# The application of volumometry as an indication criterion in blow-out fractures – the first results from a prospective study

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**Backgroung and Aim.** This work builds on our publication on the subject of creating a mathematical model for calculating the volume of proplaped soft tissue of the orbit in blow-out fractures, which aids us greatly in our choice of the most effective treatment immediately post-accident.
**Patients and Methods.** In this prospective study (2014 – 2016) we treated 29 patients with blow-out fractures. 18 (62%) were treated conservatively and in 11 (38%) we proceeded surgically. We decided whether surgical or non-surgical therapy was appropriate on the basis of clinical ENT, eye examination and the total volume of prolapsed orbital soft tissue. All procedures were perfomed by the same operating team with a uniform subciliary approach and using PMR splints adapted to the correct size and shape.
**Results.** On the basis of the mathematical model we reassessed findings in 2 patients: in one we decided against a surgical solution and in the other a surgical approach was indicated. All 18 patients treated conservatively, fully recovered and are free of diplopia. The 11 operated patients are also free of diplopia, only 1 patient (3%) displays clinically insignificant postoperative diplopia in extreme posisitons when looking upwards.
**Conclusion.** With proper selection of the optimal treatment, the rate of complete disappearance of diplopia and fully preserved motility of the eyeball ranges from 91 to 97%. Surgical treatment of orbital floor fractures is important, mainly to minimise persistent post-traumatic diplopia which significantly reduces a patient´s quality of life.

**Key words:** blow-out fractures, volumometry, diplopia, CT-assisted surgery

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## INTRODUCTION

Clinical symptoms of blow-out fractures may be seen in various combinations, but fracture symptoms are sometimes very poorly visible. The presence of an orbital floor fracture, its size and weight, are determined by CT imaging (coronal and sagittal sections) and mathematical calculation of the volume of prolapsed soft orbital tissue.

On the basis of our previous retrospective study, we identified two critical volumes for indicating surgical treatment in blow-out fractures: 500 $mm^3$ in anterior and posterior fractures and 1400 $mm^3$ in anteroposterior fractures. We focused on the creation of new quantitative indication criteria for surgical therapy by calculating the volume of proplapsed soft tissues of the orbit and determining the critical values[3,4].

## OBJECTIVES

To use a mathematical model to calculate the volume of prolapsed soft tissue of the orbit in blow-out fractures of the orbital floor as an indication criterion for treatment.

In cases of fractures of the orbital floor, to identify immediately, post-trauma patients requiring surgical treatment.

To avoid incorrect treatment indications, for either conservative or surgical therapy.

To prevent or minimise cases of permanent traumatic diplopia as a consequence of inappropriate treatment.

## PATIENTS AND METHODS

In our prospective study, we evaluated 29 patients with blow-out fractures of the orbital floor, treated in our department between 2014 and 2016. We treated 11 patients (38%) surgically and in 18 patients (62%) we opted for a conservative approach. The ratio of male to female was 6:1 and of left to right orbit, 4:3. The average age of patients was 39.3 years (19-80 years). Those who were not operated were monitored until the disappearance of the diplopia, while operated patients were monitored on a regular basis: at 1 week, 1 month, 3 months, 6 months and 1 year after surgery. The mechanism of injury most often involved direct blows, followed by falls, sports injuries and car accidents (Table 1).

**Table 1.** Mechanism of injury.

| Mechanism of injury | Blows | Falls | Sports injuries | Car accidents |
|---|---|---|---|---|
| Rate (%) | 52 | 31 | 14 | 3 |

Previously, we decided on the most appropriate method of treatment in blow-out fractures immediately post-injury on the basis of fracture identification (using CT images of coronary and sagittal planes) and clinical signs (clinically significant and progressive enophthalmos and diplopia, persisting double vision after recovery from edema of the orbital soft tissues and limited mobility of the eyeball).

Since 2014, we have also been able to use the following indication criteria: if, in anterior and posterior fractures, the volume of the prolapsed orbital soft tissue exceeds the critical value of 500 $mm^3$ or 1400 $mm^3$ in anteroposterior fractures.

If no urgent operation is indicated, then the decision about the need to operate or not is made on the basis of the development of clinical symptoms and the total volume of the prolapsed orbital tissue.

All procedures were perfomed by the same operating team with a uniform subciliary approach and using PMR splints adapted to the correct size and shape.

The main measure of success of the treatment process was the disappearance of diplopia.

## RESULTS

To calculate the volume of the prolapsed section of the orbit in a blow-out fracture of the orbital floor, we used the formula for half the volume of a rotating ellipsoid: $V = 2/3\ \pi$ abc.

The resulting volumes of prolapsed orbital soft tissue in the conservative and surgical treatment methods are shown in Table 2 and Table 3. Clinical symptoms are summarised in Table 4.

In our group of patients with fractures of the orbital floor, one received surgical treatment for a posterior fracture with a prolapse of 435 $mm^3$, diplopia without restricted mobility of the eyeball and with significant hematoma of the eyelids and pneumoorbit. Once the swelling had subsided, a conservative approach was adopted, resulting in a gradual disappearance of clinical symptoms, including diplopia, which resolved within 14 days.

In contrast, one patient initially treated conservatively had gradually receding diplopia but after the repositioning of fractured nasal bones, the diplopia persisted when the patient looked up. There was also a slightly limited range of motion and pain in the lower straight eye muscle (with no muscle entrapment). It was a posterior fracture with a prolapse of 898 $mm^3$. The operation was performed after an interval of 4 months, using the standard subciliary approach, freeing the entire prolapsed volume of the orbit and with orbital floor reconstruction using PMR plate. The patient recovered without complications, and has no diplopia.

## DISCUSSION

A number of Czech and foreign authors have addressed the issues of the appropriate timing and method of surgery in blow-out fractures.

Kwon et al. categorise orbital floor fractures as anterior, posterior and anteroposterior[6] and because of its simplicity and clarity we used the same categorisation in our publications.

Harris, in line with most surgeons[3,6-9] recommends

**Table 2.** Prolapsed volumes in blow-out fractures/conservative therapy.

| Conservative approach | | | |
|---|---|---|---|
| Fracture location | Anterior | Posterior | Antero-posterior |
| Volume ($mm^3$) | 111.6 (36 - 225) | 208.8 (16 - 435) | 0 |

**Table 3.** Prolapsed volumes in blow-out fractures/surgical therapy.

| Surgical approach | | | |
|---|---|---|---|
| Fracture location | Anterior | Posterior | Antero-posterior |
| Volume ($mm^3$) | 856.5 (480 - 1233) | 891.4 (350 - 1450) | 1802.0 (1507 - 2112) |

**Table 4.** Clinical symptoms.

| | Post-traumatic diplopia | Limited eye movement | Exophthalmos | Enophthalmos | Hematoma/ pneumoorbit | Post-op diplopia |
|---|---|---|---|---|---|---|
| Operated (%) n=11 | 91 | 73 | 18 | 9 | 100 | 9 |
| Not operated (%) n=18 | 28 | 6 | 11 | 0 | 100 | 0 |

**Table 5.** The frequency of blow-out fractures by location and the relationship between conservative and surgical therapy.

| Fracture location | Anterior (11), 38% | | Posterior (14), 48% | | Antero-posterior (4), 14% | |
|---|---|---|---|---|---|---|
| Treatment | Conserv. | Surgical | Conserv. | Surgical | Conserv. | Surgical |
| No. of fractures | 9 | 2 | 9 | 5 | 0 | 4 |
| No. of fractures (%) | 82% | 18% | 64% | 36% | 0% | 100% |

surgery for defects of the orbital floor where clinically significant enophthalmos can be expected, or in persistent and non-decreasing diplopia 14 days post-accident.

Except in cases of acute danger to the eyeball or if the optic nerve required urgent surgery, procedures were performed 4 – 5 days after the reduction of edema of the orbital soft tissue, however not more than 14 days after surgery, an approach with which a number of authors are in agreement. This waiting period allows even borderline findings to be monitored.

Again, in various authors, we note the very large dispersion of functional results, 8.7-67%, especially in the persistence of postoperative diplopia[3,7,10-15].

Worth noting is the contribution of CT-guided surgery, leading to the complete disappearance of postoperative diplopia. The first functional results with CT navigation were not published until 2014 (ref.[3,4]).

Beumer, Pham and Schramm[16-18] recommend the use of CT navigation in maxillofacial bone fractures to minimize post-traumatic enophthalmos and achieve improved facial symmetry.

In their conclusion, Mottl et al. emphasise the need for an individual approach to each patient with a fractured orbital floor, stressing this even in non-surgical treatment. The goal of surgical treatment then is the best possible reconstruction of the anatomical shape of the orbit, using new surgical approaches and reconstructive materials[19].

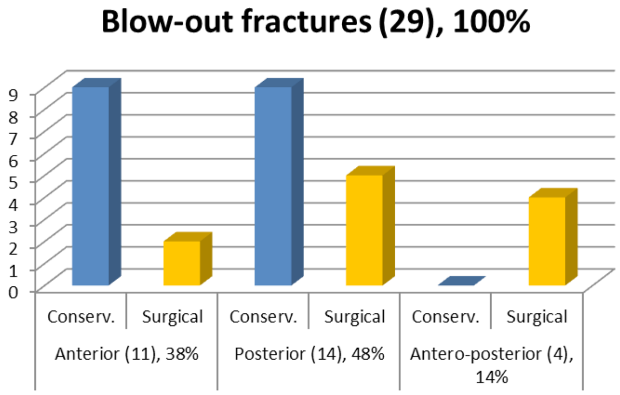


**Fig. 1.** Relationship between conservative and surgical therapy and fracture location.

## CONCLUSION

Given that on average it is repeatedly seen that less than 50% of patients with orbital floor fractures require surgical treatment, it is important to be able to predict these patients immediately after the injury. Clinical symptoms shortly after injury are affected by hematoma, pneumoorbit and subcutaneous emphysema, which usually change the clinical picture towards the expected pathology (which subsides in a few days), or they appear falsely to be functionally insignificant (symptoms appearing after a period of latency).

In anteroposterior fracturers we recommend surgery in prolapse of more than 1400 $mm^3$ and in anterior and posterior fracture types, in cases over 500 $mm^3$ after subsidence of acute edema, provided the situation is non-urgent (Table 5, Fig. 1).

The accuracy of our mathematical model is supported by excellent anatomical and functional results with minimal permanent diplopia, based on experience with CT navigated and video assisted CT-assisted surgery and consistent and long-term monitoring of patients, including of outcomes in conservative treatment.

Thanks to the introduction of CT-guided surgery in orbital floor fractures, we are convinced of the importance of freeing the full prolapsed volume of the orbit and completely covering the defect of the orbital floor. With these new methods and resorbable materials, especially thermoplastic and resorbable PMR plate, we are able to achieve excellent reconstructions of the anatomical shape of the orbital floor.

With proper selection of treatment, the rate of complete disappearance of diplopia and fully preserved motility of the eyeball ranges between 91 and 97%.

Surgical treatment of orbital floor fractures is important mainly to minimise persistent post-traumatic diplopia which significantly reduces a patient´s quality of life.

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