performed to evaluate the possible involvement of the inferior rectus muscle in fracture line and bony fragments. If the test result was positive, a 90° elevator was used to dissect some of the periorbital tissues at the fractured bony edges to free the muscle.

#### *Access to lateral rim*

To gain access to the lateral rim, a lateral eyebrow incision was used; in cases in which the lateral rim fracture needed access to frontozygomatic suture and rigid fixation, a blepharoplasty incision was used.

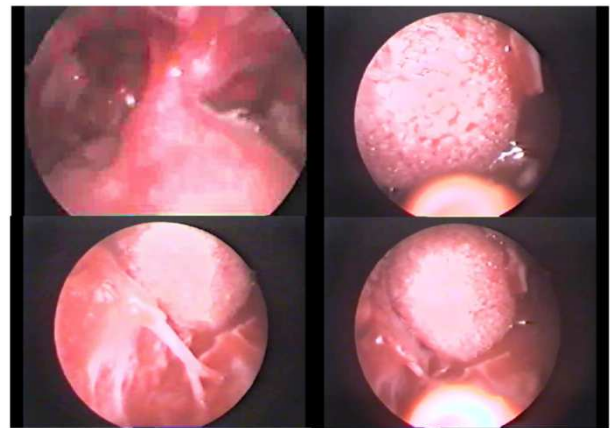
#### *Reduction and re-evaluation of the orbital floor*

After reduction of the zygomatic segment, ensuring segment fixation and evaluation and comparison of the zygomatic prominence with the healthy side, endoscopy of the orbit was carried out once again and pulse test was repeated. The hinged bony fragments (trapdoor) were returned to orbit along with periorbital tissues using the gentle pressure of a periosteum elevator. At this stage one of the two situations below encountered:

a. The orbital floor defect size was small, and there was no

need for reconstruction. Based on the results of studies carried out by Hawes and Dortzbach [5], defects larger than 2 cm or more than 50% of the orbital floor require reconstruction. In addition, considering the clinical picture of the patient, in cases in which clear enophthalmos (more than 2 mm) was present before the surgical operation, and there was comminuted fracture of orbital floor, reconstruction of the orbital floor was undertaken

b. The orbital floor defect size was larger than 2 cm or more than 50% of the orbital floor area. In such cases, reconstruction of orbital floor was indicated. Therefore, a cutaneous sub-tarsal incision was made, and a segment of Porex was placed on orbital floor. Endoscopic control was used to ensure placement of posterior edge of the implant on posterior rim of fracture. Then pressure was applied on eye, and the implant was visualized from underneath through endoscope to ensure that the implant was fixed in place (Figure 2).



**Figure 2.** Application of endoscope in evaluation of orbital floor fracture and orbital floor reconstruction with alloplastic material (Porex sheet)

#### *Repetition of forced duction test*

Forced duction test was repeated to make sure again that periorbital tissues had not been entangled after reduction.

#### *Rigid fixation*

Rigid fixation was carried out by placing a mini-plate on the lateral rim (fronto-zygomatic suture) and zygomatic buttress and in some cases on the inferior orbital rim. In cases in which inferior orbital rim fracture was not comminuted, and there was no need for placement of a plate in this area the plate was placed intraorally beneath the infraorbital nerve.

#### *Re-visualization of the sinus with an endoscope*

The whole sinus was irrigated again. Hemostasis was carried out if necessary. Any pathologic tissues such as mucocele or free or necrotic bony fragments were removed.

Finally, incisions were closed and patients received antibiotic and decongestant for 1 week. Patients were recalled for follow-up of the treatment procedure and possible complications at 1-week and 2-month intervals.

Using the questionnaires prepared, complications and

recovery of patients treated with conventional procedures (cutaneous incisions of the lower eyelid) and endoscope were compared with terms of scars, ectropion, edema, and recovery of nerve disturbances after surgery.

### Statistical analysis

The sensitivity of two techniques of the endoscope and 3-mm CT scan sections were reported to compare them with the gold standard (1-m CT scan section) for the diagnosis of orbital floor fractures.

Independent t-test, ANOVA, *post-hoc* Tukey tests, chi-squared test and Fisher's exact test were used for different comparisons with Statistical Package for Social Sciences (version 20; SPSS Inc., Chicago, IL, USA).

## Results

In the present study in Group 1 (n = 20), in which the subjects underwent diagnosis and treatment with an endoscope, there were 16 males (80%) and 4 females (20%) with a mean age of  $30.05 \pm 13.40$ . In Group 2 (n = 20), in which the results of only conventional treatment modalities were evaluated, there were 17 male (85%) and 3 females (15%) with a mean age of  $29.0 \pm 11.1$  years. T-test did not reveal any significant differences between the two groups in relation to age distribution ( $P = 0.789$ ). Fisher's exact test did not show any significant differences between two groups in relation to gender distribution ( $P = 0.500$ ).

Of 20 orbital floor fractures diagnosed by the gold standard (1-mm CT scan sections), 17 cases were confirmed by 3-mm CT scan sections and 14 cases were confirmed by endoscope; therefore, the sensitivities of the diagnostic methods were 85% and 70%, respectively.

Comparison of the pulse test with the endoscopic diagnostic technique showed that cases diagnosed with the

endoscope had yielded positive pulse test results.

Evaluation of the frequency of fractures of the internal wall of the orbit along with the orbital floor fractures in Group 1 showed that 5 out of 20 patients had such fractures, too (Table 1).

The average defect size in fractures diagnosed by endoscope technique was  $9.01 \pm 3.68$  mm, with an average defect size of  $3.19 \pm 0.84$  mm for fractures not diagnosed by the endoscopic technique. T-test showed that the mean of defect sizes of fractures were significantly higher than those which had not been determined by the endoscope ( $P < 0.001$ ).

Table 2 presents descriptive statistics of defect sizes at different fracture sites (MT, MB, and LBO). ANOVA revealed significant differences between these location groups.

*Post-hoc* Tukey tests did not reveal statistically significant differences between MT and MBO locations in defect size; however, there were significant differences in defect size between LBO on one hand and MBO and MT on the other (Table 3).

Comparison of the two therapeutic groups in relation to exploring the orbital floor (palpebral incision) and placement of implants (grafts) showed that in the group treated with routine techniques in 35.7% of the cases the orbital floor was explored without placement of any implants. However, the rate was 0% in the endoscope group. Fisher's exact test revealed statistically significant differences in the exploration of the orbital floor (palpebral incisions) and placement of implants between the routine and endoscope technique groups ( $P = 0.014$ ).

Comparison of the two groups in relation to post-operative edema showed 1 edematous case out of 4 cases (20%) in the endoscope group and 11 (55%) of edematous cases in the routine technique group, which was statistically significant based on chi-squared test ( $P = 0.024$ ).

**Table 1.** Frequency of the internal wall fractures of the orbit along with orbital floor fractures

| Fractures of the internal wall of the orbit | Frequency | Percentage |
|---|-----------|------------|
| Yes   | 5         | 25.0       |
| No  | 15        | 75.0       |
| Total                                       | 20        | 100.0      |

**Table 2.** Descriptive statistics of defect sizes at different fracture locations

| Location | Number | Defect size means (mm) | Standard deviation | P value   |
|----------|--------|------------------------|--------------------|-----------|
| MT       | 10     | 4.35                   | 1.66               | P < 0.001 |
| MBO      | 4      | 6.80                   | 1.59               |           |
| LBO      | 6      | 12.42                  | 2.98               |           |
| Total    | 20     | 7.26                   | 4.12               |           |

MT: Medial trapdoor; MBO: Medial blow-out; LBO: Lateral blow-out

**Table 3.** Tukey tests for the comparison of defect sizes at different locations

| Fracture location | N  | Subset for alpha = 0.05 |         |
|-------------------|----|-------------------------|---------|
|                   |    | 1                       | 2       |
| MT                | 10 | 4.3510                  |         |
| MBO               | 4  | 6.8075                  |         |
| LBO               | 6  |                         | 12.4250 |
| Significant       |    | 0.150                   | 1.000   |

MT: Medial trapdoor; MBO: Medial blow-out; LBO: Lateral blow-out

The chi-squared test showed significant differences in post-operative scars between the two groups, with 4 scar cases (20%) in the endoscope group and 11 cases (55%) in the conventional technique group ( $P = 0.025$ ). Fisher's exact test did not show any significant differences in ectropion between two groups, with 1 (5%) and 2 (10%) ectropion cases in the endoscope and conventional technique groups, respectively ( $P = 0.500$ ). Comparison of the recovery of disturbances of the sensory infraorbital nerve after surgery (in patients who suffered from nerve disturbances after trauma) showed that in endoscope group, 9 cases out of 15 nerve disturbance cases after trauma had recovered (60%); however, in the conventional technique group, of 18 sensory nerve disturbances after trauma, 10 cases had recovered after surgery (55.6%), with no significant differences between the two groups based on the chi-squared test ( $P = 0.797$ ).

## Discussion

Orbital floor fractures are caused by a variety of traumas, including fights, sports injuries, and MVA and might result in the herniation of orbital contents into paranasal sinuses and its subsequent complications [6]. Early diagnosis using various technique and treatment of orbit fractures are very important to achieve esthetics and preserve the function of the eye [7].

In a study by Sandler et al. [2] in 1999, in 7 patients, 6 orbital floor fractures were diagnosed with use of an endoscope, which was consistent with the results of CT scan images in the coronal section; the inability to diagnose one fracture case was attributed to the absence of disruption of the mucosa on the sinus roof.

In the present study, the sensitivity of endoscope in the diagnosis of orbital floor fractures was 70% compared to the gold standard. However, the sensitivity was 85% in 3-mm CT scan images. The low sensitivity of the endoscope technique in the present study might be attributed to an inability to correctly use the endoscope and unfamiliarity with the anatomy of the region in the endoscopic view, especially in the first few patients.

Results of present study show the importance of the use of fine 1-mm CT scan sections for diagnosis of orbital floor fractures, especially in cases in which fractures are not confined to orbital floor and other areas are also involved; in such cases use of CT scan images are absolutely necessary for all the patients as an important diagnostic tool [3].

In addition, evaluation of CT scan images in coronal sections showed that frequency of fractures of internal wall of the orbit along with the orbital floor fracture was 5 cases (25%) in 20 patients; the frequency of such fractures has been reported to be 20% invalid reports and references [6].

In a study by Ellis et al. [12] on 235 patients with fractures of orbital floor, exploration of the orbital floor was carried out without justification in 65% of the patients.

In addition, in a similar study by Covington et al. [10] in

1994 on 180 patients with fractures of the zygoma, who underwent treatment, exploration of the orbital floor was carried out in 37% of the patients without any therapeutic aims.

Direct visualization of the orbital floor using an endoscope after reduction of fractured segments and making sure of the absence of involvement of periorbital tissues provides the surgeon with thorough information about the size and position of remaining defects and the need or lack of need for reconstruction of the orbital floor. In addition, the majority of orbital floor fractures are minute or linear without significant displacement of fractured fragments [12].

In the present study in the endoscope group, only in four patients it was decided to place implants after reduction of fractured segments based on the amount of the remaining defect; a cutaneous incision was made on the eyelid for implant placement. However, in the conventional technique group, visualization of the orbital floor was only possible with palpebral incisions because an endoscope had not been used and in 35% of the cases exploration of the orbital floor was carried out without implant placement, which can be considered non-therapeutic exploration.

In this context, comparison of the two therapeutic groups showed an increased rate of post-operative complications in Group 2, including edema and scar of the lower eyelid, given the non-therapeutic exploration in this group, i.e., in the endoscope-treated group the extent of edema and scars on the lower eyelid were only confined to cases in which there was a definitive need for reconstruction of the orbital floor (20%). In the other group, this rate was 55%, significantly different from the other group ( $P = 0.240$ ).

Usually, exploration of the orbital floor is carried out through cutaneous incisions on the lower eyelid. However, ectropion and lid retraction are common complications. Manson et al. [14] reported an incidence rate of 6-37% for temporary ectropion after palpebral incisions to gain access to the orbital floor. The rate has been reported to be 6-9% in the case of permanent ectropion, which needs surgical intervention for correction [15].

In the present study, due to the limited number of subjects under study, the incidence rates of ectropion in the endoscope and routine technique groups were 5% and 10%, respectively, with no statistically significant differences between the two groups.

In a study by Jungell and Lindqvist [15] in 1987 on 68 patients with fractures of the zygoma, 56 patients had sensory disturbances of the infraorbital nerve. After treatment of the fracture, a recovery rate of 58% was observed. In addition, Westermarck et al. [16] in 1992 reported a disturbance rate of 80% for infraorbital nerve subsequent to trauma, with 22-50% of the cases remaining disturbed even after treatment of the fracture.

In the present study, a recovery rate of 60% was observed for sensory disturbances in endoscope-treated group versus 55.6% in conventional technique group, with no statistically significant differences between the two groups. Lack of

significant differences between two groups might be attributed to the fact that data on sensory disturbances were collected in a subjective manner from the patients.

## Conclusion

The majority of researchers recommend exploring orbital floor after reduction of zygoma. The results of present study showed that endoscope technique helps visualize orbital floor from underneath through the maxillary sinus without any need for palpebral incisions. Use of an endoscope provides excellent visibility of and access to the posterior rim for the surgeon and ensures proper placement of an implant.

Therefore, the following general conclusions were drawn:

1. Exploring the orbit with an endoscope through the maxillary sinus enables surgeon to accurately measure the defect size, its location and visualize the involved periorbital tissue. Data collected through this technique might help select patients who do not benefit from the lower eyelid techniques to gain access to the orbital floor. The results of present study showed a decrease in the incidence of non-therapeutic exploration and subsequent scar formation and ectropion

2. Endoscope technique was efficacious in reducing fractured fragments of orbital floor and provided access to posterior rim of fracture, ensuring correct placement of the implant

3. Endoscope technique made it possible to safely release the periorbital tissues trapped in the fracture in cases in which retraction of the eye is contraindicated.

## Recommendations

Given the results of the present study and the experience gained in its mechanics and manipulation and the anatomy of the area, it is suggested that implants might be placed by using an endoscope without palpebral incisions in future studies.

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*Conflict of Interest: 'None declared'.*

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