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GUIDELINE

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Guideline for the treatment of no light perception eyes induced by mechanical ocular trauma

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Abstract

Severe mechanical ocular trauma with no light perception (NLP) predicts a poor prognosis of visual acuity and enucleation of the eyeball. Since the innovative treatment concept of exploratory vitreoretinal surgery has developed and treatment technology has advanced, the outcomes of severe ocular trauma treatment in NLP patients have greatly improved. However, there remains a lack of unified standards for the determination, surgical indication, and timing of vitrectomy in NLP eye treatment. To address these problems, we aimed to create evidence-based medical guidelines for the diagnosis, treatment, and prognosis of mechanical ocular trauma with NLP. Sixteen relevant recommendations for mechanical ocular trauma with NLP were obtained, and a consensus was reached. Each recommendation was explained in detail to guide the treatment of mechanical ocular trauma associated with NLP.

KEYWORDS
evidence-based medicine, mechanical ocular trauma, no light perception, treatment guidelines

1 | INTRODUCTION

The concept of no light perception (NLP) after mechanical ocular trauma was first introduced by Pieramici in 1997.[1] There is a lack of epidemiological data on NLP eyes induced by mechanical ocular trauma, and the geographical specificity is obvious in the existing epidemiological studies on mechanical ocular trauma. The proportion of NLP eyes was 6%–22% in severe open globe injury.[2–4] NLP

eyes induced by mechanical ocular trauma generally have serious eye injuries.[5] In the past, surgical treatment was generally considered meaningless when the visual function was severely damaged to NLP after ocular trauma, and enucleation might be inevitable.[1,6] Nevertheless, with improvements in vitreoretinal surgical techniques and cumulative experiences in ocular trauma treatment, the visual acuity of patients with NLP eyes may partially improve.[7] Hence, mechanical ocular trauma with an initial NLP is not an indication of permanent vision loss or enucleation.[8,9] However, there is still a lack of unified standards for the identification of NLP eyes, determination of surgical indications, principles, and timing of surgery in NLP eyes.

Ophthalmologists often make diagnoses and treatments based on their experience because of the complexity and variability of mechanical eye trauma. Evidence-based medicine methods are urgently needed to formulate high-quality clinical guidelines to standardize the treatment of NLP eyes induced by mechanical ocular trauma. Therefore, worldwide ophthalmologists in the field of ocular trauma, in conjunction with the World Health Organization (WHO) Collaborating Centre for Guideline Implementation and Knowledge Translation, have developed the "Guideline for the treatment of no light perception eyes induced by mechanical ocular trauma, 2022" using the methods and procedures of evidence-based guidelines, hoping to standardize the treatment of NLP eyes induced by mechanical ocular trauma.

2 | METHODS

The guideline is based on the WHO guidebook published in 2014,[10] referring to the definition of clinical practice guidelines proposed by the American Academy of Medical Sciences[11] and following the Appraisal of Guidelines for Research and Evaluation II [12] and Reporting Items for Practice Guideline in Health Care.[13]

2.1 | Origination, development and support units for the guideline

This guideline was developed by Tianjin Medical University General Hospital, and methodological support was provided by the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) China Center/Evidence-based Medicine Center of Lanzhou University. The guideline was registered on the International Practice Guideline Registration Platform (http://www.guideline-registry.cn), registration number: IPGRP-2021CN008.

2.2 | Guideline users and target groups

This guideline is applicable to all medical institutions that manage the treatment of mechanical ocular trauma with NLP. The guideline users are ophthalmologists, and the primary target population is patients diagnosed with NLP induced by mechanical ocular trauma.

2.3 | Working group on guideline development steering

The guideline development working group was composed of the Committee of Editorial Group, Consensus Expert Group, Guideline Development Group, and Audit Expert Group. The Committee of the Editorial Group and Consensus Expert Group consisted of 53 experts from four disciplines/specialties from 10 countries, patient representatives participating in the guideline formulation process, and legal advisers participating in the external review of the guideline.

2.4 | Clinical problem selection

The research group systematically searched for guidelines, systematic evaluations, and original studies related to the treatment of mechanical ocular trauma with NLP. Combined with the results from in-depth interviews with stakeholders, a list of clinical problems and outcome indicators of the guideline was initially prepared and then classified and merged. A total of 60 ophthalmologists were surveyed using a questionnaire. We used the Delphi method to select and determine the 16 clinical problems from this guideline. Clinical experts and scientists developed clinical problems based on the Population, Intervention, Comparison, and Outcome principle. The outcome indicator list was proposed based on the literature research, in-depth interviews, and patients' wishes and values. Finally, the Guideline Development Working Group finalized the outcome indicators of this guideline after several discussions.

2.5 | Evidence collection

Relevant English literature was queried through multiple databases such as PubMed, Embase, The Cochrane Library, and Web of Science. Chinese literature was queried using China National Knowledge Infrastructure (CNKI), China Biology Medicine disc (CBM), WanFang Data, and VIP databases. Common clinical guideline websites included the National Guideline Library, International Guideline Collaboration Network, Inter-School Guideline Network in Scotland, National Institute for Clinical Excellence, and WHO. The retrieval period was from the database construction to June 2021. References in the included literature were thoroughly studied.

2.6 | Evidence screening and extraction

Research evidence included existing clinical guidelines, systematic reviews, randomized controlled trials, cohort studies, case-control studies, and cross-sectional studies, which included the diagnosis and treatment of mechanical ocular trauma with NLP. The literature was graded by reading the titles, abstracts, and full texts. The information included in the study was extracted according to

TABLE 1 Grading of evidence quality and recommendation strength

Grading of evidence quality	Detailed description
High (A)	Having high certainty on that the observation is close to the real value
Medium (B)	Having moderate certainty on observations: Observations may be close to the real value, but they may vary greatly
Low (C)	Having limited certainty on observations: Observations can be very different from real values
Very Low (D)	Having little certainty on observations: They can be extremely different from real values
Grading of recommendation strength	**Detailed description**
Strong (1)	It is clearly shown that interventions do more benefit or harm
Weak (2)	The advantages and disadvantages are uncertain or the evidence, regardless of quality, shows that the advantages and disadvantages are equal

a predesigned data extraction table. The screening and information extraction of each paper were carried out independently by two professionals, and a third party was involved if there were differences of opinions.[14,15]

2.7 | Evaluation and grading of evidence quality

AMSTAR-2[16] was used to evaluate the methodological quality of the included system. Evaluation/meta-analysis, and the Cochrane bias risk assessment tool, QUADAS-2, and Newcastle-Ottawa-Scale (NOS) were used to evaluate the methodological quality of the corresponding clinical trials. The screening and information extraction of each paper were carried out independently by two professionals, and a third party was involved if there were differences of opinions.[17–19]

GRADE[20,21] was adopted to evaluate the quality of evidence and strength of recommendation for each clinical issue. A good practice statement (GPS) was used to evaluate the qualitative research.[22] Table 1 shows the grading of the evidence quality and recommendation strength.

2.8 | Patient preferences and values

A questionnaire on clinical issues that catered to diverse patient preferences and values was developed by the Guideline Development Working Group. Patients with mechanical ocular trauma (n = 100) were selected to complete this questionnaire. The findings were analyzed statistically, collated by members of the guideline development team, and considered in the formulation of recommendations.

2.9 | Development and updating of recommendations

The Guideline Development Working Group developed 16 recommendations based on the evidence of meta-analysis and other factors, including the patient's values and personal preferences, the cost of interventions, and balancing the pros and cons. All recommendations reached consensus through a one-round Delphi questionnaire.

2.10 | Audit and approval

After reaching consensual recommendations reached, a draft of the guideline was submitted to the Audit Expert Group for review, which comprised ocular trauma experts, guideline formulation methodology experts, legal advisers, and patient representatives. The Guideline Development Working Group revised the overall opinion based on feedback from the Audit Expert Group. Finally, the Consensus Expert Group discussed and approved the guideline.

2.11 | Dissemination and implementation of the guideline

Upon the release of the guideline, the Guideline Development Working Group will disseminate, implement, and promote it in the following ways: (1) Interpret them at relevant academic conferences, (2) publish them in academic journals, and (3) promote using online platforms. Also, over the next 2 years, periodic studies will be conducted to evaluate the treatment status of mechanical ocular trauma.

3 | RESULTS

The guideline development group investigated patients' wishes and organized expert consensus meetings. Finally, 16 recommendations were formed. The flowchart of treatment for eyes with NLP induced by mechanical ocular trauma is shown in Figure 1.

3.1 | Clinical Recommendation 1: Identification of NLP eyes induced by mechanical ocular trauma

History of ocular trauma and visual acuity examinations are critical in the identification of NLP (GPS).

3.1.1 | Recommendation explanations

NLP eyes should be examined in a dark room, and the other eye should be completely covered. The light from the direct or

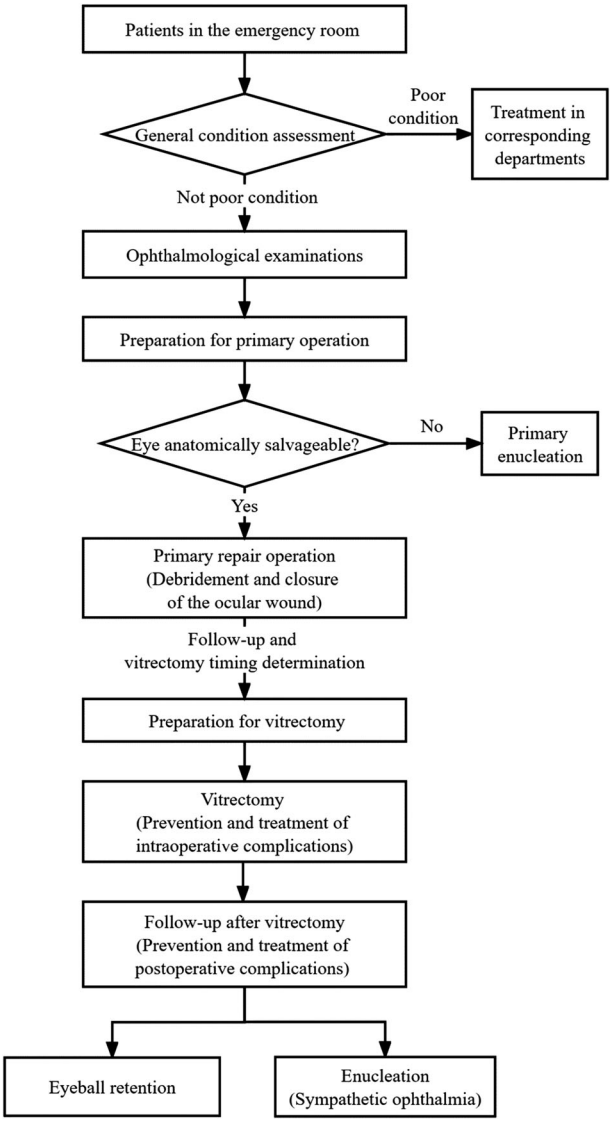

FIGURE 1 Flowchart of treatment for eyes with no light perception induced by mechanical ocular trauma

indirect ophthalmoscope, candle, and flashlight should be used to examine nine directions including normotopia, supranasal, superior, supratemporal, temporal, inferotemporal, inferior, inferonasal, and nasal parts. Lack of response across all sections would classify as NLP.

3.2 | Clinical Recommendation 2: Common causes of NLP induced by mechanical ocular trauma

Common causes of traumatized eyes with NLP include the following: (1) Direct or indirect damage to the optic nerve can cause NLP in open globe injuries, and optic nerve contusion is the leading cause of closed globe injuries. (2) Extensive ocular tissue loss or severe damage to the ocular tissue (GPS).

3.2.1 | Recommendation explanations

Loss of visual acuity after mechanical ocular trauma is due to a combination of many factors, including media opacity caused by severe corneal injury, traumatic cataracts, dense intraocular haemorrhage, and suppurative endophthalmitis.[23] Other common causes of post-traumatic NLP include intraocular tissue prolapse, injury of the optic nerve, extensive damage to the retina or choroid, severe ciliary body damage, and psychological factors (such as hysteria).[24]

3.3 | Clinical Recommendation 3: Prognostic risk factors for NLP eyes induced by mechanical ocular trauma

The risk factors for poor prognosis in NLP eyes induced by mechanical ocular trauma include rupture (2D), intraocular foreign body (IOFB) retention (2C), Zone III injury (2C), wound length ≥ 10 mm (2C), prolapse of the retina, choroid, and vitreous (2C), the timing of primary repair > 24 h (2C), excessive/overlong interval to secondary surgery (2D), lens damage (2D), severe ciliary body damage (2C), severe intraocular haemorrhage (2C), proliferative vitreoretinopathy (PVR) (2B), retinal and/or choroidal detachment (RD) (2B), relative afferent pupillary defect (2C), and traumatic endophthalmitis (2D).

3.3.1 | Recommendation explanations

The guideline development group determined the outcome indicator according to ocular trauma score variables[25,26] and provided a systematic review showing that eyeball rupture was the most important risk factor for poor prognosis. The incidence of low vision (Risk difference, RD = 0.75, 95% CI:0.57–0.92),[27] NLP (p = 0.15, 95% CI:0.07–0.30),[28,29] and PVR after vitrectomy is higher in ruptured eyes. The incidence of endophthalmitis significantly increases in the presence of IOFBs retention (Odds ratio,OR = 2.06, 95% CI:1.47–2.88).[30,31] The incidence of poor visual acuity prognosis and the possibility of long-term NLP were highest in patients with Zone III injury (OR = 5.45, 95% CI:2.65–11.21).[32] Comparatively, the possibility of the above two incidences of Zone I injuries was the lowest, and the incidence of RD and enucleation after Zone III injuries was the highest. If the length of the wound was greater than 10 mm, RD was most likely to occur (OR = 11.46, 95% CI:4.41–29.74).[33]

The timing of primary surgery and vitrectomy has a significant impact on the prognosis of mechanical ocular trauma, and a delay of primary surgery over 24 h increases the risk of endophthalmitis.[34,35] The risk of poor visual outcomes and RD was lower in patients who underwent vitrectomy 7–14 days after injury than in those who underwent vitrectomy > 14 days after injury.[36] Lens injuries caused by ocular trauma can increase the incidence of poor visual prognosis and endophthalmitis. Severe ciliary body injury and intraocular haemorrhage can also affect the prognosis of visual recovery and lead to abnormal intraocular pressure (IOP).[33]

3.4 | Clinical Recommendation 4: Influence of IOFBs on endophthalmitis and NLP eyes induced by mechanical ocular trauma

Plant-related IOFBs (2D), metallic IOFBs (2D), size of IOFBs ≥ 5 mm (2C), number of IOFBs > 1(2C), and irregularly shaped IOFBs (2D) can increase the risk of NLP after mechanical ocular trauma. Longer retention of IOFBs in the eye (2C) can increase the risk of endophthalmitis and NLP.

3.4.1 | Recommendation explanations

IOFBs can affect visual recovery and lead to a significantly higher incidence of endophthalmitis ($p < 0.05$).[30,31,37–42] Metallic IOFBs are associated with an increased incidence of NLP, among which iron IOFBs have a more serious effect on vision. Compared with glass and plastic IOFBs, wood IOFBs are more likely to cause NLP because plant-related IOFBs are more likely to cause endophthalmitis.[43,44]

IOFBs with a maximum size of ≥ 5 mm may affect the recovery of visual function and increase the incidence of NLP. Multiple IOFBs (number of IOFBs > 1) also affect the prognosis of visual acuity. In addition, according to the existing data, the incidence of low vision caused by sharp IOFBs may be lower than that caused by curved, angular, or irregular IOFBs. Retention longer than 24 h increased the risk of endophthalmitis (OR = 4.26, 95% CI: 2.48–7.32, $p < 0.05$),[45] and the incidence of NLP in patients with long-term retained IOFBs for 1 or more months was significantly increased.

3.5 | Clinical Recommendation 5: Preoperative preparation for the primary operation in NLP eyes induced by mechanical ocular trauma (including history collection, eye examination, systemic examination, preventive medication, requirements for surgeons, equipment and material preparation, and informed consent)

The medical history of patients with NLP induced by mechanical ocular trauma should be collected in detail before the primary surgery, and ophthalmic and systemic examinations should be performed on time. Prophylactic antibiotics and tetanus antitoxins should be used to prevent infections. Surgeons should communicate with patients and their family members about risks and postoperative complications related to eye injury and surgery, obtain informed consent before surgery, and ensure that the surgical equipment and instruments are ready. Operations should be performed by the attending physician or resident under attending guidance (GPS).

3.5.1 | Recommendation explanations

The patient's general state should be assessed immediately at the time of presentation and checked for any other injuries. Subsequently, a detailed medical history of eye injuries should be taken. History of eye disease, family genetic disease, allergy, and other information should also be asked in detail. For severe compound injuries, vital signs should be examined first, followed by an ophthalmological examination. Computed tomography (CT), magnetic resonance imaging (MRI), and other examinations should be used to confirm potential injuries, such as intraocular or intraorbital foreign bodies and orbital fractures. Tetanus antitoxin or immunoglobulin should be injected as soon as possible in patients with open globe injury to avoid the risk of severe infection. Systemic or intravitreal vancomycin combined with ceftazidime or cefepime in early treatment can reduce the incidence of post-traumatic endophthalmitis.[30,46,47] Some doctors have proposed that prophylactic intravitreal antibiotics should be used if the following risk factors occur: (1) dirty wound, (2) delay in primary repair of > 24 h, (3) breach of the lens capsule, and (4) retained IOFB.[48,49] Systemic glucocorticoid and glucocorticoid eye drop treatment could be administered to patients with excessive choroid prolapse during primary surgery. Communication with patients and their family members before primary surgery must include details of the condition, uncertainty of surgical treatment, risk of infection, multiple operations, or even the possibility of enucleation of the eyeball. Surgical microscopes, phacoemulsification instruments, and vitrectomy instruments should be prepared to meet the requirements of vitrectomy.

3.6 | Clinical Recommendation 6: Timing of primary operation, anesthesia, and the principle of primary surgery in NLP eyes induced by mechanical ocular trauma

Timing of primary operation, anesthesia, and the principle of primary surgery in NLP eyes induced by mechanical ocular trauma. (1) Suturing of the ocular wound should be performed within 24 h in case of open globe injured eyes (GPS). (2) Local anesthesia is generally used in primary surgery. General anesthesia can be considered prolapses are expected or in case of the presence of severe injuries to other parts of the body (GPS). (3) Appropriate methods should be selected to suture the wound according to different conditions to restore the intraocular tissues to the original position in primary surgery (GPS).

3.6.1 | Recommendation explanations

A delay of primary surgery over 24 h is associated with an increased incidence of endophthalmitis.[50,51] Therefore, the timing of primary surgery earlier than 24 h is recommended. Most doctors choose local anesthesia to treat the wounds in Zones I and II for patients whose physical conditions do not allow general anesthesia or in emergencies when the treatment time is urgent. However, general anesthesia should be considered in cases with large rupture wounds or cannot co-operate with local anesthesia due to systemic diseases.[52,53] The purpose of primary surgery is to close the ocular wound, retain the eyeball, and restore IOP. Intraocular tissue can be repositioned by filling it with a

sterilized air bubble or viscoelastic agent after suturing, laying a good foundation for vitrectomy. For perforating wounds, anterior wounds should be sutured first, whereas posterior wounds are generally not sutured. IOFBs should be removed as soon as possible.[54] Traumatic cataracts are recommended to be removed during vitrectomy.

3.7 | Clinical Recommendation 7: Preparation for vitrectomy in NLP eyes induced by mechanical ocular trauma

Preparation for vitrectomy in NLP eyes induced by mechanical ocular trauma (including local and systemic preparation, preventive medication, requirements for surgeons, equipment and material preparation, and informed consent). (1) NLP eyes induced by mechanical ocular trauma should undergo detailed examinations before vitrectomy, and preoperative anesthesia evaluation should be performed when general anesthesia is selected. Patients and their family members should be informed of operative risks and potential postoperative complications before surgery (GPS). (2) Comprehensive surgical equipment and instruments should be prepared. The operation should be performed by experienced doctors in the field of ocular trauma or vitreoretinal surgery (GPS).

3.7.1 | Recommendation explanations

Patients with NLP should undergo detailed examinations before vitrectomy for personalized surgical planning and prediction of the postoperative anatomy and visual recovery. General anesthesia should be prioritized after the patients' general conditions are assessed. Antibiotics should be used to prevent endophthalmitis. The use of antibiotics is the same as that in Clinical Recommendation 5. For patients with high IOP after primary surgery, topical eye drops, oral carbonic anhydrase inhibitors, or mannitol can be administered if necessary. Vitrectomy should be performed by an experienced ophthalmologist specializing in ocular trauma. The equipment preparation is the same as that in Clinical Recommendation 6.

3.8 | Clinical Recommendation 8: Indications, timing, and procedures of vitrectomy in NLP eyes induced by mechanical ocular trauma

Indications, timing, and procedures of vitrectomy in NLP eyes induced by mechanical ocular trauma. (1) The main indications for vitrectomy include vitreous haemorrhage (VH), RD, choroidal detachment, IOFB, and endophthalmitis (GPS). (2) The appropriate timing for vitrectomy should be determined according to the type and severity of ocular trauma. Most surgeons choose to perform vitrectomy 3–14 days after injury. Patients with IOFB or a high risk of infection should be immediately operated. Vitrectomy is not recommended to be performed later than 14 days after ocular trauma for the cause of severe PVR (GPS). (3) Routine surgical procedures include anterior segment reconstruction and reattachment of retina and choroid (GPS).

3.8.1 | Recommendation explanations

There is a view that RD and repeated VH during conservative treatment after blunt trauma are indications for vitrectomy. Currently, the timing is mainly divided into early surgery (≤ 3 days), delayed surgery (4–7 days), late surgery (8–14 days), and very late surgery (> 14 days).[55] Vitrectomy is usually performed as early as possible to reduce the incidence of endophthalmitis in patients with IOFBs or a high risk of infection. Early vitrectomy has a certain effect on preventing proliferation. However, the indication is constricted, such as without corneal rupture and large ocular wound. Suprachoroidal haemorrhage should be drained during vitrectomy, and a temporary corneal prosthesis or endoscope can be used in patients with corneal blood staining. If vitrectomy cannot be conducted easily, bimanual manipulation can be adopted with chandelier illumination. If the choroidal incarceration is in the scleral wound or if there is a large range of choroid avulsion, the choroid can be sutured after cleaning the choroidal lesion and fixed on the sclera.

3.9 | Clinical Recommendation 9: Prevention and treatment of intraoperative complications during vitrectomy for NLP eyes

Prevention and treatment of intraoperative complications during vitrectomy for NLP eyes. (1) Intraoperative haemorrhage. When removing IOFBs from the ocular wall, photocoagulation or cautery should be performed on the retina around the foreign body before removal. Sufficient cautery should be performed at the appropriate site before retinotomy or retinectomy to prevent bleeding. In cases of intraoperative bleeding, an increased infusion pressure or cautery should be conducted (GPS). (2) Iatrogenic retinal tears: Iatrogenic retinal tears can be prevented by careful manipulation. The present retinal tears can be closed by laser photocoagulation or cryotherapy, and silicone oil or inert gas is filled in the eye at the end of vitrectomy (GPS). (3) Perfluorocarbon liquid migrates into the subretinal space. When the perfluorocarbon liquid migrated into the subretinal space, it can be removed with a back-flush needle. Then the proliferative membrane peeling, retinotomy, or retinectomy were performed followed by silicone oil filling (GPS). (4) Silicone oil goes under the retina. When silicone oil goes under the retina, it can be removed by retinectomy or retinotomy at the appropriate site (GPS).

3.9.1 | Recommendation explanations

Intraoperative bleeding is mainly caused by inadequate cautery or accidental damage to the retinal vessels during the separation of the proliferative membrane adhered to the retina or near the wound. If there is intraoperative bleeding, hemostasis can be achieved by

increasing infusion pressure or cautery. If large and persistent bleeding results in blurred media and the bleeding point cannot be accurately identified, the air-fluid exchange can be temporarily performed, and intraocular cautery should be used to stop the bleeding after the intraoperative field is clear.

Possible causes of intraoperative iatrogenic retinal tears include vitreous traction when surgical instruments repeatedly pass in and out of the sclerotomy and peeling of the epiretinal membrane. According to the results of the meta-analysis, the incidence of iatrogenic retinal tears in vitrectomy is 11%, which can be reduced by being careful during the operation, selecting proper surgical instruments, and reducing the frequency of intraocular instruments in and out.[56] For present iatrogenic retinal tears, laser photocoagulation or cryotherapy can be used, and silicone oil or C3F8 can be filled in the eyes at the end of vitrectomy.

Perfluorocarbon liquid that migrates into the subretinal space is mainly caused by inadequate removal of epi-retinal proliferation or incomplete retinectomy or retinotomy. Perfluorocarbon liquids should be removed, and retinal lesions should be treated thoroughly.

The silicone oil migrated to the subretinal space mainly because the silicone oil injection needle did not directly enter the vitreous cavity, or the edges of the large retinal tears were not completely attached. Silicone oil can be injected after the retinal lesions have been completely cleared.

3.10 | Clinical Recommendation 10: Prevention and treatment of complications after vitrectomy in NLP eyes induced by mechanical ocular trauma

Prevention and treatment of complications after vitrectomy in NLP eyes induced by mechanical ocular trauma. (1) Corneal edema: Corneal edema usually gradually recovers after local treatment (GPS). (2) Hyphema: Iris damage should be avoided during vitrectomy to prevent postoperative hyphema. If the amount of hyphema is large and IOP is high, hyphema removal should be conducted as early as possible, and hemostatic drugs should be administered (GPS). (3) Complicated cataracts caused by silicone oil tamponade. Patients should be treated with cataract extraction combined with oil removal (GPS). (4) Vitreous or retinal haemorrhage. Bleeding can be prevented by thorough hemostasis during vitrectomy. Reoperation is required in patients with recurrent, unabsorbed, and severe VH (GPS). (5) Recurrent retinal or choroidal detachment: The iatrogenic retinal injury should be avoided, and retinal and choroidal lesions should be treated thoroughly. Further surgery should be considered prudently if there is no chance to recover vision (GPS). (6) Silicone oil-dependent eyes. Delayed removal of silicone oil or reoperation to replace it (GPS). (7) Abnormal IOP. There is currently no effective treatment for low IOP caused by severe ciliary body damage. Temporarily high IOP should be treated according to different causes. Anti-glaucoma surgery is required if the drug cannot control secondary glaucoma (GPS). (8) Traumatic endophthalmitis can be rescued by vitrectomy combined with silicone oil tamponade and intravitreal antibiotics (GPS).

3.10.1 | Recommendation explanations

Meta-analysis indicated that 31% of patients showed varying degrees of corneal edema after vitrectomy, caused by corneal injury, early operation time, long operation duration, or post-traumatic intraocular inflammation, usually recovers gradually after local treatment.[57,58] The incidence of postoperative hyphema is 10%. Treatment of postoperative hyphema is based on the amount of bleeding. If the amount of hyphema is large and IOP is high, hyphema should be removed in time.[59] Approximately, 16% of patients develop complicated cataracts. Vitrectomy combined with cataract surgery should be performed for complicated cataracts caused by secondary glaucoma or endophthalmitis. Complicated cataracts caused by silicone oil tamponade should be treated with silicone oil removal and cataract extraction.

The main reasons for postoperative VH may be the early vitrectomy time, accidental injury during operation, or incomplete hemostasis of intraoperative retinal bleeding. A small amount of retinal haemorrhage only needs to be followed up without any treatment. If vitreous and retinal bleeding is severe, further surgery may be required. The incidence of postoperative RD is about 10%, caused by the recurrent PVR,[60] and reoperation should be considered.

Seven per cent of patients need to delay the removal time of silicone oil, even leading to silicone oil dependence. A postponed removal of silicone oil could be considered in patients with intended RD after silicone oil removal or persistently low IOP, and long-term silicone oil tamponade can effectively maintain a certain IOP as shown in the results of the meta-analysis.[61,62] Silicone oil may be emulsified owing to its long-term retention in 8% of patients and should be removed accordingly. In silicone oil-dependent eyes, emulsified silicone oil can be exchanged with new silicone oil. Low IOP can be caused by severe ciliary body damage, retinal or choroidal defects, or PVR in 10% of patients.[63,64] Temporary high IOP in the early postoperative period could be caused by excessive silicone oil tamponade, inflammatory reactions in the anterior chamber, or closure of the peripheral iridectomy. Secondary glaucoma occurs in 11% of patients because of postoperative silicone oil emulsification, hyphema, or anterior chamber angle damage induced by blunt trauma. Anti-glaucoma surgery is required if the drug cannot control secondary glaucoma.[23,65–67]

Patients with traumatic endophthalmitis should be administered intravitreal antibiotics during surgery.[68–72] However, approximately 4% of patients still end up with eyeball atrophy, mostly caused by ciliary body damage induced by severe mechanical ocular trauma, recurrence of RD, or incomplete treatment of endophthalmitis.[73–76]

3.11 | Clinical Recommendation 11: Choice of intraocular tamponade in vitrectomy for NLP eyes

Silicone oil is recommended as the main intraocular tamponade for NLP eyes. Inert gas or balanced salt solution (BSS) can be used for minor retinal injuries. (1D)

3.11.1 | Recommendation explanations

Common tamponades in vitrectomy include silicone oil, inert gas, and BSS. Inert gas tamponade can promote retinal reattachment and absorption of subretinal fluid, which is suitable for medium- and short-term intraocular tamponades. BSS has the highest histocompatibility but does not have an expansion effect on the retina. Silicone oil has a longer duration owing to its lower density and higher surface tension than water.[77] Additionally, studies have shown that silicone oil can inhibit the growth of residual pathogenic bacteria in the eye.[78,79]

3.12 | Clinical Recommendation 12: Decisions on either salvage of the globe or enucleation in NLP eyes induced by mechanical ocular trauma (including surgical indication, contraindication, and medical ethics)

Decisions on either salvage of the globe or enucleation in NLP eyes induced by mechanical ocular trauma (including surgical indication, contraindication, and medical ethics). (1) Enucleation of the eyeball is not recommended in emergency surgery unless almost all intraocular tissues are lost (GPS). (2) The possibility of enucleation of traumatic eyes after the primary operation cannot be ruled out when severe complications such as sympathetic ophthalmia, long-term eye pain, and eyeball atrophy occur, and the possibility of restoring light perception is lost (GPS). (3) If enucleation is inevitable, ophthalmologists should fully communicate with patients and their family members and provide psychological counseling to relieve patients' anxiety (GPS).

3.12.1 | Recommendation explanations

NLP eyes can recover vision after mechanical ocular trauma, and NLP before the primary operation cannot be used as an indication of permanent visual loss.[9,33] Debridement should be performed during primary surgery, and damage to the intraocular tissue should be evaluated carefully at the same time. Vitrectomy should be performed on time in patients with potential visual recovery, and enucleation should be judged again during vitrectomy. Enucleation can be considered in the primary operation under the following conditions: (1) The affected eye has NLP before ocular trauma, meanwhile, almost all intraocular content is lost, and the anatomical structure of the eyeball is seriously damaged. (2) The anatomical structure of the eyeball is severely damaged and cannot undergo vitrectomy or any other subsequent treatment in aged NLP patients with severe systemic diseases. (3) Almost all intraocular content loss after trauma and the eyeball cannot be repaired. Ophthalmologists should be aware of NLP caused by psychosocial and mental factors before deciding on enucleation and assess whether there is any possibility of vision recovery.[80,81] Enucleation may cause severe psychological and emotional trauma to patients; hence, ophthalmologists should provide psychological counseling and humanistic care to relieve patients' anxiety.

3.13 | Clinical Recommendation 13: Criteria and prognosis of silicone oil-dependent eyes after vitrectomy for NLP induced by mechanical ocular trauma

Criteria and prognosis of silicone oil-dependent eyes after vitrectomy for NLP induced by mechanical ocular trauma. (1) The criteria for silicone oil-dependent eyes are limited potential for visual recovery or recurrent RD after silicone oil removal, persistent low IOP, and functionally monocular patients (1C). (2) Long-term silicone oil tamponade effectively maintains certain IOP (1D).

3.13.1 | Recommendation explanations

There are several problems with silicone oil as a long-term intraocular tamponade, including silicone oil emulsification, secondary glaucoma, complicated cataracts, and corneal degeneration. Silicone oil should be removed 3–6 months after vitrectomy.[82] However, in patients with severe injury, recurrent RD and persistently low IOP may occur if silicone oil is removed, leading to eyeball atrophy and potential enucleation. Hence, some patients need to extend the silicone oil removal time, or even need to permanently retain silicone oil and become silicone oil-dependent eyes. Meta-analysis showed that if NLP eyes have experienced several complications, such as the limited recovery of visual potential, recurrent RD after silicone oil removal, persistent low IOP, or functionally monocular patients, persistent silicone oil tamponade could be considered.[61,62] Long-term silicone oil tamponade can effectively maintain certain IOP and has no obvious effect on vision improvement or retinal reattachment.[23,83]

3.14 | Clinical Recommendation 14: Follow-up precautions after vitrectomy for NLP eyes induced by mechanical ocular trauma

Routine follow-up should be performed within 1 week and at 1, 3, 6, and 12 months after vitrectomy. Visual acuity, IOP, and ocular structure should be examined during follow-up. Complications, such as endophthalmitis, PVR, silicone oil emulsification, keratopathy, secondary glaucoma, and sympathetic ophthalmia should be treated on time (GPS).

3.14.1 | Recommendation explanations

Follow-up was performed no less than 6 months after vitrectomy. In most studies, the longest follow-up was 2–3 years.[23,57,84–87]

3.15 | Clinical recommendation 15. Visual outcomes and recovery process after vitrectomy for NLP eyes induced by mechanical ocular trauma

The final visual acuity of NLP eyes induced by mechanical ocular trauma has the potential to improve after vitrectomy. The rate of vision recovery gradually increases after vitrectomy (2D).

3.15.1 | Recommendation explanations

Meta-analysis showed that visual acuity was restored to light perception and hand motion in 34% of eyes with NLP after vitrectomy,[8,9,23,42,85,86,88] recovered from NLP to counting fingers (CF)-20/400 in 16% and had a long-term visual outcome better than 20/400 in 11%. Subgroup analysis showed that the light perception recovery rate gradually increased until 1 year after vitrectomy.

3.16 | Clinical Recommendation 16: Effectiveness of corticosteroids and antibiotics in the treatment of NLP induced by mechanical ocular trauma

Effectiveness of corticosteroids and antibiotics in the treatment of NLP induced by mechanical ocular trauma. (1) For patients with NLP eyes induced by mechanical ocular trauma, the use of triamcinolone acetonide or dexamethasone after primary surgery is recommended as single intravitreal drug therapy for empirical anti-inflammatory therapy (2D). (2) For patients with NLP induced by mechanical ocular trauma, vancomycin is recommended as a single intravitreal drug empirical anti-infective therapy. However, concomitant medicine with vancomycin is also recommended based on the outcomes of pathogen culture and antimicrobial susceptibility tests, which include ceftazidime, ceftriaxone, cefaloridine, cefuroxime, cefepime, moxifloxacin, levofloxacin, ofloxacin, clindamycin, and tobramycin. Voriconazole and amphotericin have been recommended for the treatment of fungal infections (2D).

3.16.1 | Recommendation explanations

Meta-analysis showed that intravitreal injection of triamcinolone acetonide can effectively reduce the incidence of postoperative ocular inflammation during complex ocular trauma surgery. Intraocular injection of vancomycin can effectively improve the surgical effect in mechanical ocular trauma patients with NLP.[89–91] In patients with penetrating ocular injuries and IOFBs, a single intravitreal injection of vancomycin can help reduce the incidence of endophthalmitis during the treatment process (RR = 0.24, 95% CI:0.09–0.63, $p < 0.05$).[92,93] Vancomycin combined with ceftazidime was used for the treatment of open globe injury, and systemic or intraocular injection can reduce the incidence of post-traumatic endophthalmitis and the rate of enucleation, and improve the prognosis of infectious endophthalmitis. Combined vitreous injection of vancomycin and ceftazidime during surgical treatment has a certain effect on postoperative visual acuity improvement in patients with open globe injury and endophthalmitis. Intraocular injection of vancomycin and ceftazidime, combined with systemic administration of cefuroxime, cefazolin, or clindamycin, can reduce the rate of enucleation after trauma.[94–96] Systemic intravenous vancomycin combined with cefepime, tobramycin, or ofloxacin can reduce the incidence of post-traumatic endophthalmitis.[97] It has been reported that hypersensitivity caused by intravitreal vancomycin may lead to haemorrhagic obstructive retinal vasculitis (HORV). Regular postoperative follow-up for ocular fundus examination should be performed. If HORV is suspected, further intraocular injection of vancomycin should be avoided.[98,99]

4 | CONCLUSION

This guideline focuses on the diagnosis, treatment, and prognosis of mechanical ocular trauma with NLP in strict accordance with WHO guideline formulation specifications and international standards. The guideline development group surveyed ophthalmologists and experts in the ocular trauma field, collected and arranged key questions on mechanical ocular trauma with NLP, comprehensively retrieved and evaluated systemically relevant research evidence, conducted in-depth interviews, and analyzed patient preferences and values. Eventually, 16 recommendations directed at the diagnosis, treatment, and prognosis of mechanical ocular trauma with NLP were developed. Each recommendation has been explained in detail, providing important guidance for the diagnosis, treatment, and long-term prognosis prediction of mechanical ocular trauma with NLP. The guideline development group reminds us that the level of some recommendations is weak because of the inadequacy or lack of clinical evidence. Ophthalmologists should receive relevant training when using this guideline. Valuable suggestions and opinions from users on the shortcomings of this guideline are warmly welcomed to ensure continuous improvement. In addition, this guideline is not intended for commercial promotion or publicity purposes.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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