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Research article

Zonular ligament abnormalities intermingled in acute primary angle closure: A diagnostic and therapeutic challenge

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ABSTRACT

Purpose: This study aims to investigate patient characteristics with lens zonular ligament abnormalities in Acute Primary Angle Closure (APAC), identifying related risk factors, and evaluating the efficacy of Pilocarpine, a miotic agent.
Design: Retrospective case-control study.
Methods: Conducted as a retrospective case-control study at Hebei Provincial Eye Hospital from January 1, 2019, to December 31, 2021, the study included APAC cases undergoing ultrasound phacoemulsification with or without glaucoma surgery. Zonular ligament status was determined by intraoperative indicators such as lens equator visibility post-mydriasis and anterior capsule wrinkling during capsulorhexis. Patients were categorized into APAC and APAC with Lens Subluxation (APACLS) groups. Demographic details, Central Anterior Chamber Depth (ACD), Axial Length (AL), ACD difference between eyes (ACDD), Lens Thickness (LT), Lens Position (LP), and Relative Lens Position (RLP) were recorded and compared. Pilocarpine's impact on intraocular pressure reduction was assessed. Statistical analysis involved bilateral t-tests (for normally distributed data comparing both eyes in each group), non-parametric tests (for comparing two groups with non-normally distributed data), binary logistic regression, and Receiver Operating Characteristic (ROC) curve analysis for cutoff value determination related to zonular abnormalities.
Results: The APAC and APACLS groups showed no significant difference in age of onset (70.11 ± 8.67 years vs. 70.11 ± 8.67 years, P = 0.159) or axial length of the eye (22.35 ± 0.64 mm vs. 22.36 ± 0.78 mm, P = 0.929). In the APACLS group, LT was greater (5.24 ± 0.37 mm vs. 5.01 ± 0.36 mm, P = 0.011), ACD was shallower (1.42 ± 0.24 mm vs. 1.69 ± 0.24 mm, P = 0.000), and ACDD was larger (0.38 ± 0.22 mm vs. 0.18 ± 0.18 mm, P = 0.000). The LP was lower (4.04 ±

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0.32 vs. 4.20 ± 0.22, P = 0.013), and RLP was also lower (0.18 ± 0.02 vs. 0.19 ± 0.01, P = 0.015) in the APACLS group. A shallow ACD and a large ACDD were identified as risk factors associated with lens zonular abnormalities in the affected eyes (ACD OR value 63.97, P = 0.027; ACDD OR value 0.029, P = 0.027). Using ROC curve analysis, the cutoff value for ACDD was determined to be 0.375 mm, and for ACD, it was 1.6 mm. After pupil constriction with Pilocarpine eye drops, the proportion of patients whose intraocular pressure normalized was 75.36 % (52/69) in the APAC group and 71.43 % (25/35) in the APACLS group.

Conclusion: ACD and ACDD in the affected eye are indicative of increased risk for APACLS. An ACD <1.6 mm and ACDD >0.375 mm should prompt consideration of zonular ligament abnormalities. Pilocarpine as a miotic treatment is safe and effective for such patients.

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1. Introduction

Acute Primary Angle Closure (APAC) is the most common type of glaucoma in Asian populations, characterized by a sudden increase in intraocular pressure and retinal ganglion cell death, leading to significant and irreversible visual impairment [1]. The lens's size and position play a pivotal role in angle-closure glaucoma, with increased thickness or abnormal positioning heightening the risk of pupillary block and angle crowding [2–4].Lens extraction is an effective surgical method for the treatment of APAC [5], but the proportion of patients with zonular ligament abnormalities is significantly increased during the operation [6,7]. In cataract surgery, additional interventions may be required, such as the application of capsular tension rings, or the need for scleral suturing for fixation. Furthermore, there's a possibility of partial dislocation of the intraocular lens within the capsule following artificial lens implantation [8]. Therefore, accurately diagnosing zonular ligament abnormalities preoperatively is crucial for appropriate treatment planning. Past research on lens subluxation in normal eyes has directly observed the zonular ligaments using an ultrasound biomicroscope (UBM) or indirectly through anterior segment biometric indicators [9], identifying typical cases of incomplete lens dislocation [6,10]. However, the anterior chamber in APAC is relatively shallow so the above diagnostic methods are not suitable for them, and there is still a lack of effective preoperative diagnostic methods [11]. In the treatment of APAC, Pilocarpine-induced miosis effectively alleviates pupillary block and opens the angle [3], but it can also induce ciliary muscle contraction, zonular relaxation, anterior lens displacement, and a shallower anterior chamber [12]. As a result, some clinicians are cautious or even against the use of miotics in eyes with zonular abnormalities due to the paucity of reports on their treatment efficacy in such cases. This retrospective study aims to identify patients with zonular ligament abnormalities in acute angle closure and evaluate the therapeutic effects of Pilocarpine.

2. Methods

This retrospective case-control study was carried out in the inpatient department of Hebei Provincial Eye Hospital in China. It included APAC patients who underwent ultrasound phacoemulsification, with or without concurrent glaucoma surgery, at Hebei Provincial Eye Hospital from January 2019 to December 2021. Approval for the study was granted by the Institutional Review Board of Hebei Provincial Eye Hospital in Xingtai, China.

2.1. Inclusion criteria

1. Patients aged 40–80 years, fitting the definition of APAC as described in Ref. [13]: (1) intraocular pressure >50 mmHg; (2) at least three signs of corneal edema, moderately dilated pupil, conjunctival congestion; (3) symptoms of eye pain, headache, nausea/vomiting; (4) shallow anterior chambers in both eyes, angle closure in the affected eye, and iridocorneal contact ≥180° in the fellow eye, with or without peripheral anterior synechiae.
2. Patients underwent ultrasound phacoemulsification for cataract extraction, either in conjunction with or without glaucoma surgery. Lens zonular ligament abnormalities were found intraoperative.

2.2. Exclusion criteria

1. Patients with a history of ocular trauma or signs of ocular trauma upon examination, such as iridodialysis, vitreous herniation, pupillary margin tear, traumatic mydriasis, angle recession, etc.;
2. Patients with a history of intraocular surgeries: such as trabeculectomy, vitrectomy, corneal transplantation, etc.;
3. Patients with high myopia, microphthalmos, retinitis pigmentosa, pseudoexfoliation syndrome, Marfan syndrome, homocystinuria, or Weill-Marchesani syndrome;
4. Patients with severe systemic diseases who are unable to comply with follow-up examinations;
5. Patients excluded based on UBM showing ciliary body detachment;
6. Patients with bilateral acute episodes and bilateral lens zonular ligament abnormalities.

2.3. Definition of abnormality of zonular ligaments

Lens zonular ligament abnormalities are identified intraoperatively by one of the following observations [7].

: 1) Zonular laxity: Radial folds in the anterior capsule during continuous circular capsulorhexis (CCC) despite full dilation, making it impossible to visualize the lens equator, or the lens equator is visible but no capsular bag contraction is observed throughout the phacoemulsification procedure; 2) Zonular breakage: The lens equator is visible under full dilation, or radial folds are seen in the anterior capsule during CCC, and capsular bag contraction is observed during surgery.

2.4. Data collection

Demographic characteristics of each patient were collected, along with data from slit-lamp examinations, UBM, and A/B-scan imaging. Six parameters were measured and recorded: ACD, AL, Difference in ACDD, LT, LP, and RLP. The process of intraocular pressure reduction treatment was documented, including local application of Pilocarpine eye drops for mydriasis, and changes in intraocular pressure following medication. Intraoperative lens zonular ligament conditions were recorded. Patients with normal zonular ligaments during cataract surgery were included in the APAC group, while those with zonular ligament abnormalities were included in the APACLS group. The use of capsular tension rings and intraocular lens implantation were noted. Postoperative follow-up of both groups was conducted for over 12 months, recording patient intraocular pressure, visual acuity, and position of the intraocular lens.

We collected data of 69 eyes in the APAC group and 55 eyes in the APACLS group for analyzing the effectiveness of mydriatic drugs. Due to the necessity of comparing the difference in ACD between both eyes for accuracy, patients who showed ciliary body detachment on UBM post-medication, those with bilateral lens zonular ligament abnormalities, and those with incomplete ocular parameter data were excluded from the statistical comparison of demographic characteristics and eye parameters (37 eyes in the APAC group and 35 eyes in the APACLS group).Regarding the interval between attack and data collection, all the patients we included were in the acute attack phase, and the data collection was generally after the eye examination on the second or third day.

2.5. Statistical analysis

The paired *t*-test (for normally distributed data comparison between both eyes in each group), independent-samples T test(for normally distributed data comparison between groups), Categorical data($n < 40$) were analyzed using Fisher exact test, and binary logistic regression were utilized for statistical analysis.Risk factors were examined using binary logistic regression, and Receiver Operating Characteristic (ROC) curve analysis for cutoff value determination related to zonular abnormalities. A P-value of <0.05 was considered statistically significant, with analyses conducted using SPSS version 26.0(SPSS,Inc,Chicago,USA).

3. Results

3.1. Demographic characteristics and eye parameters of the affected eye

The study incorporated 72 patients, 72 eyes, all having acute episodes. Divided into APAC (37 eyes) and APACLS (35 eyes) based on intraoperative zonular ligament status, all participants were Chinese. The mean age of onset in the APAC group was 70.11 ± 8.67 years, showing no significant statistical difference compared to the APACLS group (70.11 ± 8.67 years, $P = 0.159$). There was no

Table 1
Ocular characteristics and anterior segment parameters of eyes with a history of acute primary angle closure and subsequent cataract surgery (total 72 eyes).

Variables	APAC	APACLS	P-Value
No.of eyes	37	35	N/A
Age(y)	70.11 ± 8.67	67.37 ± 7.56	0.159
AL(Attack.mm)	22.35 ± 0.64	22.36 ± 0.78	0.929
LT(Attack,mm)	5.01 ± 0.36	5.24 ± 0.37	0.011*
ACD(Attack,mm)	1.69 ± 0.24	1.42 ± 0.24	<0.001***
ACDD(mm)	0.18 ± 0.18	0.38 ± 0.22	<0.001***
LP(Attack)	4.20 ± 0.22	4.04 ± 0.32	0.013*
RLP(Attack)	0.19 ± 0.01	0.18 ± 0.02	0.015*
AL(Fellow,mm)	22.41 ± 0.75	22.29 ± 0.73	0.502
LT(Fellow,mm)	4.97 ± 0.55	5.25 ± 0.32	0.011*
ACD(Fellow,mm)	1.82 ± 0.22	1.79 ± 0.24	0.632
LP(Fellow)	4.30 ± 0.33	4.41 ± 0.27	0.114
RLP(Fellow)	0.19 ± 0.01	0.20 ± 0.01	0.05

AL = axial length; LT = lens thick; ACD = control anterior chamber depth; ACDD = central anterior chamber depth difference between both eyes; LP = lens position; RLP = relative lens position; Attack, acute attack eye; Fellow, fellow eye; The LP and RLP data did not meet the homogeneity of variance = and Welch's T test was used. The other data met the normal distribution and homogeneity of variance = and the independent sample T test was used.*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

difference in axial length between the groups (22.35 ± 0.64 mm vs 22.36 ± 0.78 mm, P = 0.929). In the APACLS group, the LT was significantly thicker (5.24 ± 0.37 mm vs 5.01 ± 0.36 mm, P = 0.011), ACD was shallower (1.42 ± 0.24 mm vs 1.69 ± 0.24 mm, P < 0.001), ACDD was greater (0.38 ± 0.22 mm vs 0.18 ± 0.18 mm, P < 0.001), LP was lower (4.04 ± 0.32 vs 4.20 ± 0.22, P = 0.013), and RLP was also lower (0.18 ± 0.02 vs 0.19 ± 0.01, P = 0.015), all showing significant statistical differences (Table 1).

3.2. Comparison of affected and contralateral eyes

In the APAC group, the affected eye had a significantly shallower ACD of 1.69 ± 0.24 mm compared to the fellow eye (1.82 ± 0.22 mm, P = 0.001), while AL, LT, LP, and RLP showed no statistical differences. In the APACLS group, there was no significant difference in AL and LT between both eyes. The affected eye had a shallower ACD (1.42 ± 0.24 mm vs 1.79 ± 0.24 mm, P < 0.001), lower LP (4.04 ± 0.32 vs 4.41 ± 0.27, P < 0.001), and smaller RLP (0.18 ± 0.02 vs 0.20 ± 0.01, P < 0.001) compared to the fellow eye (Table 2).

4. Risk factors related to zonular ligament abnormalities

In Table 1, the parameters that showed significant statistical differences between the two groups were LT, ACD, ACDD, LP, and RLP. Due to the strong correlation between LP and RLP with both LT and ACD(LP = ACD+1/2LT; RLP = LP/AL), to avoid multicollinearity effects, these two parameters were not included in the logistic regression analysis. Incorporating LT, ACD, and ACDD into a binary logistic regression analysis revealed that both ACD and ACDD are risk factors associated with lens zonular ligament abnormalities (ACDD OR value 63.97,95%CI:1.587–2578.022, P = 0.027,; ACD OR value 0.029, 95 % CI:0.001–0.67, P = 0.027 see Table 3 for details).

4.1. ROC curve and cutoff values

ROC curve analysis was employed to evaluate the role of ACD and ACDD in predicting lens zonular ligament abnormalities.There are significant differences in ACD and ACDD, with AUC of 0.795 and 0.769. The cutoff value for ACDD was determined to be 0.375 mm, and for ACD, it was 1.6 mm (Table 4 and Fig. 1).

4.2. The therapeutic effect of pilocarpine

A total of 124 eyes were included in the study (69 eyes in the APAC group and 55 eyes in the APACLS group). All patients had an intraocular pressure greater than 50 mmHg upon admission. The frequency of using pilocarpine eye drops (once every 15 min, a total of 8 times, later changed to four times a day) indicated a decrease in intraocular pressure when the intraocular pressure was less than 30 mmHg, while an intraocular pressure greater than 30 indicated no decrease in intraocular pressure.The effectiveness of Pilocarpine in reducing intraocular pressure during acute episodes was compared between the two groups. In the APAC group, all patients received mydriatic medication upon admission. In this group, intraocular pressure did not decrease in 17 eyes post-mydriasis, while it returned to normal in 52 eyes, yielding an effectiveness rate of 75.36 %. In the APACLS group, 20 eyes did not undergo mydriasis. Among the remaining, intraocular pressure did not decrease in 10 eyes post-mydriasis, while it normalized in 25 eyes, resulting in an effectiveness rate of 71.43 %. The chi-square test showed no significant statistical difference between the two groups (Table 5). In the APACLS group, among the eyes that received a capsular tension ring, 17 underwent treatment with mydriatic medication. Post-mydriasis, intraocular pressure decreased in 13 eyes and did not decrease in 4 eyes, resulting in an effectiveness rate of 76.5 %.

5. Discussion

Incomplete dislocation of the lens, a condition often seen in clinical settings, is typically caused by trauma or systemic diseases such as Marfan syndrome. This dislocation can result in the anterior chamber becoming shallower, leading to an increase in intraocular pressure, and might even be misdiagnosed as primary acute angle-closure glaucoma [11]. Diagnosing a typical lens dislocation is generally straightforward. It can be identified through various signs in the unaffected eye, including iris tremor, a noticeably shallower anterior chamber compared to the unaffected eye, or vitreous entrapment. Alternatively, definitive diagnosis can be achieved through

Table 2
Intereye (Intraindividual) comparison of two groupes.

APAC				APACLS		
	Attack Eyes	Fellow Eyes	P-Value	Attack Eyes	Fellow Eyes	P-Value
AL(mm)	22.35 ± 0.64	22.41 ± 0.75	0.531	22.36 ± 0.78	22.29 ± 0.73	0.056
LT(mm)	5.01 ± 0.36	4.97 ± 0.55	0.684	5.24 ± 0.37	5.25 ± 0.32	0.722
ACD(mm)	1.69 ± 0.24	1.82 ± 0.22	0.001**	1.42 ± 0.24	1.79 ± 0.24	<0.001***
LP	4.20 ± 0.22	4.30 ± 0.33	0.067	4.04 ± 0.32	4.41 ± 0.27	<0.001***
RLP	0.19 ± 0.01	0.19 ± 0.01	0.091	0.18 ± 0.02	0.20 ± 0.01	<0.001***

AL = axial length; LT = lens thick; ACD = control anterior chamber depth; LP = lens position; RLP = relative lens position; *P < 0.05; **P < 0.01; ***P < 0.001.

Table 3
Dichotomy logistic regression analysis to assess the risk factors of zonular Instability in acute attack eyes with a history of acute primary angle closure and subsequent cataract surgery (total 72 eyes).

Variables	RC	SD	OR(95%CI)	P-Value
LT(mm)	1.78	0.978	5.93(0.872–40.31)	0.069
ACDD(mm)	4.158	1.886	63.97(1.587–2578.022)	0.027*
ACD(mm)	−3.557	1.61	0.029(0.001–0.67)	0.027*

RC = regression coefficient; SD = standard error; OR = odds ratio; CI = confidence interval; LT = lens thick; ACD = control anterior chamber depth; ACDD = central anterior chamber depth difference between both eyes; *P < 0.05; **P < 0.01; ***P < 0.001.

Table 4
Area under the receiver operating characteristic curve (AUROC) = sensitivity = specificity = and cutoff value in APAC and APACLS groups.

Value	AUC	95%CI	Cut off value
ACCD	0.769	0.658–0.881	0.375
ACD	0.795	0.692–0,897	1.6

ACDD = central anterior chamber depth difference between both eyes; ACD = control anterior chamber depth; AUC = area under the cure.

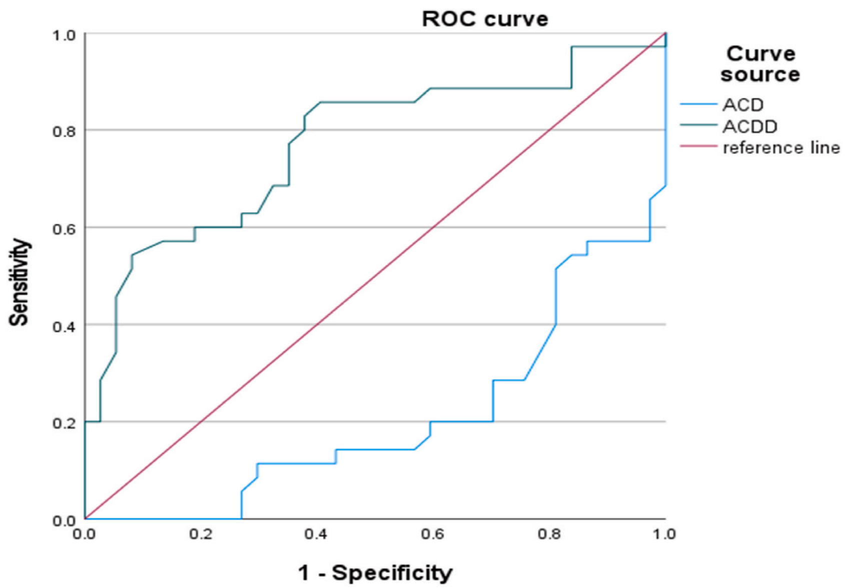

Fig. 1. ROC curve analysis was employed to evaluate the role of ACD and ACDD in predicting lens zonular ligament abnormalities.

Table 5
The therapeutic effect of pilocarpine.

Groups(number)	IOP decreased	IOP did not decrease	Not in use	Total	P-Value
APAC(69)	52	17	0	69	0.813
APACLS(55)	25	10	20	55	

IOP decreased = Intraocular pressure decreased after pilocarpine administration; IOP did not decrease = Intraocular pressure did not decrease after pilocarpine; Not in use = Pilocarpine was not used. *P < 0.05; **P < 0.01; ***P < 0.001.

UBM [11,14]. The zonular fibers (ZF), located behind the iris, are responsible for maintaining the lens in its proper position and play a role in its adjustment [15]. When mild abnormalities in these ZF are present in patients with a shallow anterior chamber, making an accurate diagnosis becomes challenging. Patients with these abnormalities often experience a more intense onset of the condition. Additionally, the excessive shallowness of the anterior chamber increases the risks associated with certain procedures, such as anterior chamber paracentesis or laser peripheral iridotomy. In treatment scenarios, patients with concurrent zonular ligament abnormalities might encounter increased risks during cataract surgery. These risks include potential capsular bag rupture, lens dislocation, or vitreous prolapse, necessitating the use of capsular tension rings, scleral suturing, or even a combination of anterior vitrectomy [6]. Therefore, correctly identifying zonular ligament abnormalities intertwined with primary angle-closure is vitally important for the effective treatment of acute angle-closure glaucoma, which is the focus of this study.

In this study, we initially divided patients with APAC into two groups based on the condition of the zonular ligaments during cataract surgery and compared their demographic characteristics and eye parameters potentially related to zonular ligaments. Our aim was to identify indicators associated with zonular ligament abnormalities and determine the optimal cutoff values. Trauma is one of the common factors causing zonular ligament abnormalities of the lens, but obviously, although the signs and characteristics of the secondary glaucoma are similar to APAC, In fact, the angle closure is caused by zonular ligament abnormalities [11, 14]. Their pathogenesis is clearly different from APAC, so we excluded patients with a history of trauma in this study. We introduced a new parameter: the difference in ACD between both eyes, known as ACDD. However, since the anterior chamber becomes shallower in patients with ciliary body detachment and both eyes exhibit abnormal ACD changes in cases of bilateral lens zonular ligament abnormalities, the accuracy of ACDD might be compromised. Therefore, we excluded patients with ciliary body detachment and bilateral lens zonular ligament abnormalities. The results showed that in the affected eyes of the APACLS group, LT was thicker, ACD was shallower, ACDD was larger, and both LP and RLP were smaller. From this, we concluded that zonular ligament abnormalities lead to a thicker lens and a more anterior LP. Binary logistic regression analysis revealed that ACD and ACDD in the affected eye are both risk factors associated with lens zonular ligament abnormalities (ACDD OR value 63.97, $P = 0.027$; ACD OR value 0.029, $P = 0.027$). Using ROC curve analysis to assess the role of these two parameters in predicting lens zonular ligament abnormalities, the cutoff value for ACDD was found to be 0.375 mm, and for ACD, it was 1.6 mm. Hence, clinically, when a patient's ACD is $<$ 1.6 mm and ACDD $>$0.375 mm, there is a high suspicion of concurrent lens zonular ligament abnormalities, necessitating careful examination of other signs and formulation of related surgical plans. It is important to note that ciliary body detachment, often occurring in APAC with rapid intraocular pressure reduction, can significantly affect ACD values [16]. If both eyes have lens zonular ligament abnormalities, ACDD is also impacted, and these factors must be considered.

It is well known that the biological parameters of the anterior segment are interrelated and together form a stable anterior structure of the eyeball. Among them, LT, LV, LP, and RLP are closely related to the lens. When the zonular ligament is abnormal or even extensively ruptured, the lens thickens [10], LV increases [6], and the position changes (most of them move forward, and a small number of completely dislocated individuals can fall into the anterior chamber or vitreous cavity). This change will occupy the anterior chamber space, and the ACD will also become shallower. Similar changes also occur in APAC patients [3,17–20]. This superimposed effect makes the anterior segment changes caused by abnormal zonular ligament less significant in APAC. Numerous researchers have attempted to calculate cutoff values by comparing sensitive biological parameters between different groups, in order to assist clinical doctors in identifying them in a simple and clear manner. Jing [21] compared acute angle closure secondary to trauma with APAC and found that the ACD and the difference in binocular ACD was correlated with diagnosis, with cut-off values of 1.4 mm and 0.63 mm. Xing [10] investigated the parameters of patients with acute angle closure secondary to lens subluxation (including trauma) and cataracts, and found out that RLP, ACD, AD, CLP, and LP had high diagnostic ability, with an ACD cutoff value of 2.67 mm. Chen [22] compared patients with and without zonular laxity in Acute Angle Closure (including trauma) and found that binocular difference of ACD, LV in affected eyes, and binocular difference of LV had high efficiency in diagnosing AAC with zonular laxity, the AUC were 0.796, 0.972, and 0.855, and cut-off values were 1.28 mm, 0.23 mm, and 0.19 mm. Chen [23] retrospective evaluated the clinical characteristics and multimodal biometric parameters of patients with acute secondary angle-closure due to lens subluxation, APAC, and cataract.They found significant differences in ACD difference and ACD, with AUC of 0.917 and 0.928, and cut-off values of 0.235 mm and 1.080 mm. The significant difference in numerical values is confusing, and we consider that it is related to the multicollinearity of the included population and multiple related indicators on the model. The above studies did not exclude patients with trauma and ciliary body detachment. The impact of ciliary body detachment on anterior chamber depth is particularly noteworthy. In our study, it was found that in an APAC patient with normal zonular ligaments, the ACD of the ciliary body detachment eye was 0.94 mm, while that of the fellow eye was 1.64 mm, with a difference of 0.7 mm. Therefore, our study corrected this point. To the best of our knowledge, this is not present in other studies.

APAC is closely related to abnormalities zonular ligament, but whether it is combined or secondary has always been a problem. Therefore, we compared the data of attack and fellow eyes in each group. In both groups, the attack eyes exhibited shallower anterior chambers compared to their fellow eyes. In the APACLS group, the attack eyes had a thicker lens and a more anterior LP. When comparing the fellow eyes of both groups, aside from the thicker lens in the APACLS group, there were no significant statistical differences in other parameters. Therefore, we hypothesize that in such patients, APAC is the primary factor in the onset of the condition, while lens zonular ligament abnormalities exacerbate the severity and damage of acute angle closure. These patients do not fall under the category of glaucoma secondary to lens zonular ligament abnormalities but are rather cases of primary angle-closure glaucoma with concurrent lens zonular ligament abnormalities.

The use of mydriatic agents in the treatment of primary angle closure is well-established. They function by causing the contraction of the pupillary sphincter muscle, reducing peripheral iris bunching in the angle, and opening the angle [13]. However, there is debate over the use of mydriatic agents in eyes with lens zonular ligament abnormalities. Some argue that mydriatic agents, by causing ciliary muscle contraction, lead to zonular laxity, anterior movement of the lens, shallowing of the anterior chamber, and further aggravation of pupillary block [12]. Consequently, some clinicians are cautious or even opposed to the use of mydriatic agents in eyes with zonular ligament abnormalities. Nonetheless, our study found that mydriatic agents are safe and effective in patients with lens zonular ligament abnormalities, without exacerbating the condition. The probability of reducing intraocular pressure reached 71 %, similar to the efficacy in APAC patients. Even in patients with tension ring implants, the efficacy rate reached 76.5 %, comparable to that in APAC. The reason for this might be related to the severity of zonular ligament damage and the cause of the condition. In cases reported where mydriatics worsened the condition, the angle closure was mostly secondary to lens dislocation, which was severe. However, as our analysis shows, APAC is the primary factor in the onset of the condition in our study, and the degree of lens zonular ligament abnormalities is relatively minor. Therefore, mydriatic agents are safe and effective, similar to their use in simple APAC cases.

In conclusion, APAC combined with zonular ligament abnormalities is distinct from angle-closure glaucoma secondary to LP anomalies. Anatomically similar to APAC, these cases feature less pronounced and more concealed lens displacement, making diagnosis challenging. Crucial risk factors include an ACD less than 1.6 mm and an ACDD greater than 0.375 mm. Miotics are identified as a safe and effective treatment method for such conditions.

The study acknowledges its limitations as a retrospective analysis with a small sample size and brief follow-up period. Further extensive studies are required to explore the implications of minor zonular ligament abnormalities, such as relaxation or increased capsular bag wrinkling observed during cataract surgery. These studies should investigate their potential impact on capsular bag stability, IOL displacement, or the onset of malignant glaucoma. The role of minor zonular ligament abnormalities in the development of acute angle-closure glaucoma also demands further research.

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Ethics approval

The study protocol received approval from the institutional review board and ethics committee of Hebei eye hospital (2024LW07). This study complied with the tenets of the Declaration of Helsinki.

Data availability statement

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CRediT authorship contribution statement

Hong Chen: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation, Conceptualization. **Juan Yin:** Investigation, Formal analysis, Data curation. **Yixiang Wu:** Supervision, Project administration, Methodology, Data curation. **Yifan Wang:** Investigation, Formal analysis, Data curation. **Yong Liu:** Data curation. **Wei Dong:** Project administration, Investigation. **Beibei Gao:** Data curation. **Rongrong Li:** Investigation, Formal analysis, Data curation. **Sumian Cheng:** Supervision, Project administration. **Lifei Wang:** Writing – review & editing, Project administration.

Declaration of competing interest

None declared.

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