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Study on the effect of simulation-based case teaching method on the preclinical teaching of tooth defects restoration

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Abstract

Background Clinical decision plays an important role in the prognosis of dental defect restoration. However, the current theoretical teaching and experimental teaching lack the training of clinical decision based on evidence-based medicine. Students have mastered theoretical knowledge and basic operating skills, they are extremely lacking in the ability to handle clinical cases before clinical practice. In order to improve students' clinical decision ability in dental defect restoration and enhance the connection of clinical practice and theory teaching, we applied the simulation-based case teaching (SCT) method in practice teaching courses.

Methods The study was carried out with 96 undergraduate dental students at Guanghua School of Stomatology, Sun Yat-sen University, including 51 females and 45 males, aged $17 \sim 20$ years, with an average of (18.23 ± 1.02) years. The SCT course included case-based group discussion, teeth preparation, group report, question defense and teacher comments. We obtained effective and comprehensive classroom feedback through teaching effect evaluation by comparing the case analysis results before and after the SCT course, and questionnaire survey from students after class. All statistical analyses were performed using SPSS 25.0. The comparison between the two groups of percentages was made using a Chi-square test. Statistical significance was set at p < 0.05.

Results The results of objective evaluation of teaching effect showed a statistically significant difference (p < 0.01) between the results before and after SCT in the diagnosis, treatment plans, restoration materials and complications. The results of the questionnaire survey showed that students agreed their improvement in the treatment decision making, aesthetic restoration and dentists-patients communication and recognized their shortcomings in clinical critical thinking and knowledge development.

Conclusions The study suggested that SCT is an excellent teaching method to cultivate students' clinical thinking, and we should integrate more imparting of experience related to clinical decision-making and medical humanities in the future preclinical teaching work.

Keywords Situational-based education, Tooth defect, Preclinical training, Treatment plan, Medical humanity

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Background

Tooth defect refers to the damage and abnormality of the shape and structure of the tooth caused by various reasons, which has adverse effects on the pulp, periodontal tissue, chewing, pronunciation, face and even the body health [1, 2]. Different types of dental defects can be repaired in different methods according to the indications of restoration [3, 4]. Dentists should provide correct treatment plans and choose reasonable restoration according to the part, range and characteristics of dental defects [5]. Meanwhile, the materials of the restorations are also different, which need to be carefully selected in clinical application according to the functional characteristics [6]. This determines that dental prosthodontic education should be closely related to the clinic.

In most cases, the same tooth defects may meet the indications of two or several types of restoration [7, 8]. This requires clinicians to follow the repair principle, strive for the best restoration effect with minimal teeth damage to meet personal satisfaction. However, for undergraduates, who have not practiced in clinic and lack the ability of treatment plans making and clinical judgement based on evidence-based medicine, they are always confused about choice selection. Therefore, how to improve the critical thinking skills of students in preclinical practice still needs to be explored.

A variety of teaching methods have been applied in medical teaching that requires clinical critical thinking skill, including imparted-teaching methods such as lecture-based learning (LBL) [9], discussion-based teaching methods like team-based learning (TBL) [10, 11], experience-based teaching methods, for instance, case-based learning (CBL) [12, 13], and problem-oriented teaching methods, also called problem-based learning (PBL) [14-16]. Simulation-based teaching (SBT) method is a high-level teaching method developed by combining the advantages of the above teaching methods. Simulationbased teaching method is based on the constructivism teaching thought, using situational problem design, systematic content and simulated classroom situation to stimulate students to participate in the discussion [17]. This method can provide students with a safe and controlled environment to practice, ultimately improving patient safety and clinical outcomes. In the curriculum, students can enhance skill acquisition and repeat practice without risk to actual patients [18]. Due to the lack of practical training, preclinical students often face a lot of uncertainties in the initial stage clinical practice. SBT method also provides opportunities to students to develop their capacity to manage uncertainty [19].

Simulation-based case teaching (SCT) is one of situational teaching method in which teachers provide background information of typical cases and students solve problems and propose different solutions through discussion and analysis through independent thinking and collective cooperation [20, 21]. The combination of scenario simulation and clinical case analysis can help students quickly think as a doctor and practice from the perspective of a clinician. A meta-analytic comparative review considered that simulation-based medical education is superior to traditional clinical medical education in achieving specific clinical skill acquisition goals [22]. In addition, the conclusions of situational case teaching are open, the curriculum pays more attention to the knowledge integration and analytical skills training. The purpose of this study was to explore the effect of situational case teaching method in the clinical critical thinking skill training of tooth defect restoration.

Methods

This study was a self before-and-after control study, conducted at Guanghua School of Stomatology, Sun Yat-sen University and received ethical approval from the Ethics Committee (the ethical approval NO. is KQEC-2024–08-01). The eligibility criteria of students include: 1. Undergraduate students majoring in stomatology; 2. Students have finished the theoretical course of dental prosthetics and the experimental course of dental defect restoration; 3. Students are physically and mentally healthy, can attend the full course. A total of 96 undergraduate dental students participated in this study, including 51 females and 45 males, aged $17 \sim 20$ years, with an average of (18.23 ± 1.02) years. Written informed consent was taken from each participant prior to the start of the study.

In Guanghua School of Stomatology, Sun Yat-sen University, undergraduates have learned the basic principles of dental defect restoration, clinical operation process, problems and treatments after wearing dentures through 22 credit hours of LBL, and practically trained abutments preparation, impression making, temporary crown making and other practical operations through 52 credit hours of practical exercise before clinic.

This SCT class was arranged at the end of the term after all LBL and practical exercise. The aim of the SCT class was to improve the ability of students' restoration decision, to promote the selection of optimal restoration plan and carrying out corresponding tooth preparation process, and to enhance the managements of intraoperative and postoperative problem and communication between dentists and patients. The flow chart of the SCT course was shown in Fig. 1.

Before SCT class

We chose 2 cases of tooth defect restorations for this course. Case 1 was used for evaluating the effect of SCT course, and Case 2 was for classroom teaching of SCT



course. The information and related questions of the 2 cases were shown in supplemental materials.

Before the class, the information of Case 1 and related questions (including diagnosis, feasible treatment plans, selection of restorations and materials, and treatments of postoperative problems, etc.) were provided to students to test the clinical critical thinking ability of students as the baseline of teaching effectiveness assessment (R1). The information of Case 2 was also provided to students for previewing and thinking independently.

In SCT class

Case-based group work

In SCT class, the medical information and images of clinical examination of Case 2 were provided again, with a teacher role playing as patient to simulate clinical scenario. Students gained the details of Case 2 by asking questions. In this process, the teacher only provided case-related information, but did not give any hints for case analysis.

Students were divided into 12 groups of 8 students each and discussed the feasible restoration plans of Case 2 in groups, then selected one plan (full crown, veneer or resin filling) to finish corresponding teeth preparation (if the selection was full crown or veneer) or restoration (if the selection was resin filling) on head model and recorded the pictures of operation process.

Subsequently, the representative of each group gave a report (including the feasible restoration plan, the reason of the choice of restoration plan and materials, the precautions for tooth preparation, the finished tooth preparation and prognosis of the restoration, ect.).

Defense and comments

After the students' report, teachers asked questions about the restoration plans in the presentation, the group members answered. Then, the teacher commented and summarized about the treatment plan, the material selection and teeth preparation. Subsequently, teachers played roles to simulate the occurrence of post-treatment problems and the students dealt with these problems. Then, teachers summarized the post-treatment problem managements and dentist-patient communication.

Teachers recorded and marked the group work (scores of Case 2) of students in operating process, finished teeth preparation, oral presentation and defense, of which the full score was 20 points, 30 points, 35 points and 15 points respectively. The total score of the group work performance was 100 points.

A questionnaire survey of Case 2 was conducted using an online real-time collection APP called "wenjuanxing" (https://www.wjx.cn/) at the end of SCT class. The questions of the questionnaire survey were shown in *supplemental materials.* Teachers can access the data in the background of the APP to gather feedback of SCT course from students as subjective evaluation of teaching effect.

After SCT class

After SCT, students answered the questions of Case 1 again, the scores were marked as R2. The comparison between the R1 and R2 was regarded as objective evaluation of teaching effect.

Data analysis

For assessing the effectiveness of SCT method, chisquare test was applied to compare R1 and R2. The results of questionnaire survey were also showed as bar graph. The difference was considered significant if the p-value was less than 0.05.

Results

Class quality evaluation *Evaluation from teachers*

According to the classroom teaching and group cooperation performance, we scored the operating process, the final work of teeth preparation, oral presentation and question defense as described above.

The total scores of the case-based group work in all groups were more than 70 points, that reflected the high quality of the class and the enthusiasm of students (Fig. 2 A). The scores of the operation process were all more than 14 points, and the scores of teeth preparation were all more than 27 points, that meant students had mastered the skills learned in the previous practical lessons well (Fig. 2 B, C). The scores of oral presentations represented the cooperation ability and the understand of evidence-based medicine of the students, that were all more than 25 points (Fig. 2 D). The scores of defenses inspected the information collection ability of students, which were all more than 9 points (Fig. 2 E).

Evaluation from students

The answers of questionnaire of Case 2 after SCT showed the evaluation from students. The questions in the questionnaire were listed in supplemental materials.

According to the answers of first 4 questions of the questionnaire (Fig. 3), there were 96.97% students evaluated that the contents in this course were well explained. Most students (96.97%) could master the course contents well. Students showed great interest in SCT teaching. More than half students expected to continue the SCT course and believed that SCT course can improve their interest in learning.



Fig. 2 The scores of the group cooperation performance about Case 2 in the SCT class. A The score obtained in the SCT class. B The score of the normalization during the operation process. C The score of the quality of teeth preparation. D The score of the rationality of the treatment plans in oral presentation. E The score of the defense process

Evaluation of teaching effect

Objective evaluation of teaching effect

The effect of SCT course was assessed by the questions of Case 1 answered by students before and after SCT.

Diagnosis of Case 1

The first question was used for testing the accuracy of diagnosis in Case 1. The five diagnosis options and the percentages of students who choose each diagnosis option were shown in Table 1. According to the information of Case 1, the best answer of this question is "ACE". Before SCT, 24.49% of students considered B was one of the diagnoses, while the percentage decreased to 8.16% after SCT. According to the X-ray image of Case 1, the tooth had already completed a thorough root canal treatment (RCT) and the apical inflammation has been eliminated, so the selection of "B" was wrong. No students selected "D: Tetracycline teeth" after SCT, while the percentage of that was 3.06% before SCT (Table 1), although the difference was not statistically significant. The tooth discoloration of Case 1 was attributed to the release of blood degradation products after pulp necrosis. Color of the teeth other than the affected tooth was normal, so the diagnosis of "Tetracycline teeth" was not correct. The percentages of students who chose ACE increased from 14.29% to 28.57% after SCT (Fig. 4).

Treatment plan of Case 1

The second question was to test the comprehensiveness of treatment options. This is an open-answer question. Students were asked to choose the feasible treatment(s). The five treatment plan options and the percentage of students who choose each treatment plan option in question 2 were shown in Table 2. The number of the combinations of answers were 15 and 17 before and after SCT respectively. The percentages of students who chose "AB, ABC, ABCE" decreased after SCT significantly compared with that before SCT, while the percentages of students who chose "ABDE, ADE, BCD" were significantly increased (Fig. 5). What is noteworthy is that no students thought tooth bleaching combined with post-core crown was feasible before SCT, while that percentage increased to 21.43% (ADE: 19.39% + DE: 2.04%) after SCT. The percentage of the students chose D and E significantly increased after SCT, while the percentage of the students chose A and C significantly decreased (Table 2).



Fig. 3 selection distribution of the first 4 questions of the Case2 questionnaire

Table 1 Percentage of students who choose each diagnosisoption

Selection	Before SCT	After SCT	p value
A: Tooth defect	100.00%	100.00%	-
B: Apical periodontitis	24.49%	8.16%	0.002*
C: Discolored tooth	52.04%	100.00%	0.000*
D: Tetracycline teeth	3.06%	0.00%	0.123
E: Internal tooth resorption	38.78%	33.67%	0.276

* The difference was significant

The optimal restoration of Case 1

The third question was used for testing the students' understanding of the indications and prognosis of each restoration method as well as the clinical analysis and decision ability. Students were asked to choose which they thought was/were the best treatment(s). The answer of this question should base on evidence-based medicine and adequate consideration of case information. Due to the insufficient thickness of the remaining labial wall of the affected tooth, the tooth tissue after tooth preparation is not enough to maintain the retention of the filling material. Therefore, it was considered that the use of a fiber post could improve the restoration prognosis. Full crown and resin filling without post might face a higher risk of fracture or loss of prostheses [23]. Limited by thickness, the ability of veneer to mask discolored teeth was not as good as that of full crown and post-core-crown. Bleaching before restoration could improve the aesthetic effect after restoration. The five treatment plan options and the percentage of students who choose each treatment plan option in question 3 were shown in Table 3. Two new answers were given after SCT: post combined with resin filling and teeth bleaching combined with resin filling (Fig. 6). Less students considered the plans of veneer or full crown combined with resin filling were best. Most students preferred post and core crown as the best restoration in this case after SCT (Fig. 6, Table 3). Moreover, more students added tooth bleaching into their treatment plans to improve the aesthetic effect of restoration (Table 3).



Fig. 4 The selection of the diagnosis of Case 1 before and after SCT. **A** Percentage of students who choose each diagnosis option. **B** The combination and distribution of students' answers of diagnoses. (*: p < 0.05; **: p < 0.01)

Table 2	Percentage of	students	who c	hoose	each	treatment
plan opti	ion in questior	ו 2				

	Before SCT	After SCT	p value
A: Resin filling	78.57%	57.14%	0.001*
B: Veneer	51.02%	57.14%	0.237
C: Full crown	83.67%	68.37%	0.009*
D: Post and core crown	39.80%	96.94%	0.000*
E: Tooth bleaching	32.65%	55.10%	0.001*

^{*} The difference was significant

The restoration materials of Case 1

The characteristics of dental materials is the basic knowledge to make clinical decision of restorations. The fourth question was used for testing students' understanding of the characteristics and indications of each material. The results of the selection of restoration materials showed more students mentioned the use of fiber posts after SCT, the percentage of fiber posts increased from 10.20% to 33.67%. Compared with porcelain-fused-metal (PFM), the use of all-ceramic materials in the anterior





Table 3 Percentage of students who choose each treatmentplan option in question 3

	Before SCT	After SCT	<i>p</i> value
Bleaching	8.16%	19.39%	0.018*
Resin filling	1.02%	4.08%	0.184
Veneer	35.71%	17.35%	0.003*
Full crown	47.96%	9.18%	0.000*
Post and core crown	16.33%	70.41%	0.000*

tooth area can achieve a more stable aesthetic effect [24]. Some students chose PFM crown before SCT, while all students preferred all- ceramic crown after SCT (Fig. 7).

Dentist-patient communication of Case 1

Dentist-patient communication should be comprehensive and focused. If the communication is not sufficient, it will affect the choice of repair plan and repair effect, and even lead to doctor-patient conflict. The fifth



Fig. 6 The selection of the optimal restoration of Case 1 before and after SCT. A Percentage of students who choose each treatment plan option in question 3. B The combination and distribution of students' answers of optimal restoration



Fig. 7 The selection of the restoration materials of Case 1 before and after SCT

question was used for assessing the comprehensiveness of dentist-patient communication. Students were asked to list the essential contents in dentist-patient communication. More than 50% students considered the patient preference, cost of the restoration, duration of treatment, visiting frequency, prognosis and restoration effect were essential content in dentist-patient communication. However, the students who mentioned the amount of tooth tissue removal, material selection, types of restoration, cautions after restoration and alternative choices were in the minority. Compared with that before SCT, more students realized the importance of patient preference (Fig. 8).

The complications of Case 1

The sixth question was to test the understanding of the prognosis and complications after restoration. Students were asked to anticipate the complications of this case after restoration. Each option was chosen by more than 50% students before SCT. However, students who chose "Occlusal pain", "Stimulation pain, spontaneous pain" and "Internal tooth resorption" decreased, even fewer than half students chose the latter two after SCT (Fig. 9). Occlusal pain is a complication that may occur in the short term after restoration, usually due to poor occlusal chest and adjustment [25]. The probability of spontaneous pain of the tooth after complete RCT is very small [26]. Internal tooth resorption is a common complication of dental bleaching [27].

Most difficult issues of Case 1

The seventh question was to investigate the difficulties of students in the treatment of Case 1. The results of selection of the difficult issues showed no significant difference before and after SCT. More than 50% students considered the treatment plan, indication, treatment design, dentist-patient communication, clinical operation details and treatment after restoration of Case 1 were difficult. About 40% students felt the treatment process were difficult (Fig. 10).

Subjective evaluation of teaching effect

After SCT, students were asked to choose the difficult issues of Case 2 and the abilities examined and improved of this class, as well as the abilities that were most wanted to be improved after SCT.

For the Case 2 discussed in class, most students considered the material selection and details during operation were difficult. Treatment flow was the least selected option for being a difficult part by students (Fig. 11 A). When students were asked to choose the abilities examined in Case 2, each option was chosen by more than 50% students (Fig. 11 B). Most students (more than 50%) considered the abilities of dentistspatients communication and prognosis prediction, integration ability of clinical information, comprehensive outlook of treatment plans, aesthetic restoration expertise and knowledge of materials were improved. More than 30% students realized their improvement in the consciousness of minimally invasive restoration and



Fig. 8 The answers of essential contents of dentist-patient communication of Case 1 before and after SCT



Fig. 9 The selection of the complications of Case 1 before and after SCT



abilities of operation and bibliographic retrieval (Fig. 11 C). At the same time, most students wanted improve their abilities of dentists-patients communication and prognosis prediction, integration ability of clinical

information, comprehensive outlook of treatment plans. More than 40% students wanted to improve their abilities of aesthetic restoration expertise and knowl-edge of materials (Fig. 11 D).



Fig. 11 The last 4 questions in the questionnaire survey of Case 2 after SCT. A The selection of the difficult parts of Case 2. B The abilities examined in Case 2. C The abilities improved after SCT. D The abilities that were most wanted to be improved after SCT.

Discussion

Dental defect is a common disease in clinic. The restoration process of dental defect includes systematic examination, complete treatment plans making, selection of the restoration plan, preparation before restoration, teeth preparation, impression, and prosthesis production [25]. In the current pre-clinical practice teaching of dental defects restoration, the content only includes theoretical knowledge imparting and tooth preparation and impression training, while students are not sufficiently trained in the acquisition of clinical examination information, the specified process of treatment plan making and the restoration plan selection. The active thinking and analysis are critical in future clinical work for students, so it is necessary to train the clinical thinking ability in dental defect restoration before clinical practice [15].

We arranged this SCT course after the completion of all theoretical courses and practical operation courses of dental defect restoration. At this time, students mastered sufficient knowledge to analyze simple restoration cases. The clinical treatment process and prognosis evaluation of dental defect restoration focused on the case-based problem and provide treatment plan with evidence-based medicine. However, the current theoretical teaching and experimental teaching lack the training of students' thinking of evidence-based medicine. As a result, although students have mastered theoretical knowledge and basic operating techniques, they are extremely lacking in the ability to handle clinical cases before clinical practice. In order to obtain the transition between theory and clinical practice, we choose the situational case teaching method to improve the pre-clinical critical thinking ability of students.

Similar to PBL, CBL and TBL teaching methods, simulation-based case teaching is also based on real cases, providing students with the opportunity to actively explore and think [20]. In addition, the problems of SCT are systematic and coherent, the cases and the environment of SCT are situational, so that students will have a stronger sense of involvement [28]. SCT takes learners as the center and the subjects of cognition and creates learning environment conforming to the constructivism teaching design concept [29]. This method pays attention to the cooperation, communication and meaning construction of students.

We provided two cases for students, Case 2 is for SCT class, and Case 1 is to evaluate the effect of SCT class by comparing the different selection before and after SCT. Both the evaluations of class quality from teachers and students showed the good classroom teaching quality and student participation. From the results, we could see the improvement of students' accuracy and certainty of diagnosis. The decrease of the selection of "B: Apical periodontitis" showed their improvement in interpretation of imaging information. The increase selection of "Post and core crown" and the decrease selection of "Full crown" and "Veneer" indicated that more students considered the tooth tissue thickness of labial wall in the case information [30]. This point was associate with the prognostic prediction that need the support of evidencebased medicine. In addition, students who selected "resin filling" also mentioned the use of fiber post after RCT. This answer reflected their understanding of minimally invasive restoration and divergent thinking of restoration after RCT [31]. It should be delighted that students think comprehensively in the doctor-patient communication. However, the explanation of different restoration plans and their advantages and disadvantages still should be emphasized. The selection of complications showed that students distinguished between complications and postrestoration problems better after SCT.

The selections of the difficult issues of Case 1 before and after SCT showed no significant differentiation. Combined with the results of the questionnaire of Case 2, the treatment flow was not a difficulty issue in the opinion of most students. Most students chose the treatment decision making, details in the operation of aesthetic restoration and dentists-patients communication as the difficulty issues. Obviously, these difficulty issues were closely related to the clinical experience. These results suggested that we should integrate more imparting of experience related to clinical decision-making and medical humanities in the future preclinical teaching work. At the same time, more guidance should be given to students in extracurricular reading.

According to the answers of the questionnaire survey of Case 2, the knowledge points examined in this SCT course are comprehensive. Most students agreed that they had improved in the treatment decision making, aesthetic restoration and dentists-patients communication. Therefore, both objectively and subjectively, this SCT course has achieved a better teaching effect. Moreover, the students recognized their shortcomings in clinical critical thinking and knowledge development, that might contribute positively to their independent learning in the future [21].

Although the evaluation of teaching effect showed delighted results, there are still some improvements to be made in SCT classroom. On one hand, the highlight of SCT is that the teaching scenario is more similar to the actual clinical medical scenario. That put forward higher requirements for the preparation of lessons and teaching supplies before class. In addition to better preparation of teachers and students before class, some virtual simulation techniques may be applied into SCT courses to improve the scenario simulation. On the other hand, as the teaching contents and the teaching processes were complex, time control was the key and difficult point in the teaching process. The necessary time optimization of the course can further improve the teaching efficiency. In general, SCT can significantly improve students' clinical critical thinking ability and is expected to become an important part of pre-clinical practice teaching.

Limitations

We chose two cases that are characteristic and meaningful for discussion, one for case analysis and clinical thinking training, the other for teaching effect evaluation. However, the clinical manifestations and classification of dental defect repair cases are varied. More cases of dental defects should be included in the future teaching curriculum, to further strengthen students' clinical case analysis ability. Sample size is crucial to the reliability of research. A small sample size may lead to poor generalization ability of medical technology research results with high variability and low statistical power. An appropriate or large sample size is helpful to improve the accuracy, statistical power and representativeness of the results. This study was a self-controlled before and after trial with a simple size of 96. Without sample size calculation, the reliability of this study was diminished. Although this study has achieved positive teaching effect, it is only conducted in one dental school at present, further promotion and indepth research still needs. Moreover, time optimization when doing case simulation with students are important for the future applications of SCT.

Conclusions

SCT course was a successful attempt in the preclinical teaching of prosthodontics in Sun Yat-sen University. We obtained comprehensive and objective teaching feedback through teaching assessment and questionnaire survey of students. The results suggested that SCT course had obvious effect on training students' clinical thinking ability. We should integrate more imparting of experience related to clinical decision-making and medical humanities in the future preclinical teaching work.

Abbreviations

- CBL Case-based learning
- LBL Lecture-based learning
- PBL Problem-based learning
- PFM Porcelain fused metal
- RCT Root canal treatment
- SBT Simulation-based teaching
- SCT Simulation-based case teaching
- TBL Team-based learning

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions

Xiaoshi Jia performed data analysis and wrote the manuscript, Xiaoshi Jia, Jiawen Guo, Maodan Wu, Xiaodong Wang, Le Fan and Yichen Yao completed the SCT course teaching together. Xiaoyi Deng collected the images and information, Ling Yang provided the cases in SCT and reviewed the manuscript. All authors have read and approved the final manuscript.

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Data availability

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

Declarations

Ethics approval and consent to participate

This study was received ethical approval from the Medical Ethics Committee of Hospital of Stomatology Sun Yat-sen University, the ethical review comments number was KQEC-2024–08-01.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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