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Application and evaluation of case-based multimodal imaging in the ocular fundus disease teaching of postgraduate students

Shi Xuehui[1*†], Wang Haiyan[1†], Yang Fan[1], Zhou Jinqiong[1] and Wei Wenbin[1*]

Abstract

Objective Ocular fundus disease is one of the most complex areas of ophthalmology and a difficulty in ophthalmic education and training. Fundus imaging is an essential tool and reliable method for teaching fundus diseases. At present, the development of fundus imaging has entered the multimodal era. The traditional teaching mode is difficult to meet the current increasing teaching needs. This study aims to evaluate the application value of case-based learning (CBL) combined with multimodal imaging in clinical teaching of ocular fundus diseases.

Methods All the thirty-four postgraduate students studying at the Ophthalmology Center of Beijing Tongren Hospital affiliated to Capital Medical University were included. All the students were during the standardized training period for residents at the same level of training. The traditional teaching group included 16 students who studied from September to December 2023, and the CBL multimodal imaging teaching group included 18 students who studied from January to April 2024. All students were initially tested for basic knowledge of ocular fundus diseases. After the basic training and examination, the traditional teaching group was taught the characteristics of various common fundus diseases in each imaging mode; the CBL multimodal imaging teaching group was taught the characteristics of multimodal imaging based on each disease of common fundus diseases. The two groups conducted single mode imaging and multimode imaging examination in stages as the teaching schedule, and finally took the theoretical examination and clinical case analysis examination. The score results of the theory examination, image analysis and case analysis examination were compared at each stage.

Results There was no statistically significant difference between the two groups in the scores of fundus basic knowledge examination, basic imaging knowledge examination, and single mode image analysis ($P=0.44$, 0.62,0.38). The scores of multimode image analysis, final theoretical examination, and case analysis in the CBL multimode imaging group were all significantly higher than those in the traditional teaching group ($P=0.02$, 0.01, 0.02). Meanwhile, the proportion of students with better performance in final theoretical examination and case analysis examination was higher in the CBL multimodal imaging teaching group than that in the traditional teaching group.

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In the questionnaire survey, CBL multimodal imaging teaching mode has incomparable advantage over traditional teaching mode in students' learning interest and initiative($P=0.001$). And students in CBL multimodal imaging teaching group also had higher recognition and subjective evaluation on their study ability, clinical thinking and case analysis ability than that in traditional teaching group($P=0.01$, 0.02, 0.01).

Conclusion CBL combined with multi-modal imaging is an efficient method in the ocular fundus disease teaching of postgraduate students. It helps to increase students' image discrimination and case analysis abilities, and improve their clinical work.

Keywords Case-based learning, Multimodal imaging, Postgraduate students, Ocular fundus disease teaching, Medical education

Background

Ocular fundus disease is one of the most complex areas of ophthalmology, encompassing a wide range of fundus diseases including retinopathy, uveal disease, optic nerve disease associated with scleral disease and ocular tumours. Any structural abnormality within the eyeball can lead to the development of ocular fundus disease. Meanwhile, fundus diseases are closely related to systemic diseases, and they are an important cause of blindness and a serious threat to people's health and quality of life [1–3]. With the development of society and changes in lifestyle, the spectrum of fundus lesions has expanded and the manifestations of fundus diseases have become more diverse and complex, making diagnosis and treatment difficult. The complexity of fundus diseases has become a challenge in ophthalmology education and training.

Fundus imaging is an essential aid to assist the diagnosis and treatment of fundus diseases, as well as a necessary and reliable tool in the teaching of fundus diseases [4–6]. Fundus imaging has intuitive characteristics, which can help students to improve their understanding of fundus diseases, expand their fundus knowledge and improve learning efficiency quickly. Fundus imaging shows rich information, which can stimulate students' desire to explore, improve the ability of fundus disease identification, especially improve the ability of independent thinking. More importantly, the interpretation of fundus images is a process of tracing the pathogenesis of diseases. Through systematic and standardized ophthalmic imaging training, students can correctly interpret the imaging manifestations of various diseases, and judge the pathological mechanism of diseases from the analysis of imaging abnormalities, and then reveal the essence of diseases. Various fundus imaging techniques are necessary in the diagnosis and treatment of fundus diseases [6, 7]. Correct interpretation of fundus photography, fundus angiography, and optical coherence tomography (OCT) imaging are the necessary clinical skills for ophthalmologists.

Currently, the teaching of fundus diseases and fundus imaging is still mainly based on traditional teaching methods. The main problem with this teaching mode is that the teachers deliver lessons only based on the concepts outlined in the syllabus. In the process of teaching, the teacher explains the image manifestations of various fundus diseases in each imaging mode, and the students passively accept the knowledge [8]. In each single imaging mode, students can only understand the lesion characteristics of the disease from a single perspective and at a single level, lacking the analysis and integration of the disease multimodal imaging data [7, 9].As a result, students' professional knowledge is fragmented and inefficiently accumulated in the learning process, and students' overall ability to analyse cases is insufficient, leading to low learning initiative and enthusiasm. This teaching mode is difficult to adapt to the current increasing teaching content and cannot meet the teaching needs. In order to help students combine theory and clinical practice more effectively, the case-based learning (CBL) method is increasingly used in medical education.

CBL is a long-established pedagogical method and positive learning strategy that "takes students at the center, cases as a bridge, and inquiry as a motivator" [10, 11]. Unlike the traditional teaching methods, the essence of CBL is a combination of theory and practice that aims to improve students' flexible application of relevant knowledge and skills, and cultivate their ability to analyse and solve problems [10, 12]. Due to the uniqueness of clinical medicine, the CBL teaching mode has a great advantage in clinical medical education. CBL provides students with opportunities to engage with authentic cases, enhances students' learning by helping them to link theory with clinical practice, and enables students to adapt to clinical practice as soon as possible [13–15]. CBL is particularly suitable for clinical training in medical education and is more in line with the needs of medical education [16–18].

In view of the current needs, this study proposes CBL combined with multimodal imaging to assist the teaching of fundus diseases. We take common fundus diseases as the main teaching content, conduct multimodal imaging integrated teaching based on specific cases, and explore

and evaluate the effect of CBL multimodal imaging in teaching fundus diseases.

Methods

Study participants

This study included all thirty-four postgraduate ophthalmology students studying at the Ophthalmology Centre of Beijing Tongren Hospital, affiliated to Capital Medical University, all during the standardised training period for resident doctors. This study research is from Education and Teaching Reform Project of Capital Medical University(Construction and application of fundus multimodal image database based on standardized training of professional master's degree students and resident doctors, 2024JYY177; Recording of eye anatomy teaching videos and its application in undergraduate ophthalmology teaching, 2022JYY218), which was launched in January 2024. So the students in this study were assigned into two groups according to the time of the training and the different teaching methods. The traditional teaching group included 16 students who studied from September to December 2023, and the CBL multimodal imaging teaching group included 18 students who studied from January to April 2024. All the students signed the informed consent and completed the courses and examinations.

Teaching design and implementation

After admission to the department, students in both groups were first trained in the basic knowledge of colour fundus photography(CFP), fluorescein fundus angiography(FFA), indocyanine green angiography(ICGA), and optical coherence tomography(OCT) imaging, including imaging methods and principles, normal fundus imaging manifestations, abnormal imaging features and interpretation of the formation mechanism. Four teachers gave lectures. According to the standardized training requirements, the same instructor conducted the teaching for each type of course, using the same teaching content and images.

Fundus disease imaging teaching

Before teaching, **the four** teachers collected imaging data on common fundus diseases according to the requirements of standardized residency training, mainly including retinal vascular diseases (diabetic retinopathy and macular edema, retinal vein occlusion and macular edema, hypoperfusion retinopathy, etc.); macular diseases(Central serous chorioretinopathy, choroidal neovascularization, polypoidal choroidal vasculopathy, etc.); uveitis(multifocal choroiditis, Harada disease) and other representative diseases.

The traditional teaching group adopted a single image teaching model, gave teaching lectures on various common fundus diseases in each imaging modality, and explained the imaging features of common fundus diseases and their formation mechanisms in each imaging modality. During the teaching process, students were guided to analyse the features of each imaging modality in each of the diseases by asking questions, and finally the clinical application and significance of each imaging modality were summarized.

The CBL Multimodal Imaging Teaching Group was a disease-based group that taught the analysis of different modal imaging feature presentations for each fundus disease. Prior to teaching, all the four teachers prepared appropriate clinical cases in advance, designing typical cases, and collecting multimodal images of each case. During the teaching, the teachers would use the case as a basis and explain the multimodal imaging performance around the disease synchronously. During the teaching process, the teacher also used questions to guide the analysis of the formation mechanism of each image feature, and finally systematically summarized the disease mechanism and its image correlation, such as the multimodal image interpretation of central serous chorioretinopathy (CSC). Fig. 1.

Teaching effectiveness assessment

According to the research programme and the teaching progress, five examinations are conducted in the following three stages. The main assessment indicators included the scores of the theoretical, image analysis and case analysis examinations at each stage, with a total score of 100 points for each examination.

Image basic knowledge examination

After the first stage of basic imaging knowledge training of all imaging modes, the two groups of students performed a theoretical examination, including various image imaging basics, normal image morphology, structure and layer annotation, abnormal image and interpretation.

Single mode image analysis assessment and multimodal image analysis assessment

These two examination were carried out after the second stage of Fundus disease imaging teaching. In the traditional teaching group, the single-mode image analysis assessment was administered after each individual imaging modality course, and the scores of all imaging modality assessments were summed to calculate the total score.

After completion of all imaging modality courses, the multimodal imaging analysis examination was administered. In the CBL multimodal imaging teaching group, the multimodal imaging analysis examination was performed after completion of the multimodal imaging teaching of all the above ocular fundus diseases. In order

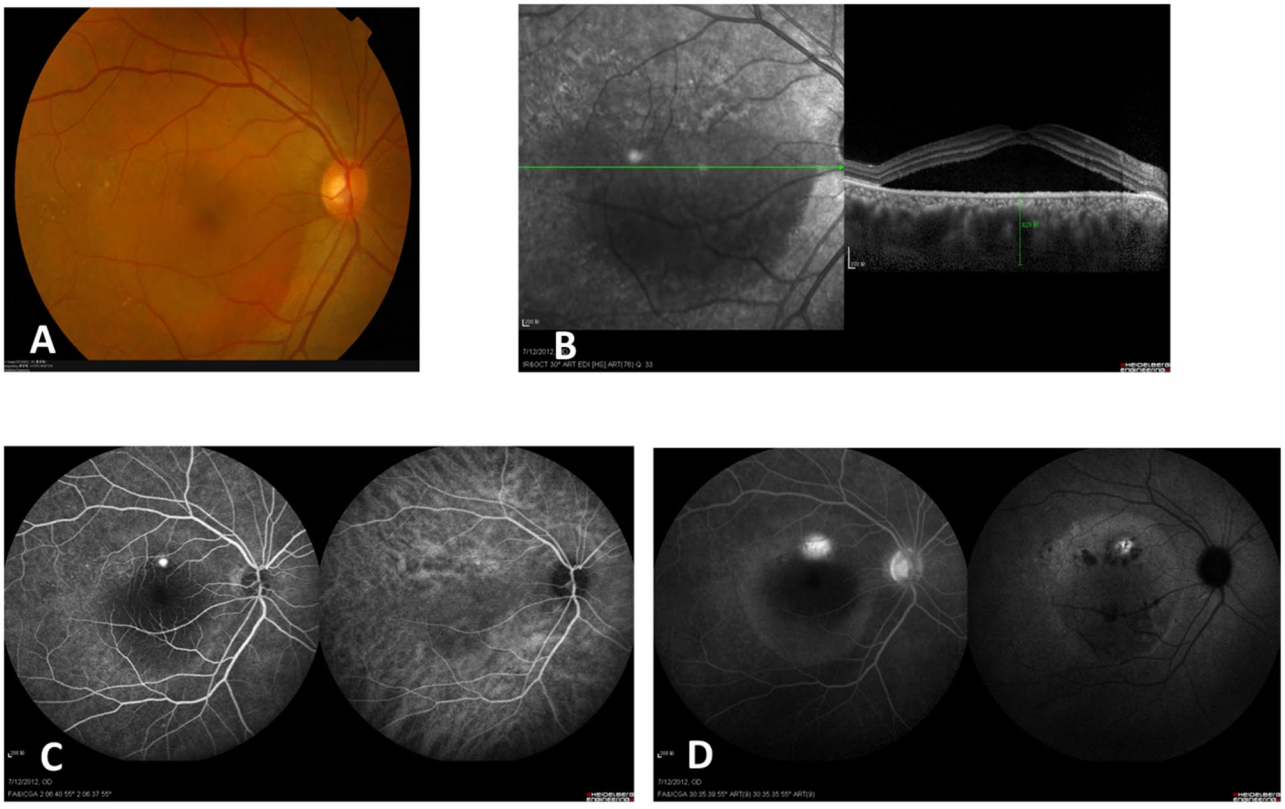

Fig. 1 Multimodal imaging of central serous chorioretinopathy in the right eye: **A** CFP shows detachment of the macular sensory layer; **B** OCT shows detachment of the macular sensory layer, increased choroidal thickness and enlarged lumen of large vessels; **C** In the venous stage of FFA (left image) and the early stage of ICGA (right image), punctate hyperfluorescence was observed in the macula, and ICGA simultaneously showed dilated choroidal vessels in the superior macula; **D** In the late stage of FFA and ICGA, punctate hyperfluorescence was extended in the macula and fluorescence accumulation was observed

to test the influence of CBL multimodal image teaching on the ability to interpret single mode images, the CBL multimodal image teaching group also underwent the same single mode image analysis examination as the traditional teaching group.

Final theoretical examination and case analysis ability examination

These two examinations are the final comprehensive examination after completing the study. After the theoretical training and image analysis practice, a final theoretical examination and case analysis ability examination were conducted at the end of the course to test the students' mastery of the course and the overall teaching effect in the two groups. The examination questions were randomly selected from the examination question bank.

The final theoretical examination included theoretical explanation of the imaging principle and interpretation points of each image, interpretation of abnormal images; and the imaging basis of diagnosis for two diseases. To assess clinical case analysis skills, 5 cases were selected from the disease database, with patients' general information (gender, age, chief complaint and medical history), CFP, FFA, ICGA and OCT images. Interpretation of imaging features, analysis and disease diagnosis were required.

Subjective evaluation

At the end of the study, an anonymous questionnaire survey was conducted on paper in the two groups to evaluate the students' satisfaction and self-assessment. All the students in both groups participated in the questionnaire survey.

The questionnaire was designed based on a modified version of the course evaluation questionnaire [19], and was constructed with reference to the first two levels of the Kirkpatrick model [20].The first level was about the students' responses, such as their interests and motivation. The second level was to measure whether the students had learned the knowledge or skills. After the teachers' discussion, the questionnaire in this study consisted mainly of five questions. The first question was course satisfaction (satisfied with the course design and teaching modalities), the second question was learning interest and initiative (with more learning interest and initiative to learn the knowledge in this course). The

Table 1 Comparison of the students' baseline characteristics [$n = 34$,(x ± s)]

group	TTG	CBL-MIG	t-value/*	*P*-value
Age (years, x ± s)	25.87 ± 1.99	25.05 ± 2.07	1.71	0.25
Male/female(n)	3/13	5/13	*	0.69
Ocular fundus basic knowledge Examination(**points**, x ± s)	89.50 ± 3.84	88.22 ± 5.39	0.78	0.44

*Fisher's exact test; TTG(traditional teaching group); CBL-MIG(CBL multimodal imaging teaching group)

Table 2 Comparison of professional examination between TTG and CBL-MMIG [$n = 34$,(x ± s)]

Group and scores (points)	TTG	CBL-MIG	t-value	*P*-value
Image basic knowledge examination	92.19 ± 3.45	91.67 ± 2.66	0.50	0.62
Single mode image analysis	91.00 ± 3.41	92.11 ± 3.80	0.89	0.38
Multimodal imaging analysis	87.19 ± 4.53	90.50 ± 3.61	2.37	**0.02**
Final theoretical examination	91.44 ± 3.86	94.78 ± 3.25	2.74	**0.01**
Case analysis	90.37 ± 4.80	93.61 ± 3.01	2.38	**0.02**

TTG(traditional teaching group); CBL-MIG(CBL multimodal imaging teaching group)

third question was learning ability (enhanced the ability of acquiring knowledge and learning skills). The fourth question was clinical reasoning ability(dialectical and logical thinking ability, inferential ability improved). and the last question was case analysis ability(analytical and diagnostic skills improved after the study). The questionnaire employed a five-point Likert scoring method to assess students' perspectives, with 5 indicating "completely satisfied/completely agree", 4 indicating "satisfied/agree", 3 symbolizing "neutral", 2 for "dissatisfied/disagree", and 1 for "completely dissatisfied/completely disagree". All the students in both groups participated in the questionnaire survey, and the effective recovery rate was 100%.

Statistical analysis

All statistical analyses were performed using SPSS 23.0 (SPSS, Inc., Chicago, IL). Age measurements and scores at each stage were expressed as mean ± SD. Independent samples t-test was used to compare the age and test scores between the two groups, and Fisher's exact test was used to compare the difference in sex composition ratio between the two groups. $P < 0.05$ was defined as statistically significant.

Results

Baseline information of the students

The age of the 34 postgraduate students included in this study ranged from 22 to 31 years (mean 25.44 ± 2.05), 8 were male and 26 were female. The general characteristics of the students in the two groups are shown in Table 1. The traditional teaching group consisted of 16 students (3 males and 13 females) with a mean age of (25.87 ± 1.99) years. The CBL multimodal imaging teaching group consisted of 18 students (5 males and 13 females), with a mean average age of (25.05 ± 2.07) years. There was no significant difference between the two groups in terms of age, gender composition ratio and the scores results of ocular fundus basic knowledge examination at enrollment ($P > 0.05$).

Comparison of professional examination results between the two groups

There was no statistically significant difference between the two groups in the scores of image basic knowledge examination and single mode imaging analysis examination ($P > 0.05$). In CBL multimodal imaging teaching group, the scores of multimodal imaging analysis, final theoretical examination and case analysis examination were higher than those of traditional teaching group, and the difference was statistically significant($P < 0.05$), as shown in Table 2. And the percentage of students with different score intervals at each examination between the two groups is shown in Figs. 2, 3, 4, 5 and 6.

Comparison of students' satisfaction and selfevaluation between the two groups

Students in both groups had similar scores in course satisfaction scores in the questionnaire survey($P > 0.05$). Students in the CBL multimodal imaging teaching group agreed with improved learning interest and initiative, study ability, clinical thinking ability and case analysis ability more than students in the traditional teaching group, and the difference in scores between the two groups was statistically significant($P < 0.05$) Table 3.

Discussion

With the development of society and the gradual expansion of the fundus lesion spectrum, the manifestations of fundus diseases have become more complex. Correspondingly, fundus imaging examinations show diversity [6, 7, 9]. There are many types of fundus imaging examinations, and different imaging examinations show different sides and characteristics of the disease, such as CFP directly shows the basic manifestations of fundus disease; FFA shows retinal circulation and the destruction of

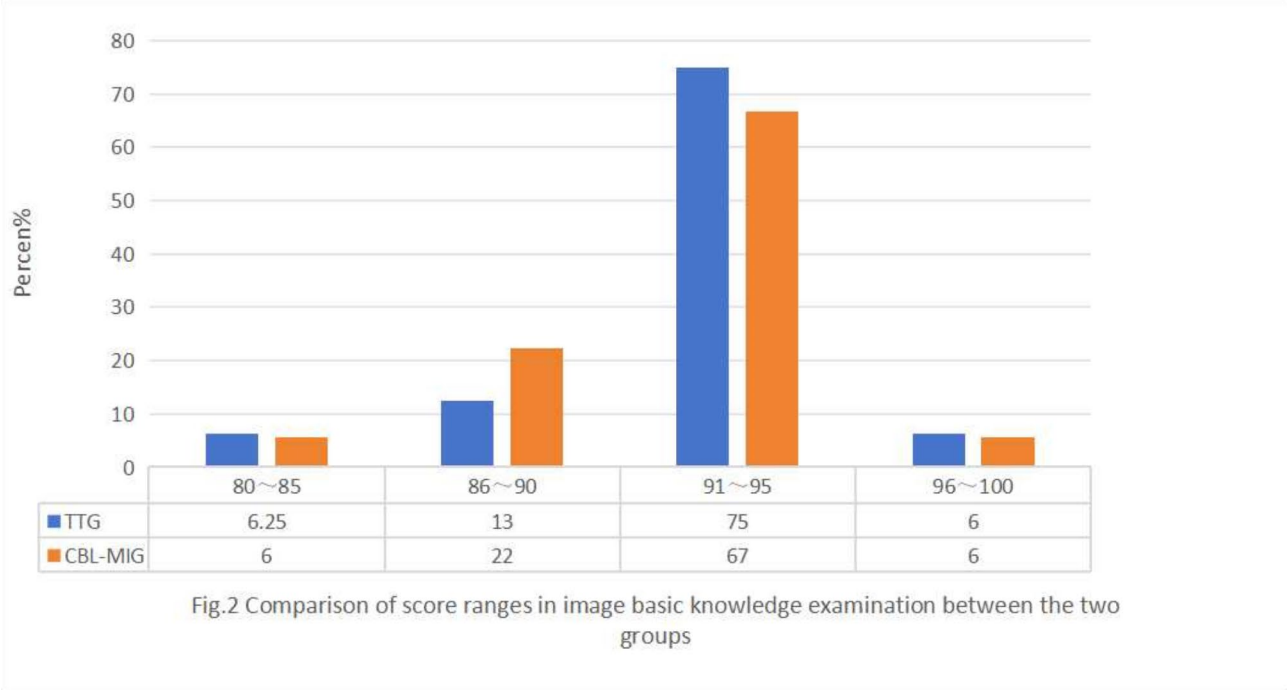

Fig. 2 Comparison of score ranges in image basic knowledge examination between the two groups

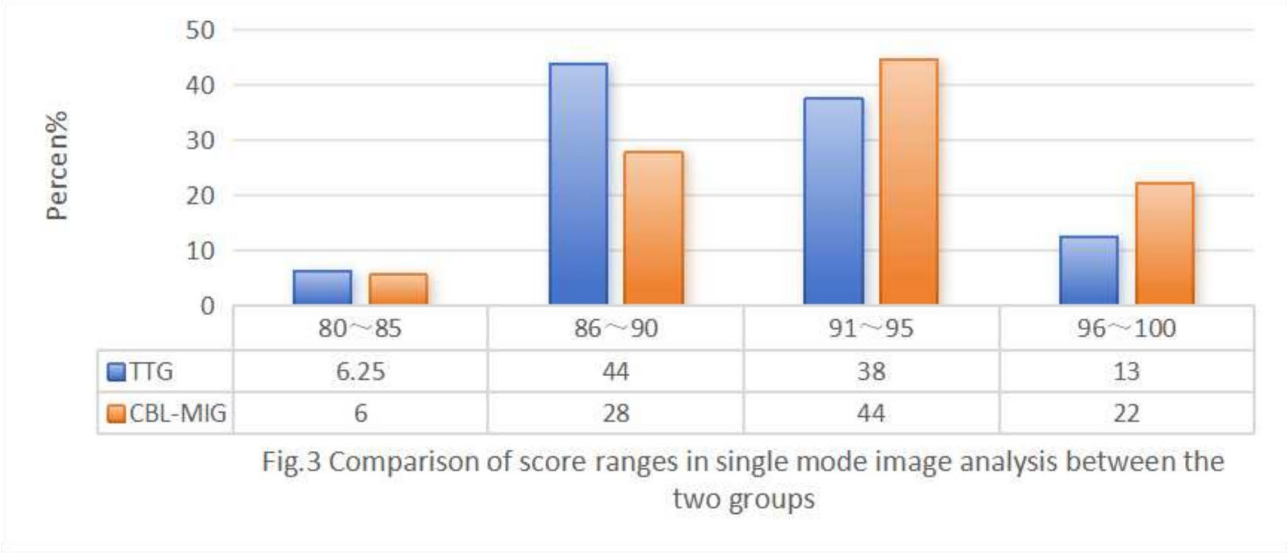

Fig. 3 Comparison of score ranges in single mode image analysis between the two groups

the blood-retinal barrier; ICGA shows the status of the choroidal circulation; and OCT displays the abnormal retinochoroidal morphology, hierarchy and structure. Correct interpretation of fundus imaging has become a necessary skill for ophthalmologists in clinical practice, and also an important component of ophthalmology teaching.

In the traditional teaching mode, teachers focus on theoretical teaching, emphasize the concepts, students listen to lectures, take notes, and passively accept the transmission of knowledge [21]. The traditional learning mode cannot activate students' participatory consciousness, which leads to lack of learning motivation, low attention and comprehension, and is unable to make the curriculum closely related to clinical practice, it is difficult to mobilize students' enthusiasm in clinical practice by only using the traditional teaching method [22]. As a result, after the final completion of all stages of ocular fundus imaging teaching, it is difficult for students to fully understand and integrate what they have learned,

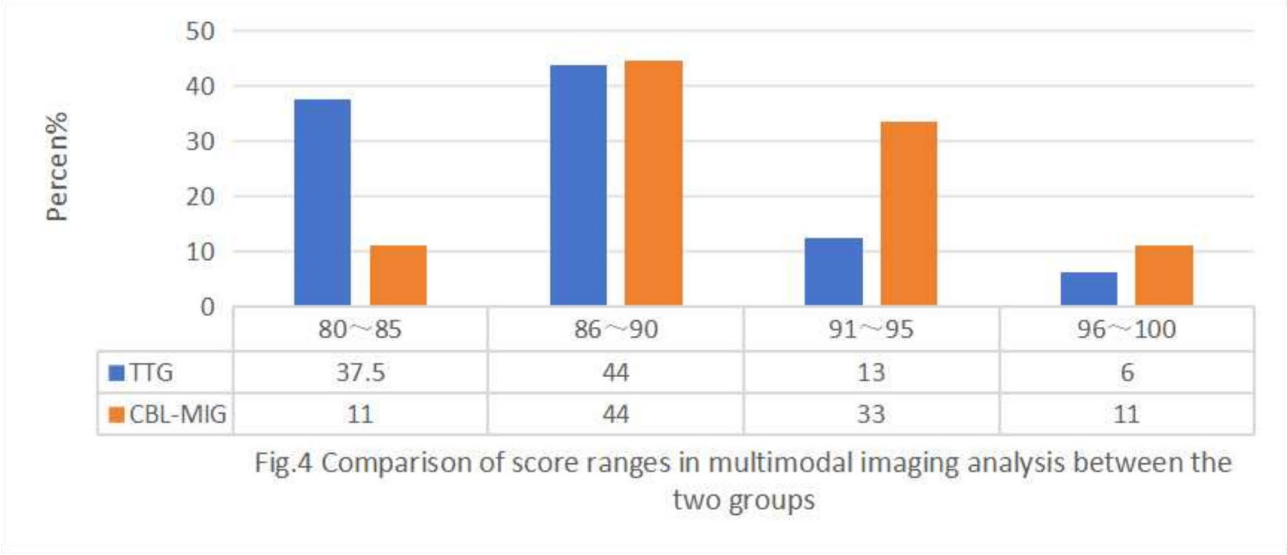

Fig. 4 Comparison of score ranges in multimodal imaging analysis between the two groups

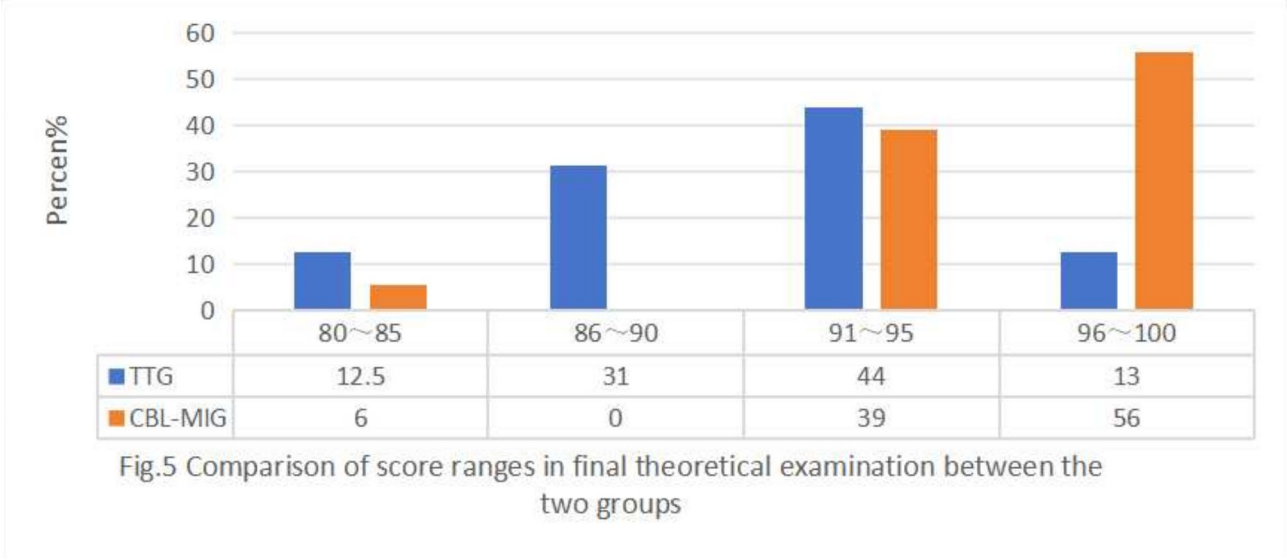

Fig. 5 Comparison of score ranges in final theoretical examination between the two groups

and the accumulation of professional knowledge is fragmented and disconnected, leading to low learning efficiency. Traditional teaching methods have been proven to be less effective than other teaching strategies in terms of dialectical thinking and practical application skills, and this problem is more pronounced in the teaching of ocular fundus diseases. In order to overcome the above problems in teaching, this study adopts CBL combined multi-mode image-assisted teaching.

CBL means that teachers use real cases to teach and provide more effective learning strategies, and under the elaborate design of CBL mode, students are guided to use the relevant knowledge to actively observe and analyse, and finally make a decision [15]. CBL teaching has many advantages: CBL teaching has the enlightening and guiding characteristics, which can improve students' awareness of participation and learning enthusiasm, and achieve better teaching results. The CBL teaching mode allows questions and discussion, which can promote students' in-depth understanding and high-level learning, so that they can apply the basic knowledge in practice, instead of the one-way teaching of curriculum content transmission through the traditional teacher-led way, which just let students' passive acceptance. CBL can effectively promote students' application and integration of knowledge, and enhance their ability to develop, communicate and solve problems [18, 23]. Under CBL teaching, students' general case analysis and reasoning training

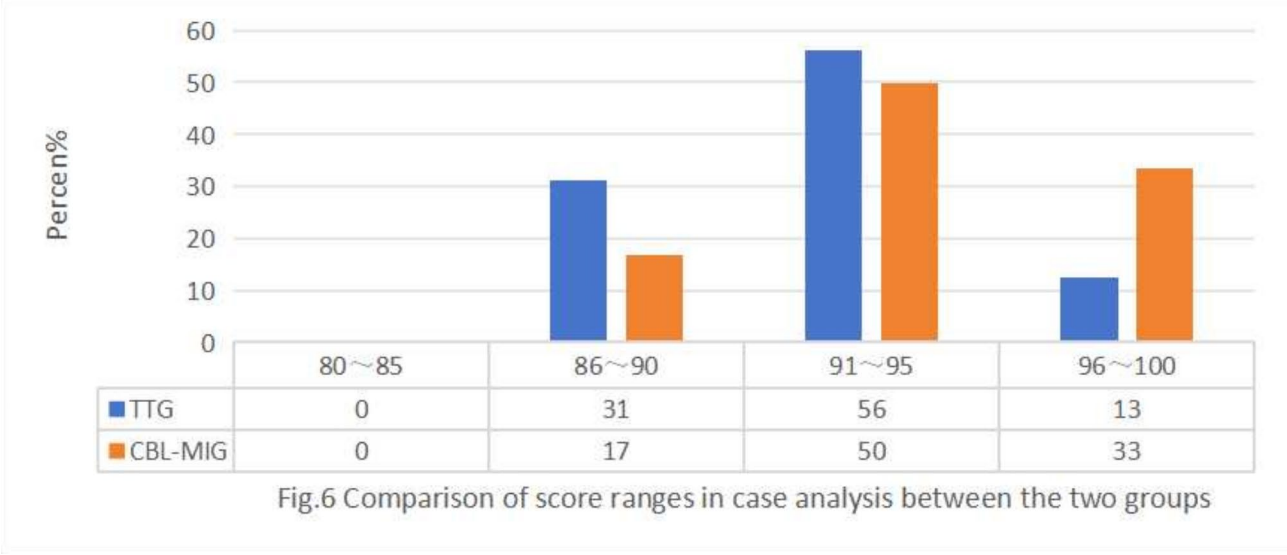

Fig. 6 Comparison of score ranges in case analysis between the two groups

Table 3 Comparison of evaluation scores between TTG and CBL-MIG models by students[$n=34$,($x \pm s$)]

Group and scores(points)	TTG	CBL-MIG	t-value	*P*-value
Course satisfaction	4.59 ± 0.30	4.62 ± 0.31	0.22	0. 83
Learning interest and initiative	4.54 ± 0.29	4.81 ± 0.16	3.50	**0.001**
Study ability	4.08 ± 0.37	4.38 ± 0.30	2.58	**0.01**
Clinical thinking ability	4.33 ± 0.24	4.54 ± 0.26	2.57	**0.02**
Case analysis ability	4.19 ± 0.33	4.47 ± 0.31	2.59	**0. 01**

are conducive to promoting their clinical thinking mode [23–24]. CBL combined with many other teaching modes can facilitate the application of students' theoretical knowledge to real-life scenarios, which can further improve students' learning efficiency and case analysis ability, thus better preparing them for future clinical practice [25–28].

At present, the development of fundus imaging has entered the multimodal era [6, 7, 9]. Fundus multimodal imaging is a necessary and reasonable combination of multiple imaging examinations, which can integrate multiple imaging manifestations of histological morphology, structure and function. Compared with the traditional single image teaching, multimodal imaging is used in the teaching of fundus diseases, which can more accurately show the degree and extent of lesions, compare the image characteristics and their correlation in different types of diseases. In our study, CBL combined with multimodal imaging teaching was used as the main teaching method. This teaching method is based on specific cases. It can display and compare the image information of various different modes of the case at the same time, which helps students to comprehensively analyse the aetiology and pathogenesis, so that they can fully understand and master the fundus diseases. For example, during the process of interpreting the characteristics of the disease, the teacher can show the blood flow changes in the lesion by fundus angiography and the defect structure of the lesion by OCT, so that students can observe the surface phenomenon and recognize the histopathological changes of the lesion. In this way, students can understand the association of multiple manifestations and the intrinsic features of fundus diseases.

In our study, the two groups of students had similar scores on the Fundamentals of Professional Knowledge Exam and the Fundamentals of Image Exam, which means they have similar professional backgrounds, so the two different teaching methods and teaching effects were comparable. In terms of single mode image analysis, the difference between the traditional teaching group and the CBL multimodal imaging teaching group is not obvious, indicating that the CBL multi-mode image teaching did not weaken the students' understanding of each single mode imaging. In contrast, in the assessment of multimodal image analysis and the final theoretical examination, the score performance of the CBL multimodal imaging teaching group is better than that of the traditional teaching group.This suggests that, in the process of learning multimodal imaging, students can analyse and integrate multi-level and multi-dimensional knowledge points at the same time, which is beneficial for students to improve their comprehensive analysis ability, and

then strengthen students' systematic understanding and mastery of the knowledge.The above results are similar to other studies on CBL collaborative teaching models [28–31].

The assessment of case analysis ability is to imitate the clinical working state, which is the ultimate assessment of students' ability to apply basic knowledge to clinical practice, think independently and solve clinical problems independently. In this study, the performance of case analysis ability in the CBL multi-mode imaging teaching group was also significantly better than that of the traditional teaching group, confirming that the students in the CBL multi-mode imaging teaching group were better than the traditional teaching group in the knowledge integration and clinical thinking. In addition, the results of the score range comparison between the two groups in Figs. 2, 3, 4, 5 and 6 show that, the percentages of image basic knowledge exams in each score range of the two groups are balanced. However, the proportion of students scoring 91 points or more in the single mode image analysis test and the multimodal imaging analysis test is higher in the CBL multimodal imaging teaching group than in the traditional teaching group. Similarly, the proportion of students scoring above 96 in the final theoretical examination and the case analysis examination is higher in the CBL multimodal imaging teaching group than in the traditional teaching group. By comparing the score range distribution map, we can conclude that CBL multimodal imaging teaching may be more beneficial in producing students with better clinical performance and skills.

The advantages of CBL multimodal imaging teaching are also reflected in students' satisfaction and identity. The main purpose of teaching mode reform is not only to promote students to consolidate their basic knowledge and learn clinical skills, but also to stimulate students' interest and enthusiasm for learning, and to cultivate students' self-directed learning and their development of soft skills [18, 31]. For example, in the CBL multimodal imaging teaching in our study, multimodal images of CSC were comprehensively analyzed and interpreted. CFP showed detachment of the macular sensory layer; leakage in the FFA indicated the site of disruption of the outer retinal barrier; ICGA revealed an enlarged lumen of the choroidal vessels. OCT displayed a sensory layer's serous detachment with increased choroidal thickness, corresponding to FFA fluorescence leakage and subretinal accumulation. All the information aggregation revealed that the true underlying pathogenesis of CSC was choroidal hyperperfusion. The above imaging analysis not only provides support for diagnosis but also for fundamental treatment to reduce choroidal perfusion. Therefore, CBL multimodal imaging teaching can explain the pathological basis and pathogenesis of lesions, and the correlation of various images, and it can make students to recognize the manifestation of disease, understand the underlying mechanism. At the same time, this teaching mode can also stimulate students' attention and enthusiasm for learning, cultivate the awareness of active thinking and independent analysis, and increase their clinical thinking ability. The subjective evaluation of our study also confirms this point. It shows that both groups had similar satisfaction with their respective teaching modes. But the CBL multimodal imaging teaching mode has an incomparable advantage over the traditional teaching mode in terms of students' learning interest and initiative. And students in the CBL multimodal imaging teaching group have higher recognition and subjective evaluation of their study ability, clinical thinking and case analysis ability than the traditional teaching group. These results were basically consistent with the objective professional examination results at each stage in both groups.

The main weakness of this study is that, it is a single-center study, and the limited number of ophthalmology postgraduates in residency training limited the sample size. Our present results provide a preliminary basis for future in-depth studies. **This study will expand the scope to incorporate other resident-trained physicians and include multicenter studies to further confirm the advantages of CBL multimodal imaging in teaching fundus diseases.** In addition, multimodal imaging is a challenge in the application of fundus teaching. Each imaging modality has its own specific interpretation criteria, and the information integration between different imaging modalities also requires teachers to have high professional knowledge and analytical ability. The application of case-based multimodal imaging in teaching is also limited by cases. Teachers need a lot of time to select representative cases and classic images, which requires continuous accumulation.

Conclusion

The above results of this study confirm that CBL multimodal imaging teaching is more helpful to improve students' image discrimination and clinical analysis ability, and helps to increase students' learning efficiency, improve theoretical knowledge and practical ability. It could enhance students' active participation and self-confidence in learning, encourage students to apply the knowledge to clinical practice and to analyse cases independently, promote students to form clinical thinking mode and foster their clinical quality, and thus to enter the clinical working state faster. And we can have the conclusion that CBL multimodal imaging teaching may be more beneficial to produce students with better clinical performance and skills. The main weakness of this study is that, it is a single-center study, and the number of ophthalmology postgraduates in residency training limits

the sample size. Subsequent studies require expanded sample size and multicenter participation.

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Author contributions
Shi Xuehui and Wang Haiyan designed the research and implemented the teaching, provided the Funding acquisition and prepared the manuscript. Shi Xuehui and Yang Fan processed the imaging data and Cases. Zhou Jinqiogn designed the tests and questionnaires and performed the statistical analysis. Wei Wenbin revised the manuscript. All authors reviewed and approved the final manuscript.

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Data availability
All data used and analysed in this study are available on reasonable request from the corresponding author (shixuehui212@126.com).

Declarations

Ethics approval and consent to participate
All procedures performed in this study complied with the tenets of the Declaration of Helsinki, and were exempt from Ethics Committee of Beijing Tongren Hospital affiliated to Capital Medical University. The informed consent was obtained from all participants.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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