

Gradual oculomotor training in blow-out orbital fracture reconstruction recovery

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Abstract

Objective: This study compared the impact of gradual oculomotor training (GOT) in blow-out orbital fracture (BOF) reconstruction recovery with the impact of high-intensity trainings.

Methods: In total, 120 patients with BOF requiring orbital reconstruction surgery were randomly divided into four groups; all groups performed postoperative oculomotor training four times per day. Patients in Groups 1, 2, 3, and 4 performed 10, 20, 30, and 50 sets of all-direction movement per training on the first 3 days, respectively; they performed 10 additional sets per training on the following 4 days. Patients in all groups performed 50 sets per training from 8 days to 3 months postoperatively. Incision healing, pain, and satisfaction rate, as well as degree of diplopia, were recorded during follow-up.

Results: At 7 days postoperatively, more patients in Group 1 had no/mild swelling and no/mild pain, compared with patients in Group 4. Patients in Groups 1 and 2 had higher satisfaction rates than patients in Group 4. The degree of diplopia did not significantly differ among the groups.

Conclusions: For patients with BOF, GOT after reconstruction surgery was more beneficial for wound healing, pain relief, and satisfaction; the degree of diplopia did not significantly differ, compared with high-intensity trainings.

Keywords

Oculomotor training, diplopia, reconstruction, blow-out orbital fracture, personal satisfaction, pain management, pain, ophthalmologic surgical procedures, postoperative period, wound healing

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Introduction

The numbers of patients with orbital fractures caused by traffic accidents, sports injuries, and other accidents have been steadily increasing in recent years. Enophthalmos, facial malformation, and most eye movement disorders caused by orbital fractures can be corrected by surgery, especially when an endoscopic navigation system is used.^{1,2} Diplopia is one of the most common blow-out orbital fracture (BOF) complications after trauma due to the occurrence of soft tissue edema, adhesions, and increased post-traumatic orbital pressure.^{3,4} Approximately 30% of patients with diplopia experience obvious limitations in social activities, and 12% of patients rely on others for assistance with their daily activities; this significantly reduces the quality of life of the affected patients.⁵ Because patients experience difficulty blinking and performing eye movements, it is challenging to perform accurate assessment of diplopia immediately after the completion of surgery.⁶ In addition, the pathophysiological characteristics of patients with all types of orbital fractures and of patients who have recently undergone orbital reconstruction surgery are relatively consistent.⁷ Therefore, no distinction can be made between diplopia due to orbital fracture and diplopia due to orbital reconstruction surgery; clinicians typically discuss the combined characteristics of post-traumatic and postoperative diplopia.⁸

Theoretically, following appropriate reconstructive surgery, the majority of patients with orbital fractures achieve relatively satisfactory appearance, exophthalmos extent, and eye movements.⁹ However, complications (e.g., wound bleeding, pain, and diplopia) related to surgery are seldom analyzed in detail and are rarely the focus of prospective studies; the study by Song et al. is a rare example of the prospective studies that are needed.¹⁰ Moreover, satisfaction during the recovery

process is an important factor that influences adherence to rehabilitation training.¹¹ Oculomotor training is increasingly accepted by medical teams. Comprehensive prevention and treatment of complications supports adherence to rehabilitation training after orbital fracture surgery, which is more conducive to clinical practice.^{2,6,10} However, there is no uniform standard for oculomotor training; to the best of our knowledge, quantitative descriptions of actions per training session are not often reported.

The purpose of this study was to explore the impact of gradual oculomotor training (GOT) in BOF reconstruction recovery, compared with the effects of high-intensity trainings, with the aim of improving the quality of medical care for affected patients during the perioperative period.

Methods

Ethical approval

Written informed consent was obtained from the participants at the time of enrollment, and the principles outlined in the Declaration of Helsinki were followed throughout the study. The study protocol was approved by the ethics committee of the Shanghai Ninth People's Hospital.

Patients

Consecutive patients diagnosed with BOF between January 2016 and December 2017 at Shanghai Ninth People's Hospital were considered for enrollment in this prospective study. The inclusion criteria were as follows: preoperative enophthalmos ≥ 3 mm; best-corrected visual acuity >0.3 in both eyes; and orbital wall reconstruction surgery by the same doctor, using the conjunctival approach. Exclusion criteria were as follows: oculomotor nerve injury, diabetes, psychological disorders, postoperative vision deterioration, abnormal liver or

coagulation function, and/or other poor cooperation.

Grouping and oculomotor training

Patients were randomly divided into four groups before surgery, using the random number table method. Pressure bandage and ice were applied to the operated eye after surgery. The bandage was removed on the first day postoperatively; oculomotor training was performed four times each day under a nurse's guidance. Each patient was asked to visually follow the nurse's index finger, such that their eyes moved upward, downward, left, and right. Eye movement once in each of the four directions was defined as one set. Patients in Groups 1, 2, 3, and 4 performed 10, 20, 30, and 50 sets per training from the first day to the third day postoperatively; they performed 20, 30, 40, and 60 sets per training from the fourth day to the seventh day postoperatively. Patients in all groups performed 50 sets per training beginning on day 8 and continuing until the end of the third month postoperatively.

Evaluation of diplopia, pain, incision healing, and satisfaction

In all four groups, diplopia was evaluated preoperatively and on the seventh day postoperatively, as well as at the ends of the first and third months postoperatively. Wound healing, pain, and satisfaction were evaluated on the seventh day postoperatively. The degree of diplopia was classified into the following four grades: Grade 0, no diplopia; Grade I, mild diplopia, only on peripheral visual field; Grade II, diplopia when looking forward, downward, inward, and/or outward; Grade III, diplopia when looking forward and on each peripheral quadrant. Patients who reached Grade 0 were considered clinically cured; patients who reached a grade lower than their

original level were considered clinically improved. Both clinically cured and clinically improved outcomes were regarded as "effective," while other outcomes were regarded as "ineffective." Pain was measured by using a verbal rating scale and was graded into the following four levels: Level 0, no pain; Level 1, mild pain (tolerable during normal life, without sleep disturbance); Level 2, moderate pain (obvious and intolerable, although analgesics were required and sleep was disturbed); Level 3, severe pain (intense and intolerable, such that analgesics were needed, sleep was seriously disturbed, and autonomic nervous disorders and passive posture were observed). Conjunctival incision healing was divided into the following two grades: Grade I, no or mild swelling; Grade II, moderate or severe swelling, with abnormal secretions. Patient satisfaction was recorded as "satisfaction" or "dissatisfaction."

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows, version 19.0 (IBM Corp., Armonk, NY, USA). Measurement data are shown as mean \pm standard deviation. Categorical data are shown as rates or constituent ratios. The chi-squared test was used for between-group comparisons. Further comparisons between groups were performed to adjust the test level (using the chi-squared test), based on the number of comparisons. Differences with $p < 0.05$ were considered statistically significant.

Results

Patient characteristics

One hundred twenty patients (68 men and 52 women) were enrolled in this study. The mean age of the patients was 34.35 ± 9.72 years (range, 19–60 years). There were

30 patients in each group. There were no significant differences among groups in terms of age, sex, or degree of preoperative diplopia.

Diplopia

Diplopia significantly improved after GOT in all four groups, but there were no significant differences in effectiveness among the groups on the seventh day postoperatively, or at the ends of the first and third months postoperatively (Table 1).

Pain, incision healing, and satisfaction

The incision healing, pain, and satisfaction results of all groups are shown in Table 2.

Among all 120 patients, 86 had one-wall orbital fracture and 34 had two-wall orbital fracture. Fifty-six patients with one-wall orbital fracture had pain Level 0 + 1, while 22 patients with two-wall orbital fracture had pain Level 0 + 1. The proportion of patients with pain Level 0 + 1 did not significantly differ between groups, based on the number of fractured walls (56/86 versus 22/34). There were significant differences in wound healing, pain, and satisfaction among the four groups. The proportion of patients with incision healing grade I was significantly greater in Group 1 than in Group 4 ($p = 0.004$). Moreover, a significantly greater proportion of patients in Group 1 had pain Level 0 + 1, compared

Table 1. Evaluation of the effectiveness of oculomotor training for resolution of diplopia.

Group (n=30 each)	Outcome	Seventh day (n, %)	First month (n, %)	Third month (n, %)
1	Effective	19 (63.33)	25 (83.33)	27 (90.00)
	Ineffective	11 (36.67)	5 (16.67)	3 (10)
2	Effective	18 (60)	22 (73.33)	26 (86.67)
	Ineffective	12 (40)	8 (26.67)	4 (13.33)
3	Effective	19 (63.33)	27 (90.00)	28 (93.33)
	Ineffective	11 (36.67)	3 (10)	2 (6.67)
4	Effective	17 (56.67)	26 (86.67)	27 (90.00)
	Ineffective	13 (43.33)	4 (13.33)	3 (10)
χ^2		0.385	3.360	0.741
p		0.943	0.339	0.864

Table 2. Evaluation of incision healing, pain, and satisfaction outcomes during oculomotor training.

Group (n=30 each)	Incision healing (n, %)		Pain (n, %)		Satisfaction (n, %)	
	Grade I	Grade II	Level 0 + 1	Level 2 + 3	Satisfaction	Dissatisfaction
1	27 (90.00)	3 (10.00)	26 (86.67)	4 (13.33)	28 (93.33)	2 (6.67)
2	22 (73.33)	8 (26.67)	20 (66.67)	10 (33.34)	26 (86.67)	4 (13.33)
3	21 (70.00)	9 (30.00)	17 (56.67)	13 (43.33)	27 (90.00)	3 (10.00)
4	17 (56.67)	13 (43.33)	15 (50.00)	15 (50.00)	15 (50.00)	15 (50.00)
χ^2	8.485		10.110		22.917	
p	0.037		0.018		0.000	

*Between-groups comparisons.

Incision healing, groups 1 and 4 ($\chi^2 = 8.523$, $p = 0.004$); Pain, groups 1 and 4 ($\chi^2 = 9.320$, $p = 0.002$);

Satisfaction, groups 1 and 4 ($\chi^2 = 13.871$, $p < 0.001$), groups 2 and 4 ($\chi^2 = 9.320$, $p = 0.002$), groups 3 and 4 ($\chi^2 = 9.603$, $p = 0.002$).

with patients in Group 4 ($p=0.002$). The satisfaction rates in Groups 1, 2, and 3 were significantly higher than the rate in Group 4 ($p<0.001$, $p=0.002$, and $p=0.002$, respectively) (Table 2).

Discussion

The major goal of treatment for BOF is to improve patients' symptoms including enophthalmos, facial malformation, and diplopia. This study demonstrated the effectiveness of GOT in postoperative eye movement rehabilitation for patients with BOF. Diplopia is one of the most common complaints of BOF patients.¹² The causes of different degrees of eye movement limitation and diplopia include oculomotor nerve injury, muscle incarceration, local edema, and compression. Surgical treatment and the forced duction test can help to release incarcerated extraocular muscles, but movement may remain limited because of local tissue edema or adhesions and fibrosis during wound healing.² Some patients exhibit varying degrees of diplopia within 1 week postoperatively. After eye muscle training of reasonable intensity, diplopia can be partially or completely relieved within 2 weeks postoperatively, although some patients require a longer duration of recovery. Diplopia caused by paralysis alone can be partially or completely cured over time, but diplopia caused by restrictive factors is difficult to resolve.⁴ The role of oculomotor training for treatment of diplopia was previously investigated, highlighting the importance of early surgery and oculomotor training, regardless of symptom severity.^{13,14}

The timing and intensity of oculomotor training after orbital reconstruction surgery are not well-established.^{15,16} Early and high-intensity training can help to relax adhesive tissues, improve local blood circulation, reduce periocular tissue edema, and promote muscle function recovery.¹²

However, severe soft tissue edema in the early postoperative period may lead to intolerable pain and poor cooperation. In contrast, late and low-intensity training may cause no pain and may result in good satisfaction, although eye movement rehabilitation and diplopia improvement may not be achieved.² Hence, optimal oculomotor training should include eye movement rehabilitation and lead to diplopia improvement, while causing minimal pain and producing a high satisfaction rate.¹⁷

In this study, different training plans were implemented in each of four groups. There were no statistically significant differences among the four groups in terms of the effectiveness of diplopia improvement. This indicated that oculomotor training was effective and that the results of the GOT approach were at least comparable to high-intensity training in the early postoperative period. There were differences in pain, incision healing, and satisfaction among the groups; pain, incision healing, and satisfaction rate were better in Group 1 than in Group 4. Lower intensity training in the early postoperative period could reduce the risk of pain or incision edema and improve patient satisfaction. Therefore, GOT is an effective method for prevention of postoperative adhesion and alleviation of diplopia.

The guidance of oculomotor training is important, especially in the early postoperative period.¹⁸ Correct training methods should be taught to patients; movement should be specifically upward, downward, left, and right, rather than in other patterns. Adequate explanation and encouragement are also necessary to achieve good patient cooperation with training and maintain the patient's confidence that diplopia will be resolved. In this study, diplopia worsened in eight patients within 1 week; among these patients, three were fearful and worried. Hence, they initially refused to continue training; however, they completed training after receiving psychological

counseling from nurses. Before surgery, clinicians should therefore emphasize the importance and necessity of oculomotor training and inform patients that local swelling and diplopia are normal postoperative phenomena; this information may prevent panic in affected patients. Furthermore, clinicians should inform patients (before discharge) that improvement or resolution of diplopia may require a considerably long duration of training. For patients with dizziness, nausea, and other symptoms, preoperative and postoperative safety education should be augmented to prevent the occurrence of adverse events (e.g., falls). Covering the affected eye is an effective method for elimination of these symptoms.

Pain is the most common difficulty encountered in oculomotor training. During initial training, no patients experienced severe pain. The proportions of patients with moderate pain in Groups 1, 2, 3, and 4 were 13.33%, 33.34%, 43.33%, and 50%, respectively. When patients experienced moderate pain, their nurses reduced the speed of index finger movement used to guide eye movement; this encouraged patients to maintain interest in training. Three patients in Group 4 reported eyeball pain in the early postoperative period and were unwilling to receive training. The training was completed by adjusting the movement speed of the guiding nurse's index finger. In addition, repeated advice and guidance were provided to ensure patients could follow the proper medical management plan. A rough grading method was used in this study, rather than a quantitative assessment; this was a limitation of our study, mainly because the ability to immediately record this relative subjective judgement resulted in poor reproducibility.

Complications of oculomotor training have been previously reported, including hemorrhage and suture rupture due to excessive activity.¹⁹ All clinicians should

carefully observe the patient during training. For patients with obvious lower eyelid subcutaneous or retrobulbar hemorrhage, eyelid or bulbar conjunctival edema, or difficulty in eyelid opening, the training should be suspended until bleeding subsides. Therefore, oculomotor training should gradually progress from low to high intensity. The implementation of individualized, multi-dimensional training management is recommended.

In summary, GOT is an effective method to prevent extraocular adhesion and alleviate postoperative diplopia in patients with BOF. GOT improves the patient's postoperative quality of life by improving pain, incision healing, and satisfaction rate.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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