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Characteristics and surgical outcomes of pediatric traumatic macular holes

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Abstract

Background Due to the small number of cases, limited knowledge exists on the surgical outcome of pediatric traumatic macular holes (MHs). This study aims to investigate the characteristics and surgical outcomes of pediatric traumatic MHs and analyse the associated factors of surgical outcomes.

Methods 59 pediatric patients that underwent vitrectomy for MHs caused by blunt trauma or laser pointer at a tertiary hospital were retrospectively recruited. Ophthalmic examination and optical coherence tomography were conducted at baseline and follow-ups.

Results The etiologies of the MHs were blunt trauma in 43 eyes and laser pointer in 16 eyes. The overall closure rate was 89.8%. MHs that did not close were larger than MHs that closed ($P=0.001$). Among eyes with closed MHs, 41.5% achieved best corrected visual acuity (BCVA) of 20/40 or better (good responder). The good responders had better preoperative BCVA ($P=0.029$), smaller minimal diameter ($P<0.001$), and smaller preoperative ellipsoid zone defect ($P=0.002$) than the poor responders (BCVA < 20/40). Patients hurt by blunt trauma were more likely to be poor responders than patients injured by laser pointer ($P=0.025$, OR = 0.240, 95%CI: 0.066 ~ 0.866).

Conclusions Pediatric MHs could be caused by blunt trauma or laser pointer. Vitrectomy was effective in closing the holes and improving visual acuity. The anatomic outcome was related with MH size. Worse preoperative BCVA, larger MH size and blunt trauma injury were predictors of poor functional outcome.

Keywords Child health (pediatrics), Macular, Ophthalmologic surgical procedures, Trauma

Background

The most common type of macular hole (MH) is idiopathic MH, which usually occurs in elderly patients [1, 2]. Pediatric MH is quite rare. The most common cause of pediatric MH is blunt trauma [3]. Laser devices can also cause traumatic MHs. In the past decade, the easy access to high-power handheld laser on the internet had led to an increase of laser-induced MHs, especially among children and teenagers [4–10]. As a result, blunt trauma and laser injury have become two main causes of pediatric traumatic MHs.

Because of the high rate of spontaneous closure of MHs caused by blunt trauma, 3 to 6 months of watchful waiting has been recommended by some [11]. However, the risk of amblyopia should be taken into consideration, especially in young children [12]. Some surgeons now choose to do surgery earlier (even within 1 month after trauma) [13]. Spontaneous closure of laser-induce MH is quite rare and thus surgical intervention is usually necessary [7].

Due to the small number of pediatric traumatic MH cases, limited knowledge exists on their surgical

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outcomes. A recent systematic review on pediatric MHs caused by blunt trauma concluded that early and delayed vitrectomy yielded similar anatomic and visual results, and that observation and vitrectomy yielded comparable final visual acuity and closure time [13]. It suggested that clinicians may choose either early surgery or delayed surgery when healing biomarkers are absent on periodic optical coherence tomography (OCT) [13].

In this study, we presented the largest cohort of pediatric traumatic MHs treated by vitrectomy and described the characteristics and the anatomic and functional outcomes. Both blunt trauma and laser injury were included. We also analyzed the associated factors of the anatomic and functional outcomes.

Methods

Study design and patient data

This retrospective study included all pediatric patients (under 16 years) who received pars plana vitrectomy (PPV) for full thickness macular holes caused by blunt trauma or accidental laser injury at Beijing Tongren Hospital from August 2013 to May 2023. The study protocol was approved by the Ethic Committee of Beijing Tongren Hospital and was conducted in accordance with the Declaration of Helsinki. Patients with open globe injury, other vitreoretinal diseases, retinal detachment that was not localized or follow up less than 6 months were excluded.

Data collected included age, gender, etiology of trauma, concomitant ocular findings, time interval from injury to surgery, surgical procedure, follow-up duration, best corrected visual acuity (BCVA) at baseline and final follow-up and MH closure status.

OCT measurements

Spectral-domain optical coherence tomography (SD-OCT) (Cirrus; Carl Zeiss Meditec, Inc., Dublin, CA, USA) was conducted before surgery and at follow-ups. OCT measurements was conducted by a trained specialist who was masked to the outcome. Preoperative OCT features included minimal diameter (MD), basal diameter (BD), preoperative length of ellipsoid zone (EZ) defect and retinal thickness at hole margin. In eyes with closed holes, postoperative length of EZ defect and central foveal thickness were also measured. MD was measured at the narrowest point of the hole [14]. BD was the length of RPE where the neuroretina was detached [15]. EZ defect was defined as loss of the hyperreflectivity characterized by the layer [15]. The average of the vertical and horizontal measurements was recorded. Retinal thickness at hole margin was measured 1,000 µm from the foveal center [16]. The average of the nasal, temporal, superior, and inferior was recorded. The eccentricity of the hole was calculated according to the method in literature. The MHs were assumed to be elliptical. We define "a" to be the radius of the larger axis (the longer of the vertical and horizontal MD) and "b" to be the radius of the smaller axis (the shorter of the vertical and horizontal MD). The eccentricity was calculated by the following formula [17]:

$$\varepsilon = \sqrt{1 - \frac{b^2}{a^2}}$$

Surgical procedures

23-gauge or 25-gauge PPV was performed. Induction of posterior vitreous detachment was performed with the use of triamcinolone acetonide to visualize the vitreous. The peripheral vitreous was trimmed. Internal limiting membrane (ILM) was peeled under the assistance of indocyanine green. Inverted ILM flap technique was adopted when the surgeon thought ILM peeling alone was inadequate in closing the hole. Peripheral tears or dialysis or localized retinal detachment were treated with photocoagulation before or after fluid-air exchange. The tamponade agents included air, inert gas or silicone oil, based on the availability of tamponade and the findings during surgery. All patients were asked to maintain a face-down position for at least one week after surgery.

Statistical analysis

SPSS version 20.0 for Windows was used for statistical analysis (SPSS Inc., Chicago, Illinois, USA). Patients were divided into two groups according to the final BCVA: good responders (final BCVA better than 20/40); poor responders (final BCVA worse than 20/40) [15]. Categorical data were compared between groups using χ^2 test. Continuous data were compared using Student's t test or Mann-Whitney U test. Snellen's visual acuity was converted to the logarithm of the minimum angle of resolution (logMAR) visual acuity for statistical analysis. Binary logistic regression analysis was performed to analyze the associated factors of anatomical and functional outcomes. Odds ratios (OR) and their 95% CI were calculated. Two-tailed P values < 0.05 were considered statistically significant.

Results

Epidemiology features and ocular findings

Fifty nine pediatric patients (59 eyes) were enrolled in the present study. Patients were predominantly male (81.4%, 48/59) with a mean age of 12.3 ± 2.2 years (range 8 to 16 years). All of the MHs were unilateral (22 right eye). The etiologies of the MHs were blunt trauma in 43 eyes and laser pointer in 16 eyes. The causes of blunt trauma included high-velocity object in 28 eyes (such as ball, stone, slingshot, bottle, racket, stick, corncob, blackboard eraser, stool and slipper), fist in 2 eyes, firecracker explosion in 3 eyes, tumble and collision in 5 eyes and unclear object impact in 5 eyes. Concomitant ocular findings of the blunt trauma group included peripheral retinal tear in 1 eye, retinal dialysis in 1 eye, localized retinal detachment in 2 eyes, commotio retinae in 6 eyes, lens subluxation in 1 eye and mild cataract in 2 eyes. No concomitant lesion was found in the laser injury group. The median follow-up time after surgery was 12 months (range 7 to 48 months).

OCT findings and comparison between different etiologies

The mean MD was 562.49 ± 228.60 μm (range 218 to 1152 μm), the mean BD was 1125.98 ± 441.94 (range 234 to 3168 μm) and the mean preoperative EZ defect was 1377.21 ± 609.82 (range 461 to 4000 μm). Intraretinal cysts at the hole margin were noted in 56/59 (94.9%) eyes. Epiretinal membrane was present in 3/59 (5.1%) eyes. All of the 16 eyes injured by laser pointer had a subfoveal hyperreflectivity, which was not observed in eyes injured by blunt trauma (Fig. 1). MHs caused by blunt trauma were larger, thinner at the hole margin and more elliptical than MHs caused by laser pointer, but the differences were not statistically significant (all $P > 0.05$) (Table 1). 6 months after surgical closure of MHs, the EZ defect was smaller and the foveal neuroretina was thicker in eyes injured by laser pointer than in eyes hurt by blunt trauma, but the differences were not statistically significant either (both $P > 0.05$) (Table 1).

Surgical intervention

The median duration from injury to surgery was 5 months (range 0.3 to 48 months). PPV and ILM peeling were performed in all patients, in addition with inverted ILM-flap technique in some patients. Patients treated with inverted ILM-flap technique had longer duration from injury to surgery ($P = 0.009$), worse preoperative BCVA ($P = 0.003$), and larger hole size ($P = 0.003$) compared with patients treated with ILM peeling alone. No difference was found between these two surgical techniques in final MH closure status or final BCVA (both $P > 0.05$) (Table 2). The tamponade agents included air in 21 eyes, inert gas in 36 eyes (C_2F_6 in 10 eyes and C_3F_8 in 26 eyes) and silicone oil in 2 eyes. Air was used when inert gas was not available. No difference was found between holes that closed with air and inert gas in the duration from injury to surgery, preoperative BCVA, the hole size or the ILM-flap rate (all $P > 0.05$). No difference was found between inert gas and air in final MH closure status or final BCVA (both $P > 0.05$). Silicone oil was chosen when the surgeon thought longer tamponade was needed. Silicone oil was used in 2 patients with large persistent holes. However, these 2 patients did not demonstrate hole closure at last follow-up.

Anatomical outcome and associated factors

Single-operation closure was accomplished in 48/59 (81.4%) eyes (Fig. 1). 11 eyes did not have successful closure after the first surgery. Among these patients, 5 had successful closure following a second operation (enlarged ILM peeling with blood coating). 3 did not had hole closure after the second surgery. 3 refused to have second surgery. Overall, 53/59 (89.8%) eyes demonstrated closure of MH at final follow-up. MHs that did not close were larger than MHs that closed ((844.00 ± 222.78)μm versus (524.96 ± 203.71)μm, $P = 0.001$, t=-3.568). Final

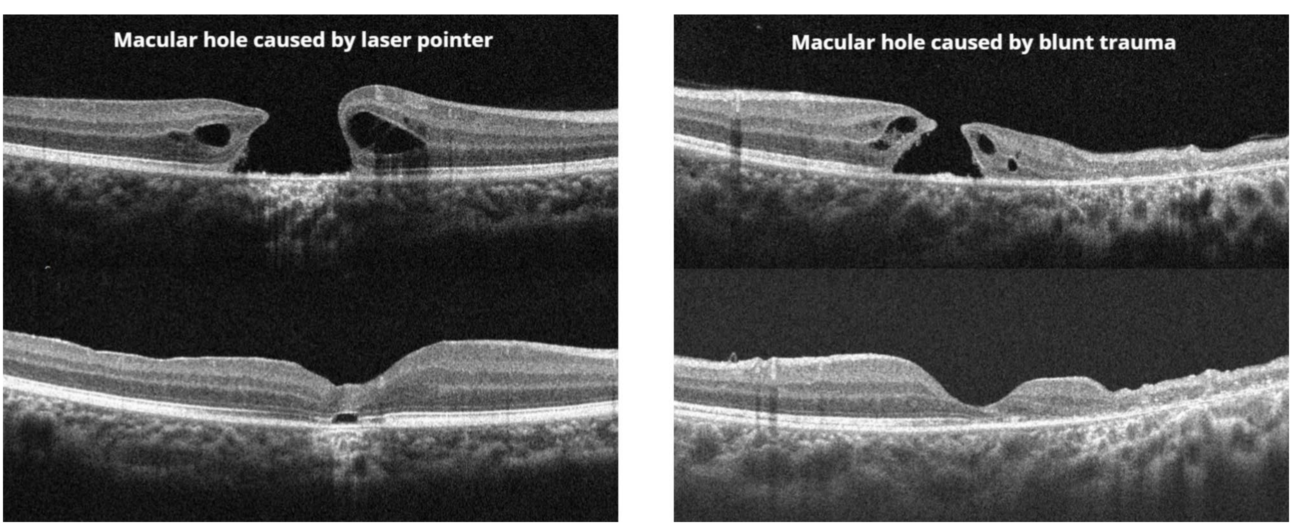

Fig. 1 Optic coherent tomography of macular holes caused by laser pointer and blunt trauma. Images before (top) and 6-months after (bottom) surgery were shown. Note the subfoveal hyperreflectivity in the laser pointer case and the atrophy of the retina in the blunt trauma case. The laser-pointer-injured patient was a 10-year-old girl. The preoperative BCVA was 20/100 and the final BCVA was 20/40. The blunt-trauma-injured patient was a 15-year-old boy. The preoperative BCVA was 20/130 and the final BCVA was 20/50

Table 1 Characteristics of patients with pediatric macular holes and comparison between patients hurt by **blunt trauma** and **laser pointer**

Variables	Total (*n* = 59)	Blunt trauma (*n* = 43)	Laser pointer (*n* = 16)	*P*
Age (years)	12.3 ± 2.2	12.4 ± 2.2	12.0 ± 2.2	0.571
Gender (male/female)	48/11	36/7	12/4	0.697
Laterality (right eye/left eye)	22/37	14/29	8/8	0.218
Time interval (months, median (range))	5 (0.3–48)	5 (0.3–48)	6 (1–24)	0.745
Preoperative BCVA (logMAR)	1.03 ± 0.41	1.08 ± 0.43	0.90 ± 0.33	0.162
MD (µm)	562.5 ± 228.6	578.8 ± 217.1	526.8 ± 255.8	0.456
BD (µm)	1126.0 ± 441.9	1142.6 ± 440.8	1084.3 ± 458.6	0.681
Preoperative EZ defect (µm)	1377.2 ± 609.8	1449.1 ± 663.1	1207.8 ± 435.4	0.218
Retinal thickness at hole margin (µm)	323.4 ± 37.7	319.3 ± 40.3	336.8 ± 25.4	0.256
Eccentricity	0.41 ± 0.19	0.43 ± 0.19	0.38 ± 0.19	0.456
Final BCVA (logMAR)	0.54 ± 0.38	0.60 ± 0.39	0.40 ± 0.35	0.086
Good responders / Poor responders	21/38	11/32	13/3	**0.025**
MH closed / MH not closed	53/6	39/4	14/2	1.000
Postoperative EZ defect at 6 months (µm)	307.1 ± 357.3	340.2 ± 383.4	222.6 ± 281.9	0.411
Postoperative fovea thickness at 6 months (µm)	101.0 ± 31.7	97.5 ± 30.6	112.9 ± 35.1	0.267

Time interval, time from injury to surgery; BCVA, best corrected visual acuity; MD, minimal diameter; BD, basal diameter; EZ, ellipsoid zone; Good responders (final BCVA ≥ 20/40); Poor responders (final BCVA < 20/40);

Table 2 Comparison between patients treated with **inverted ILM flap technique** and patients treated with **ILM peeling alone**

Variables	Inverted ILM flap (*n* = 22)	ILM peeling alone (*n* = 37)	*P*
Age (years)	12.2 ± 2.3	12.3 ± 2.2	0.929
Gender (male/female)	18/4	30/7	0.944
Laterality (right eye/left eye)	11/11	11/26	0.119
Time interval (months, median (range))	12 (0.5–48)	4 (0.3–24)	**0.009**
Etiology (blunt trauma/laser injury)	18/4	25/12	0.234
Preoperative BCVA (logMAR)	1.23 ± 0.42	0.91 ± 0.36	**0.003**
MD (µm)	650.2 ± 242.1	510.4 ± 206.7	**0.003**
BD (µm)	1226.6 ± 355.2	1067.6 ± 481.1	0.228
Preoperative EZ defect (µm)	1516.3 ± 540.7	1290.9 ± 642.9	0.222
Retinal thickness at hole margin (µm)	317.6 ± 38.6	328.1 ± 37.4	0.429
Eccentricity	0.43 ± 0.21	0.40 ± 0.17	0.601
MH closed (yes/no)	21/1	32/5	0.511
Final BCVA (logMAR)	0.61 ± 0.36	0.50 ± 0.40	0.322
Postoperative EZ defect at 6 months (µm)	381.0 ± 309.3	241.9 ± 392.5	0.279
Postoperative fovea thickness at 6 months (µm)	89.9 ± 31.7	110.2 ± 29.4	0.075

ILM, inner limiting membrane; Time interval, time from injury to surgery; BCVA, best corrected visual acuity; MD, minimal diameter; BD, basal diameter; EZ, ellipsoid zone

MH closure status was not associated with age, gender, etiology, retinal thickness at hole margin, eccentricity of the hole or time interval from injury to surgery (all $P > 0.05$). (Table 3)

Functional outcome and associated factors

Among the 53 eyes with closed MHs, BCVA improved from 1.02 ± 0.42 logMAR (approximately 20/200) to 0.50 ± 0.38 logMAR (approximately 20/63) ($P < 0.001$, t = 8.682). 22 (41.5%) of the 53 eyes with closed MHs had final BCVA better than 20/40. 43 (81.1%) of the 53 eyes with closed MHs had VA improvement of 2 or more lines. Linear regression analysis showed that final BCVA was not associated with follow up period ($P = 0.138$, B=-0.008, 95%CI: -0.018 ~ 0.002). Also, no difference in vision improvement ($P = 0.422$, t = 0.809) or final BCVA ($P = 0.650$, t=-0.456) was found from those that have longer follow up (> 12 months) compared to the shorter follow up (< = 12 months).

The characteristics of good responders (final BCVA better than 20/40) and poor responders (final BCVA worse than 20/40) were compared. The good responders had better preoperative BCVA ($P = 0.029$), smaller MD ($P < 0.001$), BD ($P = 0.007$) and preoperative EZ defect ($P = 0.002$). Patients hurt by blunt trauma were more likely to be poor responders than patients injured by laser pointer ($P = 0.025$, OR = 0.240, 95%CI: 0.066 ~ 0.866). (Table 4)

Table 3 Comparison between patients whose **maculer hole closed** and **not closed** in univariate manner

Variables	MH closed (*n* = 53)	MH not closed (*n* = 6)	*P*	OR	95% CI
Age (years)	12.3 ± 2.3	12.3 ± 1.6	0.999	1.000	0.677 ~ 1.477
Gender (male/female)	43/10	5/1	1.000	0.860	0.090 ~ 8.197
Laterality (right eye/left eye)	22/31	0/6	0.075	-	-
Time interval (months, median (range))	5 (0.3–48)	6 (1.2–12)	0.811	1.038	0.914 ~ 1.178
Etiology (blunt trauma/laser injury)	39/14	4/2	1.000	1.393	0.229 ~ 8.459
Preoperative BCVA (logMAR)	1.03 ± 0.42	1.03 ± 0.35	0.982	0.976	0.124 ~ 7.661
MD (μm)	525.0 ± 203.7	844.0 ± 222.8	**0.001**	**0.741**	**0.597 ~ 0.920**
BD (μm)	1051.4 ± 330.1	1660.3 ± 754.4	**0.001**	**0.865**	**0.756 ~ 0.989**
Preoperative EZ defect (μm)	1279.0 ± 462.7	2048.3 ± 1043.7	**0.003**	**0.918**	**0.851 ~ 0.991**
Retinal thickness at hole margin(μm)	320.8 ± 37.0	350.3 ± 41.1	0.200	0.334	0.063 ~ 1.815
Eccentricity	0.42 ± 0.19	0.33 ± 0.18	0.359	23.085	0.030 ~ 17900.286

MH, macular hole; Time interval, time from injury to surgery; BCVA, best corrected visual acuity; MD, minimal diameter; BD, basal diameter; EZ, ellipsoid zone

Table 4 Comparison between **good responders** and **poor responders** in univariate manner

Variables	Good responders (*n* = 22)	Poor responders (*n* = 37)	*P*	OR	95% CI
Age (years)	12.3 ± 2.3	12.0 ± 1.9	0.708	1.059	0.789 ~ 1.422
Gender (male/female)	18/4	29/8	0.620	1.450	0.326 ~ 6.526
Laterality (right eye/left eye)	13/19	17/20	0.669	0.773	0.237 ~ 2.521
Time interval (months, median (range))	3.5 (0.5–24)	6 (0.3–48)	0.376	1.038	0.914 ~ 1.178
Etiology (blunt trauma/laser injury)	11/11	28/9	**0.025**	**0.240**	**0.066 ~ 0.866**
Preoperative BCVA (logMAR)	0.84 ± 0.29	1.10 ± 0.43	**0.029**	**0.134**	**0.020 ~ 0.919**
MD (μm)	401.3 ± 99.7	682.6 ± 238.2	**< 0.001**	**0.606**	**0.442 ~ 0.832**
BD (μm)	909.9 ± 269.2	1313.7 ± 518.0	**0.007**	**0.828**	**0.715 ~ 0.958**
Preoperative EZ defect (μm)	1034.9 ± 262.1	1667.7 ± 709.3	**0.002**	**0.834**	**0.730 ~ 0.952**
Retinal thickness at hole margin (μm)	323.2 ± 19.8	323.7 ± 49.4	0.976	0.985	0.368 ~ 2.637
Eccentricity	0.38 ± 0.22	0.46 ± 0.18	0.302	0.112	0.002 ~ 6.654
Postoperative EZ defect at 6 months (μm)	144.8 ± 221.3	531.4 ± 399.3	**0.007**	**0.778**	**0.627 ~ 0.966**
Postoperative fovea thickness at 6 months (μm)	117.3 ± 27.1	80.6 ± 23.5	**0.002**	**28.743**	**1.616 ~ 511.105**

Time interval, time from injury to surgery; BCVA, best corrected visual acuity; Good responders (final BCVA ≥ 20/40); Poor responders (final BCVA < 20/40); MD, minimal diameter; BD, basal diameter; EZ, ellipsoid zone

In eyes with closed holes, the postoperative EZ defect at 6 months was smaller ($P = 0.007$) and the foveal neuroretina was thicker ($P = 0.002$) in good responders than in poor responders. (Table 4)

Discussion

Pediatric MH is a rare condition. Previous studies on pediatric MH had relatively small sample size [3, 18–21]. In this study, we included 59 pediatric traumatic MHs treated by vitrectomy, comprising the largest cohort on this condition. A comprehensive analysis of the characteristics and surgical outcomes, as well as the associated factors of outcomes was performed. Our findings contribute to the limited body of knowledge on pediatric traumatic MHs and offer insights that may guide clinical treatment.

Liu et al. presented a comparatively large case series of pediatric MHs with multiple etiologies and found that blunt trauma was the most prevalent cause for pediatric MHs, accounting for 70% of all the 40 cases [3]. MHs secondary to other vitreoretinal diseases were also included in their study [3]. The other two relatively large studies on pediatric MHs only included MHs caused by trauma [20, 21]. Unlike these previous studies, we found that laser injury was also an important cause of pediatric MHs, accounting for 27.1% of the whole cohort.

We compared the OCT features and clinical characteristics of MHs caused by blunt trauma and laser pointer. All of the laser-induced MHs had characteristic subfoveal hyperreflectivity, which was not observed in eyes injured by blunt trauma. The subfoveal hyperreflectivity in laser-induced MHs might be related to the photocoagulation effect of laser. On the other hand, biomechanical impact was the main pathology for blunt trauma-induced MHs. We also found that MHs caused by blunt trauma were larger, thinner at the hole margin, more elliptical, and had worse preoperative BCVA than MHs caused by laser pointer, although the differences were not statistically significant. Similarly, Huang et al. had found that compared to idiopathic MHs, traumatic MHs were larger at the base, thinner at the hole margin, less circular, and were associated with worse vision [22]. These findings indicate the strong biomechanical impact of blunt trauma on the fovea. The higher eccentricity of MHs caused by blunt trauma may be related to the avulsive force exerted on the fovea by the vitreous as a result of anteroposterior compression and decompression and equatorial expansion of the globe. This foveal avulsion is likely to cause jagged, irregular edges, resulting in higher eccentricity of the hole.

The primary (81.4%) and overall (89.8%) closure rate of MHs in this study were high and comparable to previous studies, corroborating the effectiveness of vitrectomy combined with ILM peeling in treating pediatric traumatic MHs [3, 19–21]. Our study showed that MHs that did not close were larger than MHs that closed, highlighting the importance of MH size as a prognostic factor for surgical success of pediatric traumatic MHs. In our study, surgeons tended to choose inverted ILM-flap technique over ILM peeling alone in patients with longer duration from injury to surgery, worse preoperative BCVA, and larger hole size. In spite of the above-mentioned differences at baseline, the two techniques achieved comparable anatomic and functional outcomes, indicating the effectiveness of inverted ILM-flap technique in improving the outcome of large or persistent holes.

Among the successfully operated eyes, the improvement of visual acuity was 0.52 logMAR (approximately 5 lines), with 41.5% achieving BCVA of 20/40 or better. The visual improvement was higher in our study compared with previous studies on pediatric MHs [3, 20, 21], possibly because of the inclusion of laser-induced MHs, which had better functional outcome than MHs caused by blunt trauma. Our study demonstrated that worse preoperative BCVA, larger MH size and blunt trauma injury were predictive factors of worse visual outcome.

Patients injured by blunt trauma were more likely to be poor responders than patients injured by laser pointer. By comparing the two groups, we found that MHs caused by blunt trauma were larger, thinner at the hole margin, more elliptical, and had worse preoperative BCVA than MHs caused by laser pointer. These facts potentially indicated a more severe biomechanical impact on the retina by blunt trauma, which resulted in poorer visual recovery. In Liu et al.'s study, significant predictor of poor final BCVA was the presence of macular lesions (commotio retinae), most of which developed after high-velocity impact injury [3]. Photoreceptor apoptosis and necrosis was the underlying pathological mechanism.

The smaller EZ defect and thicker foveal neuroretina at 6 months postoperatively in good responders support the notion that preservation of retinal architecture is crucial for visual recovery.

Based on the findings of previous studies and the present study, we propose different treatment between the two groups. For MHs caused by blunt trauma, because of the high spontaneous closure rate and because there is no difference in outcomes with delayed surgery, clinicians may choose surgery or vigilant observation [13]. While for laser-induced MHs, surgical intervention is usually necessary because spontaneous closure is quite rare and because the visual outcome of surgery is promising. Early surgery is recommended during the amblyogenic age regardless of the etiology.

The limitations of this study lie in the following aspects: First, it only included pediatric traumatic MHs that received surgical intervention, whereas the information on spontaneous closure was missing. Second, due to the retrospective nature of the study, the optimal surgical procedure could not be determined. Third, multiple surgeons performed the surgeries, increasing the heterogeneity of the study. However, all of the surgeons were experienced consultants with similar proficiency in the procedure. Fourth, the final BCVA was recorded at different timepoints. However, linear regression analysis showed that final BCVA was not associated with follow up period. Also, no difference in vision improvement or final BCVA was found from those that have longer follow up compared to the shorter follow up.

Conclusions

In conclusion, pediatric traumatic MHs are most commonly caused by blunt trauma and laser pointer. Vitrectomy combined with ILM peeling is effective in closing the holes and improving visual acuity. The anatomic outcome is related with MH size. Worse preoperative BCVA, larger MH size and blunt trauma injury are predictors of poor functional outcome.

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Author contributions
Conceptualization and design of the work, Y.C. and X.S.; Data collection and data analysis, Y.C. and G.W.; Data interpretation, Y.C. and X.S.; Writing—original draft preparation, Y.C.; Writing—review and editing, X.S.. All authors have read and agreed to the published version of the manuscript.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study protocol was approved by the Ethics Committee of Beijing Tongren Hospital (TREC2024-KY028). Due to the retrospective nature of the study, the Ethics Committee of Beijing Tongren Hospital waived the need of obtaining informed consent from a parent and/or legal guardian.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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