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Application Research of Head-mounted Magnifying Lenses Combined with Digital Result Evaluation System in the Preparation Training of All-Ceramic Crowns for the First Molar of the Left Lower Jaw

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Abstract

Objective: To explore the effect of head-mounted magnifiers combined with a digital result evaluation system in the teaching of all-ceramic crown preparation training for the left mandibular first molar among undergraduate students majoring in stomatology.

Methods: Forty fourth-year undergraduates majoring in stomatology were selected and randomly divided into Group A and Group B. They performed two rounds of tooth preparation for full ceramic crowns on the mandibular left first molar using the CLINSIM dental simulation system. After each round of preparation, the results were evaluated with the Nissin FAIR GRADER 2000 system before the next round of preparation was conducted.Group A first completed tooth preparation for a full crown on the maxillary right central incisor under unaided vision, followed by another round of tooth preparation using a head-mounted magnifier. In contrast, Group B first finished tooth preparation for a full ceramic crown on the maxillary right central incisor with a head-mounted magnifier, and then performed tooth preparation under unaided vision.

The quality of tooth preparation was scored, and the differences between the two groups were compared. In addition, a questionnaire survey was conducted to analyze and evaluate the students' experience of using the head-mounted magnifiers. The Nissin FAIR GRADER 2000 system was adopted to score the tooth preparation outcomes. Independent samples t-test was used to compare the total scores and detailed deduction items between Group A and Group B. Meanwhile, a questionnaire survey was carried out to assess the students' experience with the head-mounted magnifiers.

Results: In the tooth preparation for full ceramic crowns on the mandibular left first molar performed by undergraduate stomatology students, the deduction scores for the shoulder margin item when using a head-mounted magnifier were lower than those under unaided vision, while the deduction scores for the convergence degree item were higher. However, none of these differences were statistically significant.The results of the questionnaire survey showed that the use of a head-mounted magnifier improved visual field clarity and yielded better tooth preparation outcomes, yet it compromised operational fluency compared with the unaided-vision operation.

Conclusion: The application of head-mounted magnifiers in auxiliary teaching can effectively improve the quality of all-ceramic crown preparation for the left mandibular first molar among stomatology students.

Introduction

Tooth defects are a very common condition in the field of dentistry, with a high incidence rate in clinical diagnosis and treatment. When the degree of tooth defect is severe and cannot be repaired through simple methods such as filling, a restoration that can completely cover the surface of the tooth crown, namely a full crown, is often required to repair the affected tooth and restore its normal shape and function. Tooth preparation remains a crucial aspect in the restoration process, and this process still depends on the operator. Correct and uniform tooth preparation, including clear marginal morphology,

the amount of axial and occlusal surface preparation, and axial convergence degree, are essential initial conditions for ensuring the good restoration of all-ceramic crowns.

At present, there are relatively few studies evaluating the quality of tooth preparation using digital assessment methods. Some research shows that digital assessment software can effectively evaluate the cone angle and undercut problems of tooth preparation [1]; another study indicates that digital assessment can significantly improve the consistency within and between assessors in the simulation laboratory assessment [2]. However, some studies have shown that digital assessment technology has no significant impact on students' oral restoration technical ability and self-assessment ability [3]. The FAIR GRADER 2000 dental digital virtual teaching assessment system (hereinafter referred to as the FAIR GRADER 2000 system) developed by Japan's Nihen Co., Ltd. is a digital tool focused on teaching result assessment. It scans the prepared tooth and conducts analysis with the accompanying software to accurately evaluate the operator's tooth preparation quantity and surface smoothness.

Research on magnifying glasses is also relatively limited. Multiple studies support the use of magnifying glasses, believing that they can help improve operational accessibility and vision [4], increase operational efficiency [5], and improve the operator's posture, thereby reducing neck and back strain or pain [6, 7]; in addition, for dentists with decreased vision due to age or other issues, magnifying glasses can also be of some help [8-10]. From an educational perspective, a study found that using real-time magnification technology for teaching can help undergraduate students better understand the concept of cone angle and improve their critical assessment ability of tooth preparation quality [11]. However, in actual clinical practice, most dentists do not routinely use magnifying glasses due to factors such as comfort, weight, and cost [12, 13]. Although many literatures have mentioned the advantages of magnification equipment in dental applications, there is currently insufficient scientific evidence to clearly confirm whether magnifying glasses can improve the quality of tooth preparation [14]. To prove its positive impact on the restoration operation, more targeted research is needed. Based on this research status, this study compares the actual application effects of naked eyes and using a 2.5x magnifying glass in the tooth preparation teaching scenario of the left lower first molar using the FAIR GRADER 2000 system, aiming to provide reference for the experimental course teaching and clinical teaching of optimizing tooth preparation operation techniques.

Materials and Methods

1.1 Test Subjects, Inclusion Criteria

Forty fifth-year clinical dental undergraduate students (in the first semester of the fourth year of university). FAIR GRADER 2000 system (Nihen, Japan), 80 resin teeth of the left lower first molar (Nihen, Japan), and 40 standard dental models (Nihen, Japan).

Inclusion criteria: (1) All students have received theoretical lessons on the anatomy of the left lower first molar and completed the learning of tooth carving in the experimental operation project; (2) All students have received theoretical lessons on the preparation of all-ceramic crowns for the left lower first molar in

oral restoration. (3) All students have mastered the operation methods of the CLINSIM head simulation model (from Sensory, Japan). No human participants, human tissues, or animals were recruited or involved in the research. Therefore, a Consent to Participate declaration is not applicable to this study.

1.2 Experimental Grouping and Procedure

Forty students were randomly divided into Group A and Group B, with 20 students in each group. All 40 students simultaneously reviewed the theoretical knowledge of tooth preparation and were demonstrated by an oral restoration teacher the method of full-ceramic crown tooth preparation for the lower first molar and the result evaluation method of the FAIR GRADER 2000 system. Before using the magnifying glass, the teaching assistant trained the students on the usage of the magnifying glass, including how to adjust the interpupillary distance and focal length (Figure 1A). After the demonstration, the 240 resin teeth were randomly numbered and evenly distributed to the 40 students.

To reduce the impact of the number of tooth preparations and the accumulation of experience on the results, the 20 students in Group A first performed tooth preparation without the magnifying glass and then under the magnifying glass; the 20 students in Group B first completed the tooth preparation under the magnifying glass and then without the magnifying glass (Figure 1B, C). The number of tooth preparations without the magnifying glass and with the head-mounted magnifying glass was 40 each, totaling 80 teeth. After tooth preparation, the teacher used the FAIR GRADER 2000 system to score the results. After the scoring, students could view the scoring results to understand their scores and the points of loss.

A dedicated questionnaire was developed specifically for this study to evaluate the application effect of the head-mounted magnifying glass combined with the Fair Grader 2000 system in the training and teaching of full-ceramic crown tooth preparation for the lower first molar.The full version is available as Supplementary Material.

1.3 Statistical Analysis

The data were analyzed statistically using SPSS 18.0 software. The t-test was used to compare the differences in the overall scores and the deductions of different items between Group A and Group B after tooth preparation,the significance level $\alpha = 0.05$. The FAIR GRADER 2000 system was used to conduct a comprehensive scan and scoring of the resin teeth prepared by the students.The changes in the two preparations of Group A and Group B were compared, and the changes in the deductions of the four detailed items (cutting volume, shoulder, convergence degree (i.e., axial surface convergence degree), and volume ratio (i.e., the ratio of the measured prepared body to the standard prepared body of the system)) were compared on the basis of the assessment of the changes in the overall score.

Results

2.1 Comprehensive score

Based on the data standards of the full-ceramic crown tooth preparation of the left mandibular first molar entered into the FAIR GRADER 2000 system, the overall score was obtained through a comprehensive assessment of cutting volume, shoulder, convergence degree, and volume ratio, etc., for the reference of teachers and students (Figure 2). With the increase in the number of preparation sessions (Figure 3), the overall scores of both groups gradually increased. At the first training session, there was no significant difference in the score between group A and group B ($P > 0.05$); at the second training session, the score of group A was higher than that of group B, but the difference was not statistically significant ($P > 0.05$).

Figure 2 Comprehensive scoring interface of FAIR GRADER 2000 system

Figure 3 Comprehensive scoring of Group A and Group B

2.2 Cutting volume deduction: The cutting volume deduction for both Group A and Group B showed a significant downward trend during the training process (Figure 4A), and the difference was not statistically significant ($P > 0.05$).

2.3 Shoulder platform deduction: The shoulder platform deduction for both groups decreased gradually with the increase in training sessions (Figure 4B). In the first training session, the shoulder platform deduction of Group A (with magnifying glass) was lower than that of Group B (without magnifying glass), but the difference was not statistically significant ($P > 0.05$); in the second training session, the shoulder platform deduction of Group A (without magnifying glass) was higher than that of Group B (with magnifying glass), but the difference was not statistically significant ($P > 0.05$).

2.4 Convergence degree deduction: The convergence degree deduction for both groups decreased gradually with the increase in training sessions (Figure 4C). In the first training session, the shoulder platform deduction of Group A (with magnifying glass) was higher than that of Group B (without magnifying glass), but the difference was not statistically significant ($P > 0.05$); in the second training session, the shoulder platform deduction of Group A (without magnifying glass) was lower than that of Group B (with magnifying glass), but the difference was not statistically significant ($P > 0.05$).

2.5 Volume ratio deduction: The volume ratio deduction for both groups decreased gradually (Figure 4D). In the first training session, the shoulder platform deduction of Group A (with magnifying glass) was slightly lower than that of Group B (without magnifying glass), but the difference was not statistically significant ($P > 0.05$); in the second training session, the shoulder platform deduction of Group A (without magnifying glass) was lower than that of Group B (with magnifying glass), but the difference was not statistically significant ($P > 0.05$).

Figure 4 Comparison of deduction items between Group A and Group B

2.6 Questionnaire Scores

The results of the questionnaire survey on the usage experience of bare-eye tooth preparation and using a head-mounted magnifying glass for tooth preparation (Table 1) showed that in terms of visual clarity, using the head-mounted magnifying glass was considered superior to bare eyesight, while in terms of operational smoothness, using the head-mounted magnifying glass was considered inferior to bare eyesight.

Table 1 Results of the questionnaire survey on the usage experience of trainees for bare-eye tooth preparation and using a head-mounted magnifying glass for tooth preparation (%)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Evaluation of Operational Precision and Quality					
Using Head-mounted Magnifying Lenses helps me distinguish the fine structures of tissues (e.g., dental margins) more clearly.	8(20.0%)	24(60.0%)	8(20%)	0(0)	0(0)
UsingHead-mounted Magnifying Lenses has improved the precision of my operations.	3(7.5%)	24(60%)	11(27.5%)	2(5.0%)	0(0)
Using Head-mounted Magnifying Lenses helps reduce procedural errors, which may consequently improve patients' treatment outcomes.	4(10.0%)	22(55.0%)	14(35.0%)	0(0)	0(0)
Using Head-mounted Magnifying Lenses for tooth preparation is more conducive to improving my proficiency in dental preparation.	5(12.5%)	18(45.0%)	15(37.5%)	2(5.0%)	0(0)
Using Head-mounted Magnifying Lenses for tooth preparation can deepen my understanding and retention of theoretical knowledge.	5(12.5%)	18(45.0%)	13(32.5%)	4(10.0%)	0(0)
Evaluation of Work Efficiency and Learning Curve					
When I first used Head-mounted Magnifying Lenses, I experienced a sense of discomfort, and my operational speed slowed down significantly.	8(20.0%)	22(55.0%)	9(22.5%)	1(2.5%)	0(0)
After proficient use, Head-mounted Magnifying Lenses can help me improve work efficiency and reduce the time spent on tooth preparation.	2(5.0%)	21(52.5%)	17(42.5%)	0(0)	0(0)
I need to invest a considerable amount of time in adapting to and mastering the use of Head-mounted Magnifying Lenses for tooth preparation.	6(15.0%)	18(45.0%)	15(37.5%)	0(0)	0(0)
Evaluation of Ergonomics and Occupational Health					
Head-mounted Magnifying Lenses improve my operating posture and reduce bending and head lowering.	3(7.5%)	20(50.0%)	16(40.0%)	1(2.5%)	0(0)
After using Head-mounted Magnifying Lenses, the fatigue or soreness in my neck and shoulders has been relieved to some extent.	1(2.5%)	19(47.5%)	16(40.0%)	4(10.0%)	0(0)
Prolonged use of Head-mounted Magnifying Lenses may cause occasional visual fatigue, dizziness or nausea for me.	6(15.0%)	19(47.5%)	8(20.0%)	6(15.0%)	0(0)
Evaluation of Subjective Experience and Overall Performance					
Using Head-mounted Magnifying Lenses has boosted my confidence in clinical procedures.	1(2.5%)	18(45.0%)	18(45.0%)	3(7.5%)	0(0)
Using Head-mounted Magnifying Lenses for tooth preparation has boosted my interest in learning.	1(2.5%)	24(60.0%)	12(30.0%)	3(7.5%)	0(0)
Compared with tooth preparation under direct vision, I prefer to perform tooth preparation with Head-mounted Magnifying Lenses.	2(5.0%)	16(40.0%)	13(32.5%)	9(22.5%)	0(0)
Tooth preparation with Head-mounted Magnifying Lenses can replace the conventional tooth preparation method.	2(5.0%)	10(25.0%)	17(42.5%)	11(27.5%)	0(0)
It is necessary to train dental students in tooth preparation with Head-mounted Magnifying Lenses.	8(20.0%)	23(57.5%)	9(22.5%)	0(0)	0(0)
It is hoped that Head-mounted Magnifying Lenses can be applied to other tooth preparation procedures.	7(17.5%)	23(57.5%)	9(22.5%)	1(2.5%)	0(0)
Before undergoing training in tooth preparation with Head-mounted Magnifying Lenses, I had certain expectations for this training method.	9(22.5%)	22(55.0%)	9(22.5%)	0(0)	0(0)
After undergoing training in tooth preparation with Head-mounted Magnifying Lenses, this training method has met my expectations.	4(10.0%)	15(37.5%)	19(47.5%)	2(5.0%)	0(0)
I believe that the use of Head-mounted Magnifying Lenses represents the developmental trend for refined tooth preparation procedures in the future.	9(22.5%)	24(60.0%)	7(17.5%)	0(0)	0(0)

Discussion

At present, the relevant evidence regarding the application of magnifying glasses in the preparation of full crown teeth is very limited. As far as we know, this study is the first to use a digital quantitative

method to evaluate the effects of using a magnifying glass (2.5 times) and not using a magnifying glass in combination with the FAIR GRADER 2000 system for the tooth preparation of the left lower first molar.

This study selected the mandibular left lower first molar as the prepared tooth, as this tooth position allows the subjects to obtain a direct view and the operating space is easier to control, thereby minimizing the additional interference caused by non-research variables to the greatest extent. This tooth position selection has also been supported by other scholars, who used a similar tooth position in their research targeting preclinical undergraduate students. From an ergonomic perspective, this tooth preparation operation can also demonstrate the advantages of using a magnifying glass in improving the posture and position of the operator.

From the perspective of the scoring items, the main scoring errors of both groups of students were in the insufficient control of the tooth cutting volume. However, with the prompt of the FAIR GRADER 2000 system evaluation results, both groups of students were able to promptly adjust their problems, resulting in a significant decrease in the deduction scores. In the preparation of the shoulder, the scores of magnifying glass preparation (Group A first time, Group B second time) were lower than those of bare eye preparation, because when using the head-mounted magnifying glass, the control of details was better than the control group. The magnifying glass provided an enlarged view and clear detail presentation, helping the operator precisely control the key indicators of the tooth preparation, thereby significantly improving the quality of tooth preparation. However, in terms of the degree of polymerization, the scores of magnifying glass preparation (Group A first time, Group B second time) were higher than those of bare eye preparation, because the control of the degree of polymerization of the abutment teeth after the restoration preparation requires a higher spatial sense, and the magnifying glass preparation due to the limitation of the field of view is prone to causing people to overlook the overall shape, resulting in inconsistent axial surface grinding. This lower scoring problem is not due to the defect of the tool itself, but due to the insufficient adaptability of the operator to the tool and the unmet operational skills. In terms of cutting volume and volume ratio, the deduction scores of Group A students were lower than those of Group B. However, with the assistance of the FAIR GRADER 2000 system, the deduction scores of both groups of students were reduced. It suggests that the FAIR GRADER 2000 system can help students analyze the advantages and disadvantages in the preparation process, accelerate the mastery of quantity and shape, and achieve the goal of precise tooth preparation as much as possible. At the same time, using the head-mounted magnifying glass for preparation in the shoulder area is superior to bare eye preparation, and the progress is faster, while in terms of the degree of polymerization, it is lower than bare eye preparation. There is no significant difference in cutting volume and volume ratio.

From the specific survey questionnaire results, in terms of operation accuracy and quality assessment, most students indicated that with the assistance of the magnification equipment, they could more clearly distinguish the fine structures of the tissues, improve the accuracy of operation, help reduce operational errors, improve the level of tooth preparation, and deepen the understanding and memory of theoretical knowledge. However, a small number of students disagreed, and the reason might be that the

short-term practical operation, some trainees did not fully master the adjustment of the magnifying glass equipment, resulting in a different usage experience.

In terms of work efficiency and learning curve, most students indicated that they were not accustomed to using the head-mounted magnifying glass for the first time, and the operation speed was significantly slower. After becoming proficient, the head-mounted magnifying glass can help improve work efficiency. Therefore, it requires a considerable amount of time to adapt and become proficient in using the head-mounted magnifying glass for tooth preparation. Some students reported that using a magnifying glass was more time-consuming for operation. This might be due to the need to manually adjust the model during the tooth preparation training, and the lack of assistant cooperation, resulting in frequent switching between naked-eye and magnified views by the operator, leading to a less smooth process and a longer overall time consumption. Moreover, it was difficult to accurately grasp the actual spatial distance under the magnifying glass, and the operating field was limited, making it easy to exceed the field of vision when the operation amplitude was large. In the early stage of use, some students might even experience mild visual disorders, temporary blurriness, etc. [15]. This requires a certain adaptation process. Especially in the tooth preparation process on the lingual side, the challenge for beginners might be greater when the operator needs to prepare the teeth through the oral mirror view. It is suggested that in actual patient oral operations, it is very necessary to practice the head-mounted magnifying equipment on the model in advance, which can improve work efficiency and fluency.

In terms of ergonomics and occupational health, most trainees indicated that using a head-mounted magnifying glass improved the operation posture, reduced the need to bend over and look down, and alleviated the fatigue or pain in the neck and shoulders. However, long-term use of the head-mounted magnifying glass can cause visual fatigue, dizziness or nausea. The 2.5x magnifying glass used in this study does not have personalized lenses to adjust the operator's naked-eye vision differences. Magnifying equipment with adjustable naked-eye vision might have better clinical application effects.

In terms of subjective experience, most trainees indicated that using a magnifying glass for tooth preparation enhanced their learning interest and operational confidence, and they were more inclined to use the head-mounted magnifying glass for tooth preparation. They believed that tooth preparation under the magnifying glass was the development trend of future precise tooth preparation operations and hoped to promote it to more tooth preparation operations. However, they did not support its replacement of traditional naked-eye tooth preparation. It is worth noting that most students had expectations for tooth preparation under the magnifying glass before the operation, but after the operation, nearly half of the students believed that tooth preparation under the magnifying glass did not fully meet these expectations. Based on the subjects of this study, all of whom were beginners and had not yet mastered the use skills of the magnifying glass, and considering the complexity of the magnifying glass operation skills and the higher requirements for the operator's adaptability, this situation may have a negative impact on the final expectations of the subjects.

In conclusion, the head-mounted magnifying glass combined with the FAIR GRADER 2000 system can assist teachers in improving the quality of tooth preparation teaching, enhance the overall quality of tooth preparation for students, and help students improve their self-assessment ability during practice.

Declarations

Ethics approval

This study included in vitro experiments using commercially available resin teeth and anonymous questionnaire surveys. The in vitro experiments did not involve human participants, human tissues, or clinical data, and thus required no ethical approval.

For the questionnaire survey, all procedures were conducted in accordance with the Declaration of Helsinki. The questionnaire was anonymous with no personal identifying information and no potential risks to participants. Ethical approval was waived by the Ethics Committee of Affiliated Hospital of Jiangnan University. Informed consent was obtained from all participants before they completed the questionnaire.

Consent to participate

The vitro experiments using commercially available resin teeth was conducted using standard resin tooth models. No human participants, human tissues, or animals were recruited or involved in the first part. Therefore, a Consent to Participate declaration is not applicable to this part.Informed consent was obtained from all participants prior to the questionnaire survey.

Consent for publication

All authors declare that we agree to the publication of the research findings presented in this manuscript entitled "Application Research of Head-mounted Magnifying Lenses Combined with Digital Result Evaluation System in the Preparation Training of All-Ceramic Crowns for the First Molar of the Left Lower Jaw" in the BMC Oral Health BMC. Linwei Peng(First Author):Conceptualization, Methodology, Formal Analysis, Writing - Original Draft;Jingjing Huang、Zhuyu Han、Liupin Yu: Data Curation, Writing - Original Draft;Jinlin Zhang: Visualization、Writing - Review & Editing、Peixiang Zhu、Fangyong Zhu、Yufeng Gao(Corresponding Author): Conceptualization, Funding Acquisition, Resources, Supervision, Writing - Review & Editing.

Data Availability.

Not applicable

Competing interests

l declare that the authors have no competing interests as defined by BMC, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

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Not applicable

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Figures



Figure 1

Experimental preparation：A: Schematic diagram of head-mounted magnifier; B: Tooth preparation with naked eyes; C: Tooth preparation under magnifier；

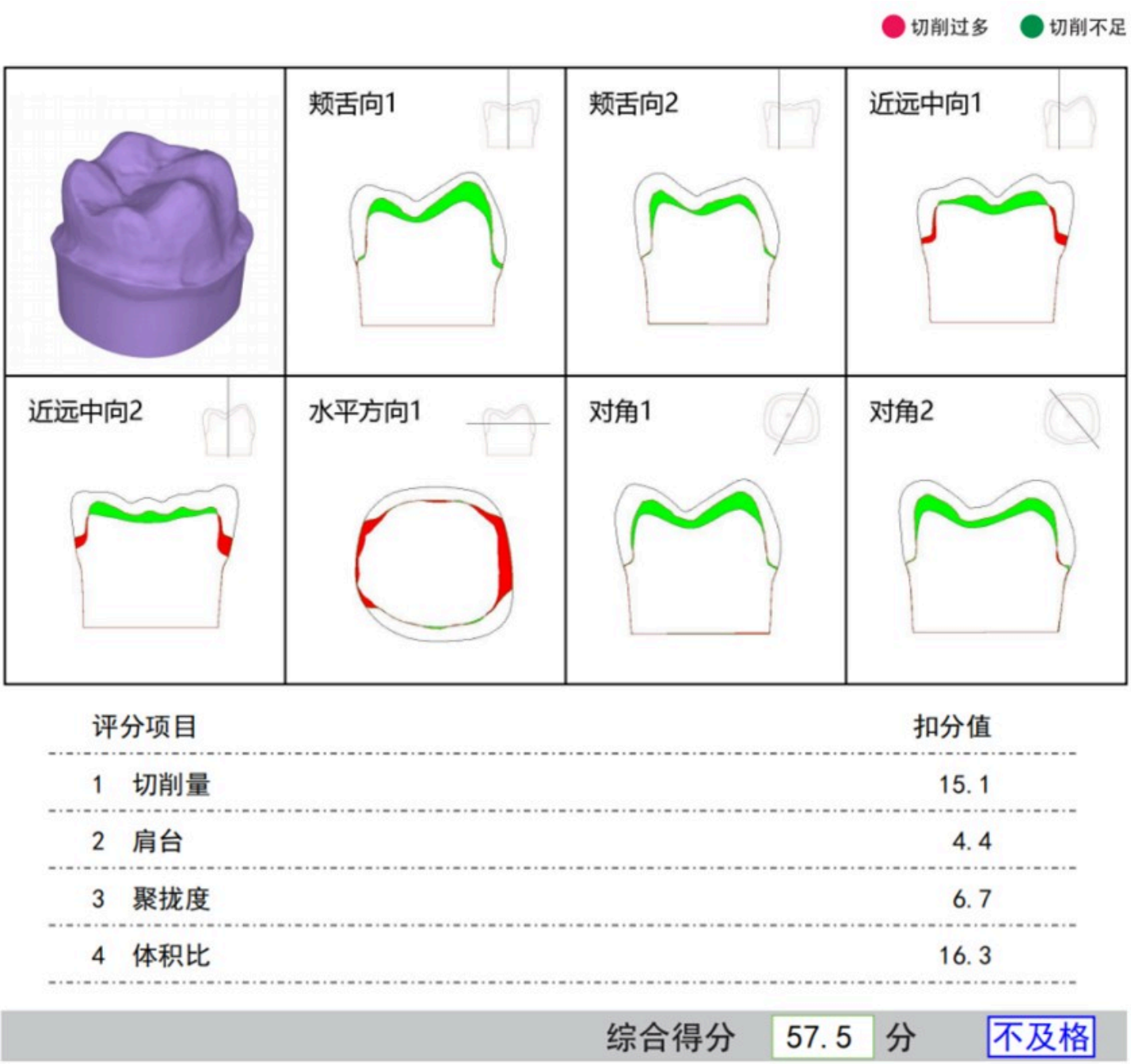


Figure 2

Comprehensive scoring interface of FAIR GRADER 2000 system

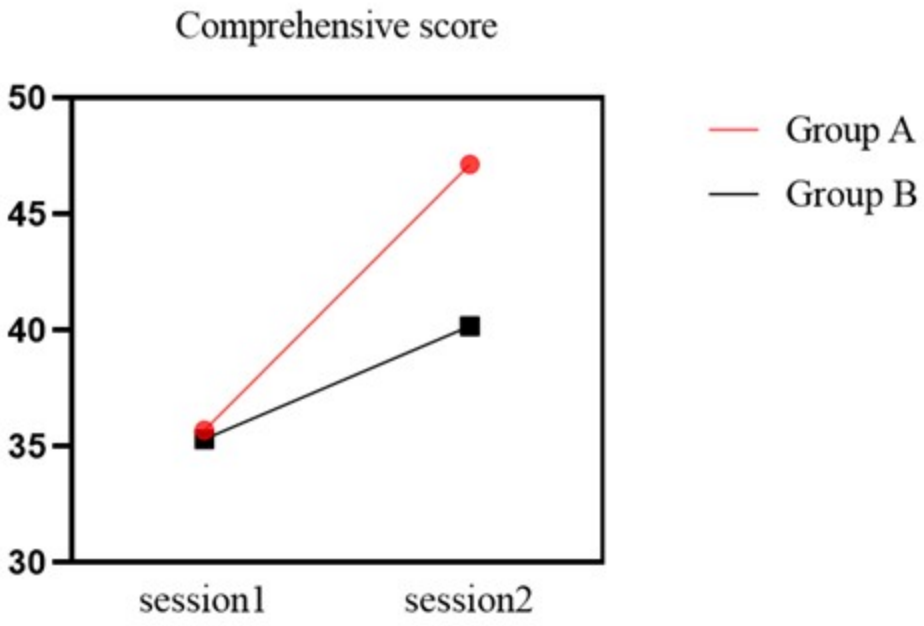


Figure 3

Comprehensive scoring of Group A and Group B

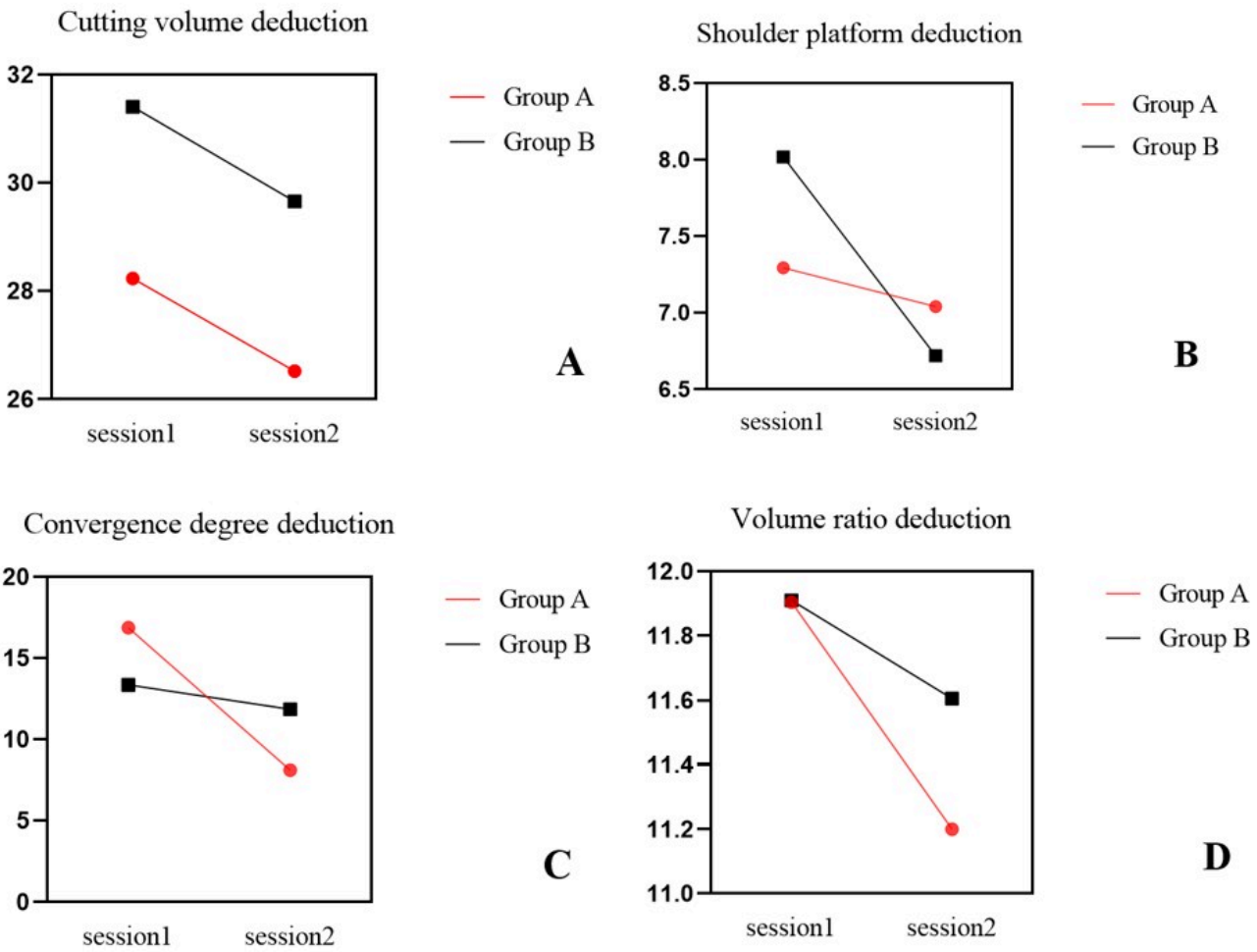


Figure 4

Comparison of deduction items between Group A and Group B

Supplementary Files

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