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ARTICLE

Identifying Prognostic Factors of Central Serous Chorioretinopathy Patients Treated With Micro-Pulse Laser Therapy and Development of a Predictive Model

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Abstract

Aims/Background The prognosis of central serous chorioretinopathy (CSC) patients treated with micro-pulse is affected by various factors. Developing a predictive model can be helpful in assessing treatment efficacy and patient outcomes. This study investigated the key factors influencing CSC prognosis and developed a predictive model.

Methods This retrospective study included 230 CSC patients who received micro-pulse laser therapy in the Second Affiliated Hospital of Zunyi Medical University, China, between January 2020 and May 2024. Using a random number table approach, patients were divided into a modeling group (n = 138) and a validation group (n = 92) in a 3:2 ratio. The modeling group was subdivided into a good prognosis group (n = 86) and a poor prognosis group (n = 52). Univariate and binary logistic regression analyses were performed to identify factors influencing poor prognosis in these patients, and a prediction model was constructed. Furthermore, the R programming language was employed to create receiver operating characteristic (ROC) curves. Moreover, calibration curves were built, and decision curve analysis (DCA) was used to assess the clinical utility of the model.

Results There were no statistically significant differences in terms of general data among patients between the modeling group and validation group ($p > 0.05$). In the modeling group, the differences in age, body mass index (BMI), gender, residence, monthly family income, education level, number of leaks, and onset type were statistically insignificant ($p > 0.05$), while disease duration, leakage area, leakage type, and distance to leakage point showed statistically significant differences ($p < 0.05$). Binary logistic regression analysis revealed that disease duration, degree of retinal pigment epithelial detachment (PED), leakage type, and distance of leaks were significant factors influencing the prognosis of CSC patients undergoing micro-pulse laser therapy ($p < 0.05$). The model equation was Logit (P) = $-2.217 + (1.059X_1) + (1.344X_2) + (1.258X_3) + (1.494X_4)$. The model demonstrated strong agreement between predicted and actual risks in both the modeling and validation groups, evidenced by calibration curves with slopes close to 1. In the modeling group, the model had an area under the curve of 0.942 (95% confidence interval (CI): 0.896–0.969, $p < 0.001$), with a standard error of 0.021 and a Youden index of 0.75, indicating a sensitivity of 93.6% and a specificity of 81.7%. In the validation group, the model's area under the curve was 0.860 (95% CI: 0.826–0.912, $p < 0.001$), with a standard error of 0.036 and a Youden index of 0.63, showing a sensitivity of 82.9% and a specificity of 79.8%. DCA revealed that the model had a significant positive net benefit, indicating good clinical utility.

Conclusion Disease duration, degree of retinal PED, leakage type, and distance of leaks were significant prognostic factors in CSC patients undergoing micro-pulse laser therapy. A predictive model was successfully established and validated, enabling physicians to perform more accurate outcome assessments and facilitating tailored management approaches.

Key words: therapeutics; micro-pulse laser therapy; central serous chorioretinopathy; retina

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Introduction

Central serous chorioretinopathy (CSC) is a self-limiting ocular disease characterized by the accumulation of subretinal fluid and detachment under the neurosensory retina, usually accompanied by changes in the retinal pigment epithelium (RPE). Epidemiological research on CSC remains unsystematic. The disease predominantly affects middle-aged people between 30 and 50 years, with a high incidence in men, affecting about 10 individuals per 100,000 annually. Male patients account for 72% to 87.5% of reported cases. However, its incidence in older women is comparable to that in men and may be more severe. Additionally, there are ethnic variations in CSC incidence, with Asians potentially more susceptible to the disease (Zhang et al, 2023).

The majority of CSC cases can resolve spontaneously within 3–6 months, with approximately 60%–80% of patients recovering within 3 months, while an additional 10%–20% within 3–6 months (Myslík Manethová, 2024). However, about 20% of cases may persist beyond 6 months. Recurrent or prolonged disease can lead to mild to moderate vision loss, persistent metamorphopsia, and incomplete restoration of visual functions like contrast sensitivity and recovery time of the afterimage (Varghese et al, 2022). Despite its self-limiting nature, effective management and intervention are crucial in clinical practice, especially for cases with prolonged durations, frequent recurrences, or associated complications (Zeng and Zhang, 2024).

Micro-pulse laser therapy emerged as an effective treatment option for CSC and has been widely used in recent years (Viggiano et al, 2024). Through precise photocoagulation, it helps seal the leakage sites in the retinal pigment epithelium, reducing the accumulation of subretinal fluid (SRF) and improving patients' visual function (Sorrentino et al, 2024). Furthermore, it exerts therapeutic effects through various mechanisms, such as promoting the functional recovery of retinomas, reducing inflammatory responses, and inducing cell regeneration, all of which are crucial for CSC treatment. Micro-pulse laser treatment is specifically indicated for ocular macular lesions such as macular edema, central serosa, and macular degeneration. A study reported that this method is minimally invasive, highly effective, and significantly improves visual outcomes while maintaining a reduced likelihood of postoperative complications (Kim et al, 2024). In treating macular edema, micro-pulse laser treatment has shown promising efficacy, resulting in significant improvement in both vision and retinal structure. However, the prognosis of CSC after micro-pulse laser therapy remains uncertain, as various factors affect its effectiveness. However, clinical studies on this treatment method remain limited, emphasizing further investigations.

Therefore, investigating the prognostic factors affecting micro-pulse laser therapy in CSC and establishing a corresponding predictive model is crucial for guiding clinical decision-making, optimizing treatment strategies, and enhancing patients' quality of life. This study aims to explore various factors affecting the prognosis of CSC treated with micro-pulse laser therapy through a retrospective study design and to develop a prognostic prediction model. The ultimate goal is to provide more precise treatment guidance and prognosis assessment for CSC patients undergoing this therapy.

Methods

Recruitment and Stratification of Research Participants

This retrospective study included 230 CSC patients admitted to the Second Affiliated Hospital of Zunyi Medical University, China, between January 2020 and May 2024. The sample size was calculated using the formula $N = Z_{\alpha/2}{}^{2}\pi(1\text{-}\pi)/\delta^{2}$, where π is 40%, the significance level α is 0.05, and the allowable error δ is 0.06. Based on this formula, the required sample size was 256. To address the invalid data, a 10% expansion was applied, resulting in a sample size of 282. Hence, 289 patients were initially recruited, while after screening, a cohort of 230 individuals was selected for final analysis (Fig. 1).

For model performance evaluation, the data set was divided into the training (model group) and validation set following a 3:2 ratio. The training set contained sufficient data for model development while maintaining an adequate validation set for evaluating the generalization ability of the model. This division helps reduce the risks of overfitting and underfitting, allowing the model to receive timely feedback during training, thereby improving stability and accuracy. A random number table method was used to assign patients to a modeling group (n = 138) and a validation group (n = 92). Within the modeling group, patients were further categorized into a good prognosis group (n = 86) and a poor prognosis group (n = 52).

The inclusion criteria were as follows: (1) patients meeting the diagnostic criteria for CSC (Daruich et al, 2015), (2) diagnosis confirmed through optical coherence tomography and fluorescein angiography, with at least one diffuse leakage area, one leakage point, and a distance from the fovea >250 µm, (3) patients aged between 18 and 65 years, (4) first diagnosis, (5) non-acute patients, and (6) those with complete clinical data. However, the exclusion criteria included: (1) patients who have previously received photodynamic therapy (PDT) or intravitreal Anti-Vascular Endothelial Growth Factor (anti-VEGF), (2) patients with concomitant other retinal diseases, such as polypoidal choroidal vasculopathy (PCV), choroidal neovascularization (CNV), macular degeneration, and other retinal vascular diseases, (3) patients with a history of systemic corticosteroid treatment, and (4) patients who are pregnant or breastfeeding.

Patient Treatment Protocols

The patients receiving micro-pulse laser treatment for CSC were assessed by skilled professionals, ensuring the treatment accuracy and patient safety. Follow-up assessments were performed for 6 months after treatment, including vision testing and fundus examinations, with assessments scheduled once a month to observe patient recovery closely.

The Zeiss-Humphrey optical coherence tomography (OCT) (ZEISS, Oberkochen, Germany) diagnostic instrument was utilized to assess CSC treatment outcomes. The examination was started with pupil dilation using adequate tropicamide eye

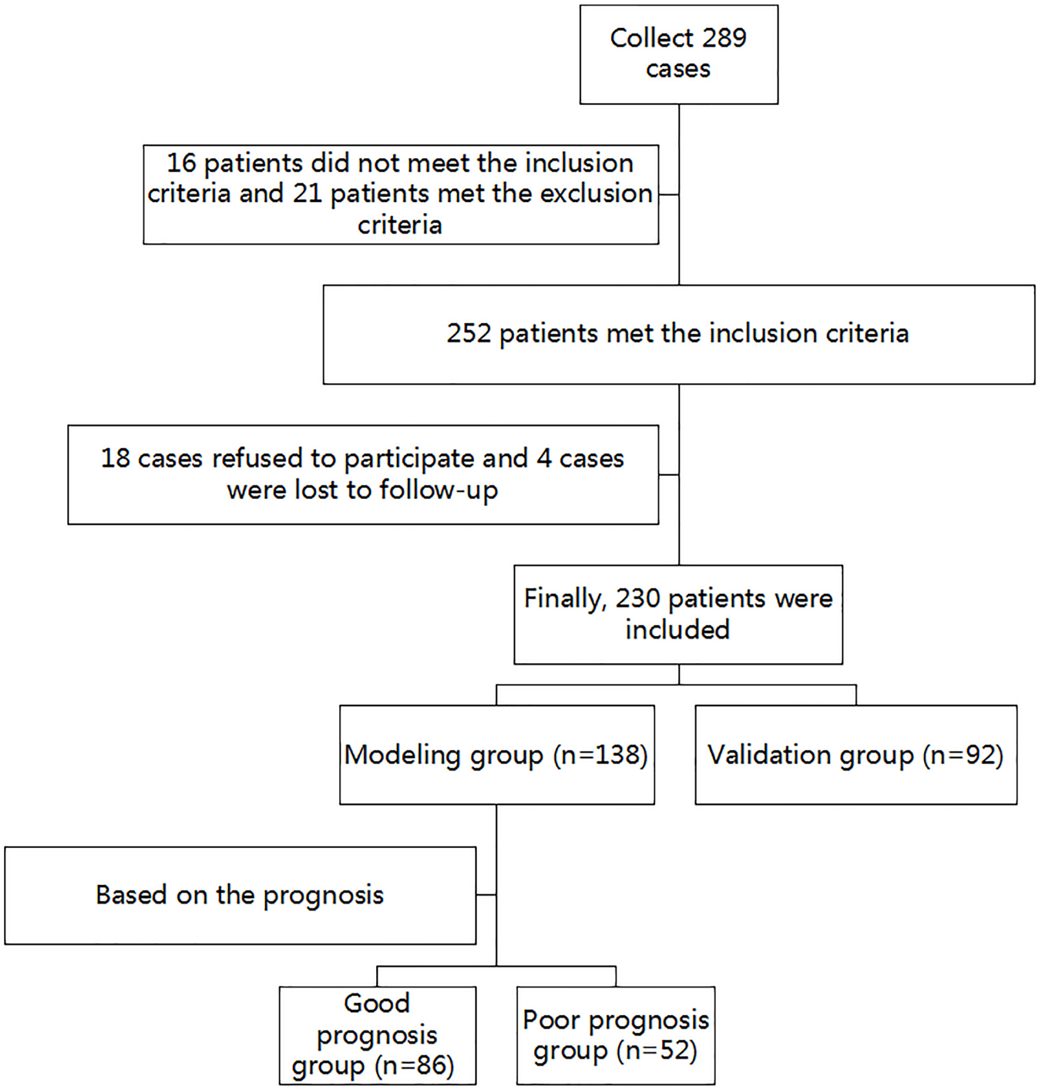

Fig. 1. A flowchart of patient selection and their stratification. The figure was drawn using Microsoft Word 2016 (Microsoft Corporation, Redmond, WA, USA).

drops, followed by fundus photography under dim lighting conditions. Subsequently, fluorescein sodium dilution was slowly injected into the antecubital vein while the patient was observed for any allergic reactions or discomfort. Once safety was ensured, 3 mL of undiluted fluorescein sodium was rapidly injected, and the timing of the procedure began simultaneously.

Fluorescein angiography (FFA) was conducted utilizing a fundus camera, with a scan length of 4 mm, maximum light intensity of 750 µm, and a scan depth of 2 mm to obtain high-resolution retinal vascular images. Following treatment, patients underwent a 6-month follow-up period, during which regular visual acuity checks and repeat fundus angiography were performed to assess the disease progression and prognosis comprehensively. At the end of the follow-up period, prognosis was categorized as follows:

• Good prognosis: When vision returns to normal or improves by at least 50%, with no leakage observed on FFA reassessment.

• Poor prognosis: When visual improvement was less than 50%, or persistent leakage was observed on FFA reassessment.

Table 1. Comparison of general data between the modeling and validation groups.

Baseline data	Modeling group (n = 138)	Validation group (n = 92)	t/χ^2 value	p-value
Age (years)	49.25 ± 5.06	49.27 ± 6.17	0.027	0.979
BMI (kg/m^2)	21.92 ± 1.73	21.96 ± 1.68	0.174	0.862
Gender			0.015	0.902
Male	103	68		
Female	35	24		
Residence			0.317	0.574
Urban	115	74		
Rural	23	18		
Monthly family income			0.355	0.551
<5000 (RMB)	27	21		
≥5000 (RMB)	111	71		
Duration of illness (years)			0.065	0.798
≤6	107	70		
>6	31	22		
Education level			0.086	0.770
High school and below	41	29		
Above high school	97	63		
Onset type			0.381	0.537
Primary	129	84		
Recurrent	9	8		
Degree of retinal PED			0.003	0.956
≤1/3	82	55		
>1/3	56	37		
Number of leaks (points)			0.000	1.000
≤2	133	89		
>2	5	3		
Leakage type			0.188	0.910
Ink stain	40	27		
Jet-like	57	40		
Multiple lesions	41	25		
Distance of leaks			0.442	0.931
I	31	22		
II	32	24		
III	33	20		
IV	42	26		

Leak point distance is defined as follows: I indicates that the leak point is located within 1 mm concentric circles around the macular fovea; II indicates that the leak point is located within 0.5 mm in the ring inside the foveal non-vascular area; III indicates that the leakage point is located within a 2 mm-wide ring surrounding the central concavity; IV indicates that the leakage point is located beyond 1.5 mm from the fovea. 1 USD = 6.97 RMB (January 2020). BMI, body mass index; PED, pigment epithelial detachment.

Table 2. Univariate analysis of factors influencing the prognosis of CSC patients undergoing micro-pulse laser therapy.

Baseline data	Good prognosis group (n = 86)	Poor prognosis group (n = 52)	t/χ^2 value	p-value
Age (years)	49.27 ± 4.96	49.21 ± 5.26	0.067	0.946
BMI (kg/m^2)	21.87 ± 1.74	21.99 ± 1.72	0.394	0.694
Gender			0.230	0.631
Male	63	40		
Female	23	12		
Residence			0.025	0.875
Urban	72	43		
Rural	14	9		
Monthly family income			0.134	0.715
$<$5000 (RMB)	16	11		
$\geq$5000 (RMB)	70	41		
Duration of illness (years)			7.074	0.008
$\leq$6	73	34		
$>$6	13	18		
Education level			1.863	0.172
High school and below	22	19		
Above high school	64	33		
Onset type			0.006	0.938
Primary	81	48		
Recurrent	5	4		
Degree of retinal PED			10.133	0.002
$\leq$1/3	60	22		
$>$1/3	26	30		
Number of leaks (points)			0.000	1.000
$\leq$2	83	50		
$>$2	3	2		
Leakage type			6.822	0.033
Ink stain	26	14		
Jet-like	41	16		
Multiple lesions	19	22		
Distance of leaks			9.590	0.022
I	15	16		
II	18	14		
III	19	14		
IV	34	8		

1 USD = 6.97 RMB (January 2020). CSC, central serous chorioretinopathy.

Statistical Analysis

Data were statistically analyzed using SPSS 29.0 (International Business Machines Corporation, Armonk, NY, USA). The Shapiro-Wilk test was used to determine the normality within the data. Metric data following normal distribution were represented as $\bar{X} \pm$ S, with comparisons performed using independent sample *t*-tests. Count data were presented as frequencies, with comparisons conducted using χ^2 test or chi-square correction formula. Furthermore, to control the family-wise error rate, the Bonferroni correction was used for multiple comparisons.

Univariate and binary Logistics regression analyses were employed to identify factors influencing poor prognosis in CSC patients undergoing micro-pulse laser therapy. A predictive model was constructed using SPSS, while receiver operating characteristic (ROC) curves were generated in R programming language 4.3.2 (R Foundation, University of Auckland, Auckland, New Zealand). Moreover, calibration curves and decision curve analysis (DCA) were used to assess the model's predictive performance. Statistically significant was set at a *p*-value of $<$0.05. Using appropriate sample size ensured sufficient statistical power, improving the reliability of results and providing strong support for model optimization.

Results

Comparison of General Information Between the Two Groups

A comparison of general information between the modeling and validation groups showed statistically insignificant differences ($p > 0.05$, Table 1).

Univariate Analysis of Factors Influencing Prognosis of CSC Patients Undergoing Micro-Pulse Laser Therapy

In the modeling group, there were no significant differences between the good and poor prognosis groups regarding age, body mass index (BMI), gender, residence, monthly family income, education level, number of leaks, and onset ($p >$ 0.05). However, statistically significant ($p < 0.05$) differences were found in the duration of illness, degree of retinal pigment epithelial detachment (PED), leakage type, and distance of leaks (Table 2).

Binary Logistics Regression Analysis

As shown in Table 3, duration of illness, degree of retinal PED, leakage type, and leakage distance as independent variables were used, with poor prognosis as the dependent variable (occurrence = 1, non-occurrence = 0). The results revealed that these factors substantially impact the prognosis of CSC patients undergoing micro-pulse laser therapy ($p < 0.05$, Table 4).

Table 3. Variable assignment.

Factor	Assignment
Duration of illness	$\leq$6 = 0, $>$6 = 1
Degree of retinal PED	$\leq$1/3 = 0, $>$1/3 = 1
Leakage type	Ink stain = 0, Jet-like = 1, Multiple Lesions = 2
Distance of leaks	I = 3, II = 2, III = 1, IV = 0

Table 4. Results of binary logistics regression analysis.

Dependent variable	β	Standard error	Wald	p-value	Exp (β)	95% CI	
						Lower limit	Upper limit
Duration of illness (1)	1.059	0.458	5.349	0.021	2.884	1.175	7.077
Degree of retinal PED (1)	1.344	0.416	10.423	0.001	3.833	1.695	8.665
Leakage type	-	-	6.869	0.032	-	-	-
Leakage type (1)	0.852	0.513	2.756	0.097	2.345	0.857	6.413
Leakage type (2)	1.258	0.486	6.692	0.010	3.518	1.356	9.123
Distance of leaks	-	-	8.402	0.038	-	-	-
Distance of leaks (1)	1.494	0.593	6.355	0.012	4.456	1.394	14.237
Distance of leaks (2)	–0.059	0.559	0.011	0.915	0.942	0.315	2.816
Distance of leaks (3)	0.314	0.562	0.311	0.577	1.368	0.455	4.119
Constant	–2.217	0.657	11.378	0.001	0.109	-	-

CI, confidence interval.

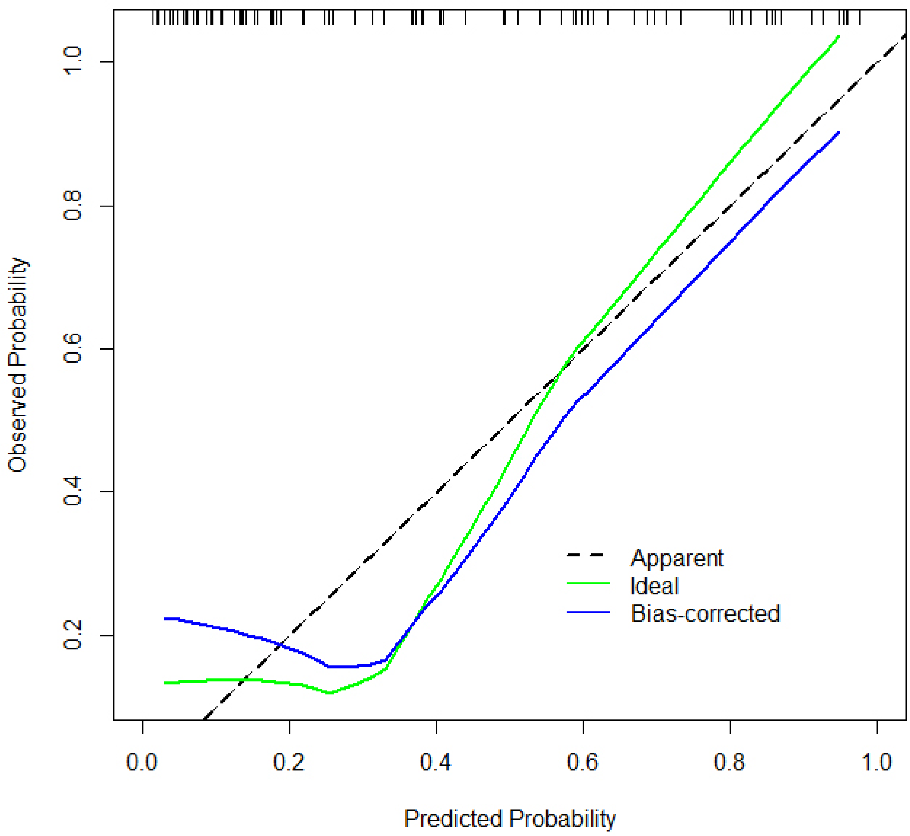

Fig. 2. Calibration curve of the modeling group. The curve slope is close to 1, which indicates a strong agreement between predicted and actual risk of poor prognosis in CSC patients undergoing micro-pulse laser therapy.

Construction of a Predictive Model

Based on the logistics regression analysis, a predictive model was constructed incorporating disease duration (X_1), degree of retinal pigment epithelial detach-

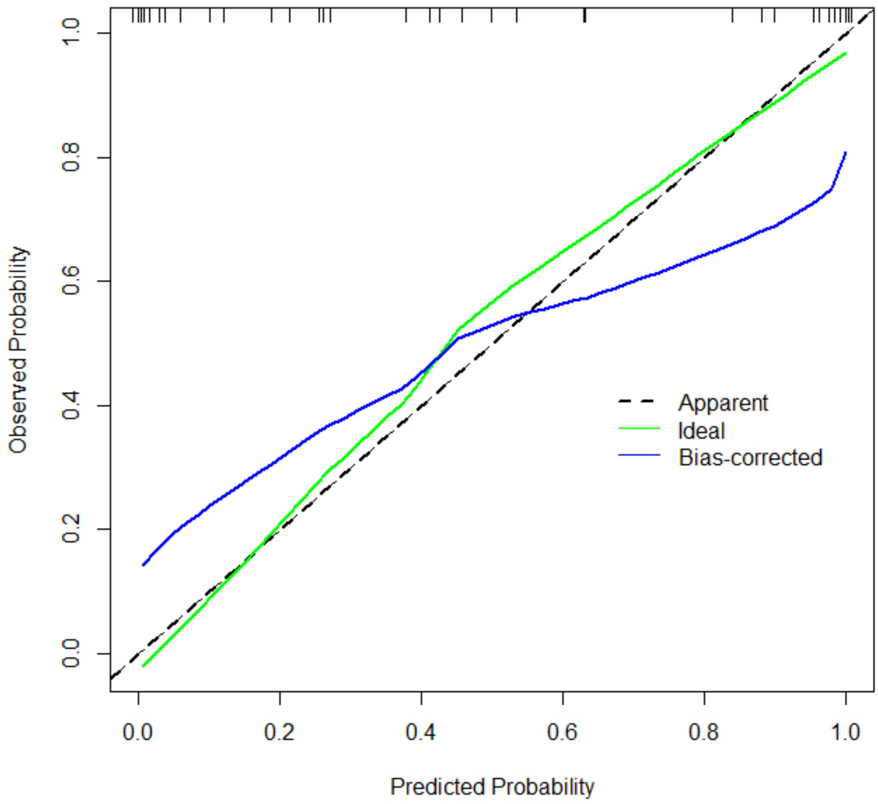

Fig. 3. Calibration curve of the validation group. Although the curve deviates from the ideal in the 0.6–1.0 area, it is generally close to the slope of 1, indicating good agreement between the predicted and actual risk of poor prognosis in CSC patients receiving micro-pulse laser therapy.

ment (X_2), leakage type (X_3), and leakage distance (X_4). The joint detection factor model is given below: Logit(P) = –2.217 + (1.059X_1) + (1.344X_2) + (1.258X_3) + (1.494X_4).

In both the modeling and validation groups, the calibration curve slopes were close to 1, indicating good consistency between the predicted and actual risk of poor prognosis in CSC patients undergoing micro-pulse laser therapy (Figs. 2,3).

ROC Analysis of the Model

The ROC analysis revealed that in the modeling group, the area under the curve for predicting the prognosis of CSC patients undergoing micro-pulse laser therapy was 0.942 (95% CI: 0.896–0.969, $p < 0.001$), with a standard error of 0.021. The Youden index was 0.75, with a sensitivity of 93.6% and specificity of 81.7%, as shown in Fig. 4. In the validation group, the area under the curve was 0.860 (95% CI: 0.826–0.912, $p < 0.001$), with a standard error of 0.036. The Youden index was 0.63, with a sensitivity of 82.9% and a specificity of 79.8% (Fig. 5).

Analysis of Predictive Model's Clinical Benefit

A DCA curve was plotted to evaluate the clinical utility of the model in predicting therapeutic efficacy. The findings demonstrated a clear positive net benefit, indicating good clinical utility, as shown in Figs. 6,7.

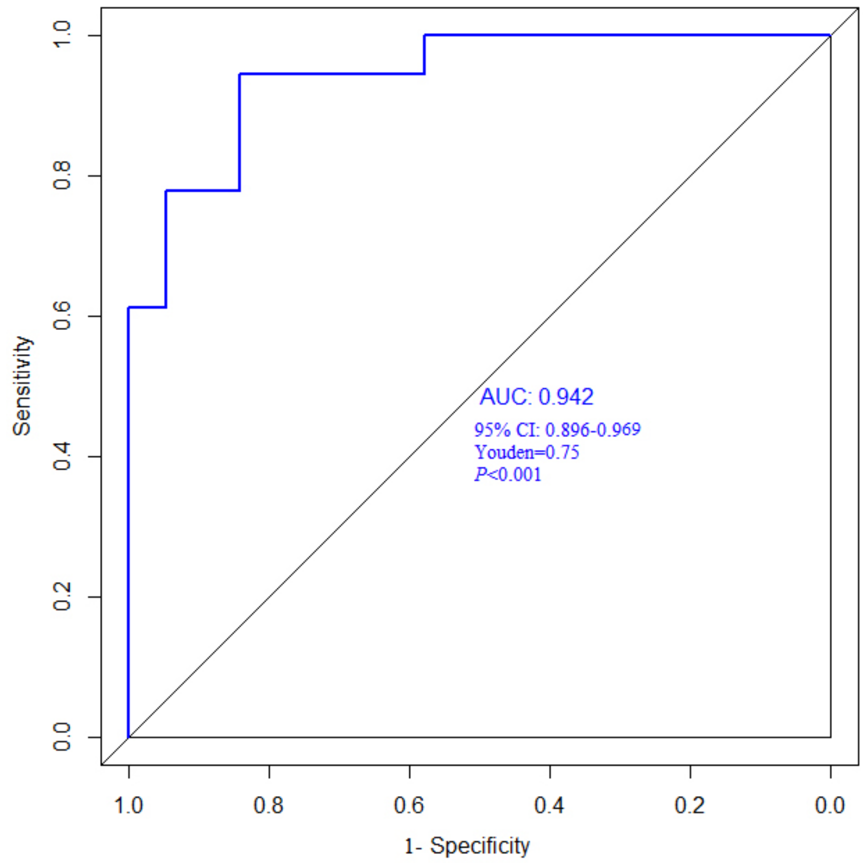

Fig. 4. Receiver operating characteristic (ROC) curve of the modeling group. The area under the ROC curve is close to 1, indicating the excellent predictive performance of the model in the modeling group. AUC, area under the curve.

Discussion

CSC, a common retinal disease, poses a serious threat to patients' visual health. Micro-pulse laser therapy has emerged as an effective treatment modality, demonstrating significant clinical efficacy. However, the prognosis after receiving micro-pulse therapy varies substantially among patients. In this study, factors influencing prognosis were identified, and a predictive model was constructed. Furthermore, the model's predictive performance was validated in a distinct verification group.

Previous studies highlighted the impact of individual factors on photodynamic therapy outcomes for CSC patients (Forte et al, 2024; Yu et al, 2022). In contrast, we applied a broader approach by analyzing a range of factors that affect outcomes and constructing a more comprehensive predictive model. Our study indicated that disease duration, size of the leakage area, leakage types, and number of leakage sites were all crucial factors influencing the prognosis of CSC patients following micro-pulse therapy. Chen (2017) identified similar risk factors, supporting the findings of this study. The duration of the disease may reflect the cumulative effects of retinal damage. A longer duration implies that the retina, including RPE cells, may experience more extensive damage, making treatment more challenging and requiring longer interventions to restore normal retinal function (Chen et

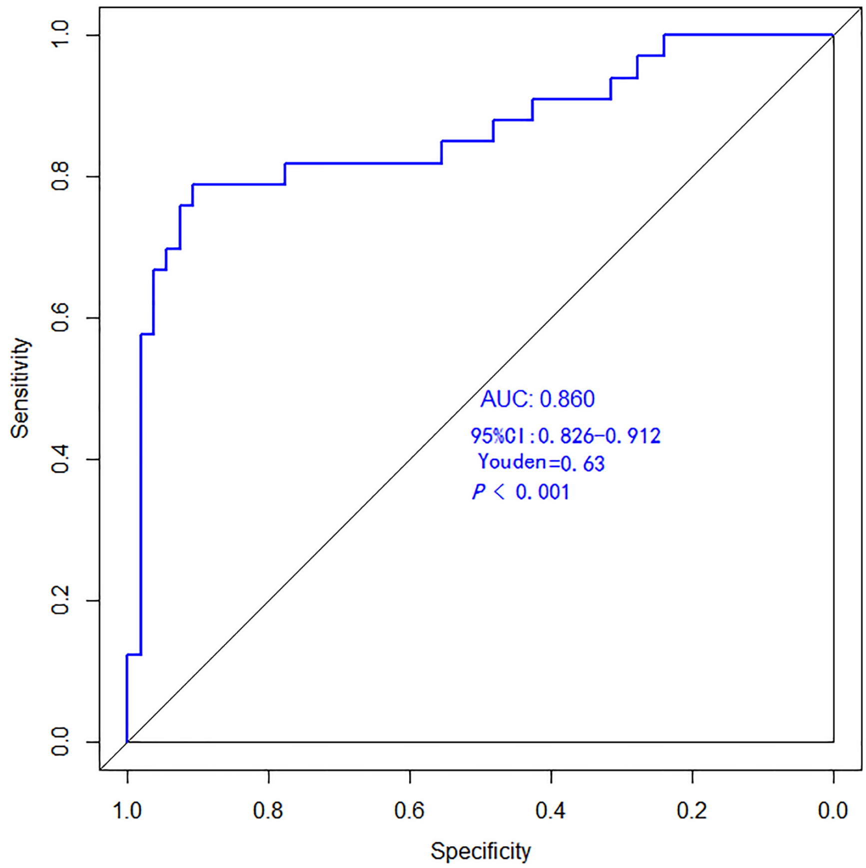

Fig. 5. ROC curve of the validation group. The area under the curve (AUC) of $0.7 < \text{AUC} \leq 0.9$, demonstrates a good predictive performance in the validation group.

al, 2022; Zhou et al, 2018). The size of the leakage area is directly linked to the extent of retinal damage. A larger leakage area may indicate more extensively damaged photoreceptor cells, leading to more severe visual impairment (Kustryn et al, 2024). Additionally, extensive retinal damage may complicate treatment and require a broader intervention to stabilize the condition and promote recovery (Zeng et al, 2022).

Furthermore, the types of leakage also play a crucial role in prognosis, as different patterns of damage can result in varying degrees of damage to the retina (Shaimova et al, 2023). Some leakage types are more likely to cause detachment of the retinal pigment epithelium or may be more challenging to manage effectively using micro-pulse laser therapy (Yadav et al, 2015), contributing to variations in treatment responses and outcomes. Furthermore, the number, size, and location of leakage sites are crucial in determining treatment difficulty and effectiveness (Chen et al, 2022; Gao et al, 2024; Vignesh et al, 2020). For example, leakage sites near the fovea may be more challenging to treat due to the importance of this area for vision and its complex anatomical structure.

Based on the above analysis, we developed a predictive model expressed as follows: $\text{Logit(P)} = -2.217 + (1.059X_1) + (1.344X_2) + (1.258X_3) + (1.494X_4)$, where X_1 represents the disease duration, X_2 represents the leakage area, X_3 shows the leakage type, and X_4 indicates the leakage point. By incorporating these four

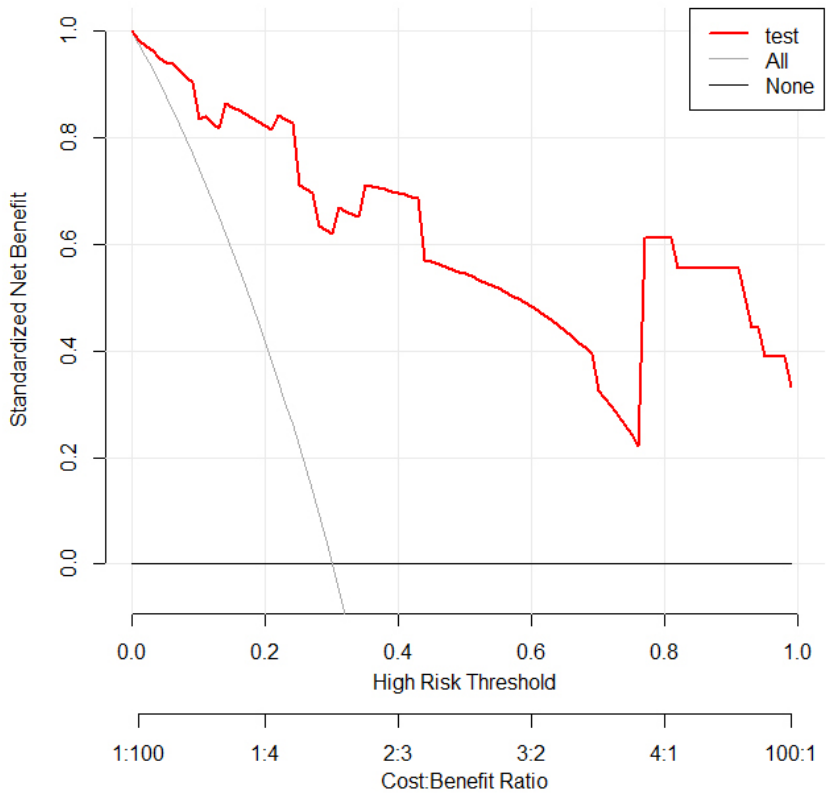

Fig. 6. Decision curve analysis (DCA) curve of the model in the modeling group.

factors, the model enables accurate prediction of the prognosis of CSC patients undergoing micro-pulse laser therapy. During the model validation phase, multiple assessment approaches, such as ROC analysis, calibration curve, and decision curve analysis (DCA), were used to evaluate the model's predictive performance. The ROC analysis showed that the model had an area under the curve (AUC) of 0.942 in the modeling group, indicating high predictive accuracy. Similarly, in the validation group, the AUC was 0.860, confirming the model's good predictive performance across different samples. The calibration curve slopes were close to 1, indicating strong agreement between the predicted and actual poor prognosis risk. These observations further enhance our confidence in the model's predictive reliability.

Additionally, the DCA curve showed a clear positive net benefit, highlighting the model's clinical utility in predicting outcomes for CSC patients after micro-pulse laser therapy. Notably, in constructing the predictive model, this study accounted for individual differences and disease characteristics. By including multiple prognosis-related factors and applying rigorous statistical methods, this study successfully established a model with high predictive accuracy. This model not only enhances our understanding of the crucial factors influencing CSC prognosis, but it also serves as a valuable clinical tool, helping clinicians in personalized risk assessment and optimizing management approaches for CSC patients undergoing micro-pulse laser therapy.

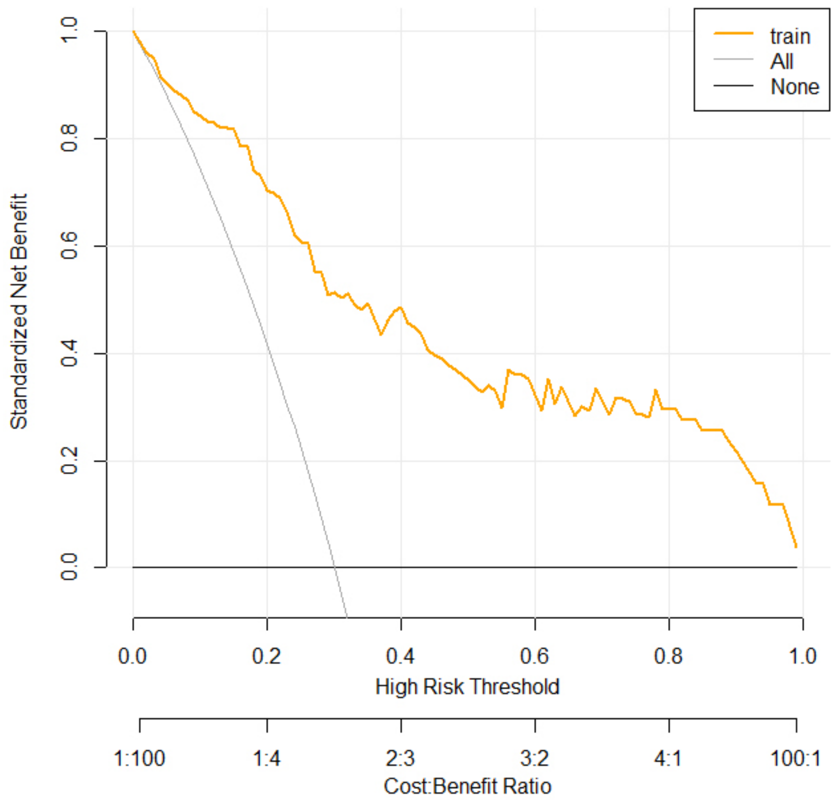

Fig. 7. DCA curve of the model in the validation group.

However, this study has certain limitations. Firstly, as a retrospective study with a relatively limited sample size, the predictive accuracy of the model may have been affected. Future studies should increase the sample size and accumulate additional data to further optimize the model and improve its predictive performance. Secondly, this study was limited to a single center, which may reduce the generalizability and applicability of the results. Furthermore, this limited sample representation could affect the broader clinical significance of the findings. To address these limitations, future studies should include multicenter or prospective cohort studies to further verify the model's reliability and applicability across various populations. Moreover, the retrospective study design may introduce potential biases, restricting the model's utility to diverse patient populations. Future research should investigate additional prognostic factors, incorporating them into predictive models for a more comprehensive analysis. Furthermore, this study highlights the significance of considering individual differences and disease characteristics when treating CSC patients. Patients with longer disease duration, larger leakage areas, complex leakage types, and multiple leakage sites require closer monitoring and prompt intervention. Early detection and management can effectively reduce the risk of poor prognosis and improve treatment outcomes.

Conclusion

This study successfully constructed and validated a predictive model for evaluating the prognosis of CSC patients undergoing micro-pulse laser therapy. The disease duration, leakage area, leakage type, and leakage sites were identified as crucial factors influencing prognosis. The model provides clinicians with a powerful predictive tool, aiding in more accurate outcome assessment and devising personalized treatment plans. However, given the study's limitations, further research is needed to verify these findings. Future efforts will focus on optimizing the model's predictive accuracy, exploring additional prognostic factors, and conducting prospective studies to further validate its reliability. Additionally, advanced technologies and novel therapeutic strategies for CSC should be explored, aiming to improve treatment efficacy and patient safety.

Key Points

- This study investigated the key factors affecting the prognosis of CSC patients who received micro-pulse laser therapy and established a predictive model for evaluating treatment effectiveness and patient outcomes.
- ROC curve analysis demonstrated high sensitivity and specificity for the model, with stable performance in the validation set.
- Calibration and decision curve analysis further validated the model's clinical significance.
- Disease duration, PED degree, leakage type, and leakage point distance significantly affect CSC prognosis after micro-pulse laser therapy.

Availability of Data and Materials

The datasets used and analysed during the current study are available from the corresponding authors upon reasonable request.

Author Contributions

XMN conceived the study, designed the methodology, collected and analyzed OCT/FFA imaging data, developed the prediction model, and drafted the manuscript. QL managed patient recruitment, clinical data collection, and follow-up evaluations. YGB performed data processing and implemented the machine learning algorithms. MBL conducted statistical analyses and model validation. HM optimized treatment parameters and ensured quality control. SJC provided expert guidance in chorioretinopathy management, coordinated multicenter collaboration, and critically revised the clinical interpretations. GS and SJC jointly proposed the concept and design ideas, obtained, analyzed and interpreted the data results. All authors reviewed and approved the final version. All authors contributed to revising the manuscript critically for important intellectual content. All authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics Approval and Consent to Participate

All methods were carried out in accordance with the Declaration of Helsinki and relevant guidelines. The treatment methods were carried out strictly according to the laser operation procedure, and all research protocols were approved by Medical Ethics Committee of Zunyi Medical University (Number: Follow the medical ethics: [2020]1-064). Informed consent was obtained from all subjects for this study.

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Conflict of Interest

The authors declare no conflict of interest.

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