

REVIEW ARTICLE

The impact of magnification on undergraduate dental students' performance during cavity preparations: A systematic review

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Abstract

Purpose/Objectives: Loupe magnification is a commonly utilized tool within dental education due to its proposed benefits of improving working posture, visual acuity, and procedural quality. Although procedural quality has been researched at the graduate level, literature encompassing the undergraduate level remains scarce. Therefore, this systematic review aims to critically assess the available literature to ascertain the effects of loupe magnification on the performance of undergraduate dental students' cavity preparations.

Materials and Methods: A systematic search was conducted across electronic databases, including PubMed, MEDLINE via Ovid, The Cochrane Library for Cochrane Reviews, and Scopus, to identify relevant studies published from inception to February 15, 2023. We included English language studies that evaluated the effect of loupe magnification on the performance of undergraduate dental students in cavity preparations.

Results: In total, six studies fulfilled the inclusion criteria. The outcomes assessed encompassed tooth preparation accuracy. Of these six articles, one was conducted on endodontic access cavity preparations, four on restorative cavity preparations, and one on nonstandard cavity preparation designs performed on acrylic blocs. Four articles determined that loupes positively impacted undergraduate students' performance in cavity preparations, while two articles established no significant difference in performance between loupes and naked-eye cavity preparations.

Conclusion: This systematic review suggests that loupe magnification positively impacts undergraduate dental students' performance in cavity preparations.

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However, the heterogeneity of the studies and the variations in methodologies limit the ability to draw definitive conclusions.

KEYWORDS

loupes, magnification, systematic review, tooth preparation, undergraduate

1 | INTRODUCTION

Loupes are magnification devices mounted onto glasses that aim to improve visual acuity, operator ergonomics, and procedural quality.^{1–4} Carr and Murgel⁵ investigated human vision's importance and its application in clinical dentistry. The authors proposed that the unaided eye cannot discriminate fine details at a distance lesser than 0.2 mm. However, with the aid of magnification, such details can be visualized more easily.⁵

In the field of dentistry, the ability to perform accurate tooth preparations is of paramount importance for successful restorative procedures. Thus, the incorporation of loupe magnification in dental education has garnered attention due to its potential to augment students' ability to visualize morphological nuances, ultimately leading to improved preparations of various kinds.⁶

Various designs have been introduced with differences in magnification amount (ranging from 2× to above 6×) and magnification form (Galilean or Keplerian).⁶ Loupes have been shown to enhance the performance of graduate dental practitioners within the clinical setting.⁷ However, there is no consensus regarding whether this conclusion can be drawn at the undergraduate level.^{1,8} A recent qualitative study⁹ conducted at King Abdulaziz University identified that 82% of students were aware of the proposed benefits of loupes magnification, yet only 22% of all responders incorporated loupes into their clinical practice. Despite its supposed benefits, the study raised concerns about the underutilization of loupes in dental education. In addition, other authors have also shown that magnification loupes do not appear to significantly improve the quality of tooth preparation for complete coverage crowns or influence the visual acuity and operator distance on the undergraduate level.^{10,11}

Currently, no systematic reviews explore the impact of loupe magnification on undergraduate dental students' performance in cavity preparations. Within the limited nonreview studies in this field, there is conflicting evidence as to whether the proposed benefits are significant.^{1,8} Therefore, this systematic review aims to synthesize the available literature to assess the impact

of loupes magnification on students' performance during tooth preparations.

2 | MATERIALS AND METHODS

The reporting of this review complies with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement guidelines.¹² The study was registered in PROSPERO (REF: CRD42023408866).

2.1 | Literature search strategy

Two independent reviewers (AR and JH) conducted a search in the following electronic databases: PubMed, MEDLINE via Ovid, The Cochrane Library for Cochrane Reviews, and Scopus. Articles published up to February 15, 2023 from inception were considered. No other filters were placed during database searches. Various Medical Subject Headings (MeSH) terms were used to retrieve the articles (Table 1).

Two reviewers (AR and JH) independently commenced the identification of relevant articles using the predetermined search strategy, and citations of relevant articles were exported into a reference management software (EndNote 20). Once duplicates were removed, the reviewers (AR and JH) proceeded with the screening phase, where they evaluated the titles and abstracts of the remaining studies to identify those that potentially satisfied the inclusion criteria. Disagreement between reviewers was resolved through discussion. A third reviewer (JMMN) was consulted if consensus was not reached.

Two researchers (AG and HP) utilized preconstructed forms to independently extract data from the selected studies. The extracted information covered study design, matched variables, participants (including undergraduate dental students, undergraduate oral health therapy students, and undergraduate dental hygiene students), loupe type, loupe magnification amount, and tooth preparation type. In cases where crucial data were absent in the retrieved articles, efforts were made to contact the authors for additional information.

TABLE 1 Databases search and MeSH terms used.

Database	MeSH terms and search strategy
PubMed	(magnific* OR loupe OR "dental operating microscope*") AND (prepar* OR drill OR fill* OR restor* OR acuity OR skill OR train* OR work) AND (student OR undergraduate OR predoctoral OR train* OR teach*) AND (dent* OR endodont*)
MEDLINE via Ovid	<ol style="list-style-type: none"> 1. magnific*.mp. 2. loupe.mp. 3. dental operating microscope.mp. 4. prepar*.mp. 5. drill.mp. 6. fill*.mp. 7. restor*.mp. 8. acuity*.mp. 9. skill*.mp. 10. train*.mp. 11. work.mp. 12. student.mp. 13. undergraduate.mp. 14. predoctoral.mp. 15. train*.mp. 16. teach*.mp. 17. dent*.mp. 18. endodont*.mp. 19. 1 or 2 or 3 20. 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 21. 12 or 13 or 14 or 15 or 16 22. 17 or 18 23. 19 and 20 and 21 and 22
Cochrane Library	(magnific* OR loupe OR "dental operating microscope*") AND (prepar* OR drill OR fill* OR restor* OR acuity OR skill OR train* OR work) AND (student OR undergraduate OR predoctoral OR train* OR teach*) AND (dent* OR endodont*)
Scopus	(magnific* OR loupe OR "dental operating microscope*") AND TITLE-ABS-KEY (prepar* OR drill OR fill* OR restor* OR acuity OR skill OR train* OR work) AND TITLE-ABS-KEY (student OR undergraduate OR predoctoral OR train* OR teach*) AND TITLE-ABS-KEY (dent* OR endodont*)

2.2 | Focus question

In accordance with the population, intervention, control, and outcomes (PICO) framework, a straightforward question was devised, "How does the use of magnification influence performance in dental procedures undertaken by undergraduate students compared to students without magnification?"

- Population: undergraduate dental students, undergraduate oral health therapy students, undergraduate dental hygiene students.
- Intervention: Use of dental loupes magnification.
- Comparison: Undergraduate dental students without dental loupes magnification aid.
- Outcomes: Performance in simulated endodontic access cavity preparations and restorative cavity preparations.
- Additional outcomes: Nil.

2.3 | Inclusion criteria

Various types of studies involving the impact of loupes magnification on performance during simulated dental procedures were considered. Simulated dental procedures that were considered for this review include endodontic access cavities, shape outline cavity preparations, and Greene Vardiman Black cavity preparations. The study designs encompassed observational studies (all types),

cohort (longitudinal) studies, cohort studies, before–after studies, case–control studies, and cross-sectional studies.

2.4 | Exclusion criteria

Studies that involved nonundergraduate dental students (postgraduate dental students, general dentists, dental specialists, oral health therapists, and dental hygienists), conducted on patients, as well as studies that focused on working posture, caries identification, surgical operating microscopes, and post-tooth preparation evaluation via loupes, were excluded. Furthermore, papers that were not peer-reviewed, gray literature (including conference abstracts, opinion pieces, and editorials), non-English literature, case reports, and all types of reviews, including systematic reviews, were also excluded.

2.5 | Assessment of bias within studies (quality assessment)

Six studies were included in this systematic review. The risk of bias in the included papers was assessed by two reviewers independently (AG and CH) using the Cochrane Risk of Bias tool (RoB 2).¹³ The risk of bias was determined either as "low risk," "some concerns," or "high risk."¹³



PRISMA 2009 Flow Diagram

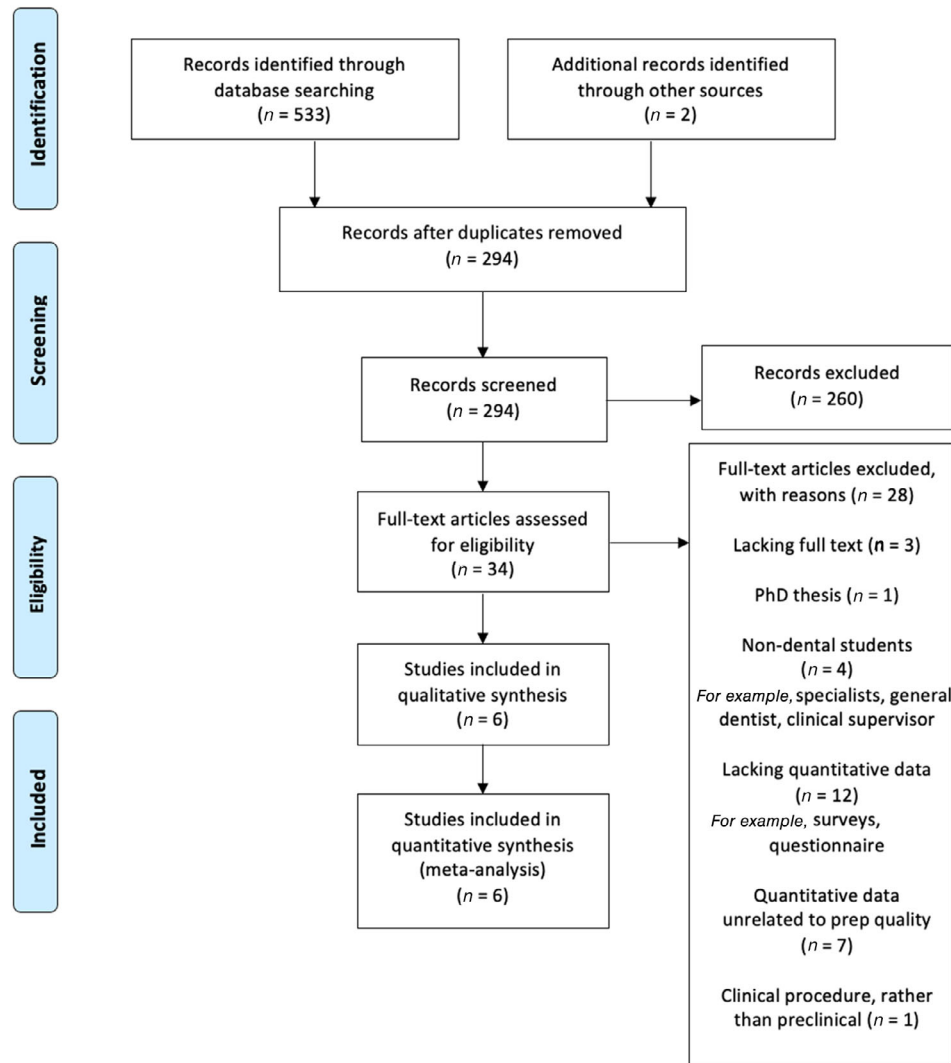


FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart of the online databases searched and selection of studies for inclusion.

3 | RESULTS

The electronic search of the databases identified a total of 533 papers as follows: PubMed ($n = 215$), MEDLINE via Ovid ($n = 115$), The Cochrane Library for Cochrane Reviews ($n = 28$), and Scopus ($n = 175$). All the relevant articles identified through the manual search were observed in the articles retrieved through the electronic search. After the elimination of duplicates and analyses of the titles and abstracts, 33 full texts were analyzed. Finally, six articles were included in the qualitative analysis (Figure 1).

3.1 | Background characteristics of the included studies

In total, six studies, two cohort studies and four cross-sectional studies, were included in this systematic review. A confirmed total of 424 students (undergraduate dentistry students and dental interns) participated in these studies. One hundred and fifty-four students only used loupes, 170 did not use loupes at all, and 100 students used both loupes and no loupes. One study did not confirm the number of dental students participating in the study.¹⁴ One study assessed endodontic cavity preparations,¹ four studies

assessed G.V. Black classification cavity preparations,^{14–16} and one study assessed outline shape preparations.⁸ Some studies also accounted for the effect of loupes on working posture and crown preparations¹; however, these results were not incorporated into this systematic review due to irrelevance to the aim of this systematic review. Geographically, one study was conducted in Australia,¹ one study conducted in India,¹⁴ one study conducted in Brazil,¹⁵ one conducted in France,¹⁶ one conducted in Switzerland,⁸ and one study was conducted in the United States.¹⁷ In summary, four articles demonstrated loupes had a positive impact on performance with preparation procedures,^{1,8,14,17} and two articles demonstrated that loupes had no significant impact on preparation procedure performance.^{15,16} Table 2 is a summary of the results from the articles included in this systematic review.

3.2 | Results from individual studies

3.2.1 | Endodontic access cavity preparation

Endodontic cavity preparation of acrylic tooth 36 was performed in one study. Braga et al.¹ conducted a cohort study comparing students wearing no loupes with students wearing 2.5× magnification loupes (unbranded). The students were assessed on access opening, access cavity size and shape, internal form taper, internal outline, and canal location.¹ Braga et al.¹ reported a significantly higher pass rate with students wearing loupes compared to students without loupes ($p = 0.038$).

3.2.2 | General outline cavity preparation

General two-dimensional and three-dimensional cavity preparations on acrylic boxes were performed in one study.⁸ In the crossover study conducted by Eggmann et al.,⁸ all students performed S-shaped (two-dimensional cavity preparation) and O-shaped (three-dimensional cavity preparation) with 2.5× magnification Galilean loupes (Carl Zeiss AG Eyemag custom-fitted loupes) and without loupes. Eggmann et al.⁸ reported a significant increase in accuracy with two-dimensional preparations ($p = 0.0001$); however, no significance with three-dimensional preparations ($p \geq 0.1865$).

3.2.3 | Class I preparation

Class I cavity preparations were performed in two studies.^{15,17} Maggio et al.¹⁷ conducted a cohort study comparing a cohort of students performing class I cav-

ity preparations with 2.5× through-the-lens magnification loupes (Designs for Vision) with another cohort of students who completed the same preparations without loupes. Pazos et al.¹⁵ conducted a crossover study with the participant using no loupes, 3.5× magnification monocular loupes (Bioart Simple), 3.5× magnification Galilean loupes (Ymarda Optical Factory) and 4.0× magnification Keplerian loupes (Ymarda Optical Factory). Maggio et al.¹⁷ demonstrated that students with loupes performed better than students without loupes. Students with loupes completed more tooth preparation procedures per model ($p = 0.0001$), spent less time to complete preparation models ($p = 0.001$), and spent less time interpreting computer-generated assistance and evaluations per module ($p = 0.002$). No statistical difference was observed between no loupes and loupes cohort for the mean number of computer-aided assistance and computer-generated enquiries.¹⁷ Pazos et al.¹⁵ showed that loupes do not significantly affect the quality of class I cavity preparations ($p = 0.082$).

3.2.4 | Class II preparation

Class II preparations were performed in three studies.^{14,16,17} One study¹⁷ compared a cohort of students performing class II cavity preparations with 2.5× through-the-lens magnification loupes (Designs for Vision) against students performing without loupes. Two studies^{14,16} were crossover studies; Carpentier et al.¹⁶ had participants use no loupes and 2.5× flip-up magnification medical loupes (Carl ZEISS AG EyeMag smart). Narula et al.¹⁴ had participants use no loupes and 2.5× magnification loupes (Heine). Carpentier et al.¹⁶ reported no significance between loupes and no loupes ($p = 0.8221$). Narula et al.¹⁴ reported a significant improvement when students used loupes compared to no loupes. Maggio et al.¹⁷ demonstrated a better performance in the cohort of students who used loupes. Students with loupes had a more significant number of successfully prepared tooth preparation procedures per module ($p = 0.036$), less time spent in each successfully completed module ($p = 0.021$), the lower mean number of computer-aided assistance and computer-generated evaluations ($p = 0.001$), less time spent interpreting computer-generated assistance and evaluations per module ($p = 0.0001$).¹⁷

3.2.5 | Class III preparation

Class III preparations were performed in one study,¹⁷ comparing a cohort of students using no loupes with a cohort of students using 2.5× through-the-lens magnification loupes

TABLE 2 Summary of results.^{1,8,12-15}

Title	Year—country	Students—distribution	Type of study—control group	Loupes types and magnification	Results
The impact of the use of magnifying dental loupes on the performance of undergraduate dental students undertaking simulated dental procedures ¹	2021—Australia	Ninety-two third-year undergraduate dental students—38 wore loupes, 54 did not wear loupes	Cohort study—the control group did not wear loupes	2.5X magnification loupes (unbranded)	Loupes > no loupes for endodontic access cavity on the lower left molar tooth ($p = 0.038$)
Do magnification loupes affect the precision of cavity preparations made by undergraduates? A randomized crossover study ⁸	2022—Switzerland	Fifty-nine undergraduate dental students (no specific year level)	Cross-sectional study—no control group (all students wore loupes and no loupes)	2.5X magnification Galilean loupes (EyeMag, Carl Zeiss AG custom-fitted loupes)	No statistical difference in three-dimensional preparations ($p \geq 0.0625$), loupes > no loupes for two-dimensional preparations ($p = 0.0001$)
Evaluation of tooth preparations for class II cavities using magnification loupes among dental interns and final-year BDS students in preclinical laboratory ¹²	2015—India	Undergraduate dental students and dental interns (no specific number)	Cross-sectional study—no control group (all students wore loupes and no loupes)	2.5X magnification loupes (Heine)	Loupes > no loupes for class II cavity preparations
Implementing magnification during preclinical training: effects on procedure quality and working posture ¹³	2020—Brazil	One third-year undergraduate dental student	Cross-sectional study—no control group (all students wore loupes and no loupes)	3.5X magnification monocular loupe (Bioart Simple), 3.5X magnification Galilean (Ymarda Optical Factory) and 4.0X magnification Keplerian (Ymarda Optical Factory)	The quality of class I cavity preparation did not differ significantly among the different magnification systems ($p = 0.082$)
The effect of magnification loupes on spontaneous posture change of dental students during preclinical restorative training ¹⁴	2019—France	Thirty-nine second-year undergraduate dental students	Cross-sectional study—no control group (all students wore loupes and no loupes)	2.5X magnification loupes (flip-up Carl ZEISS AG EyeMag smart medical loupes)	Loupes did not improve performance for class II preparations on tooth 16, no statistical difference ($p = 0.8221$)

(Continues)

TABLE 2 (Continued)

Title	Year—country	Students—distribution	Type of study—control group	Loupes types and magnification	Results
The effect of magnification loupes on the performance of preclinical dental students ¹⁵	2011—the United States	Two cohorts of 116 first-year undergraduate dental students (2009 and 2010)	Cohort study—control group did not wear loupes	2.5X through-the-lens magnification loupes (Designs for Vision)	<p>Number of successfully prepared tooth preparation procedures per module (more is better): Class I, class II, class III, and class V preparations, loupes > no loupes ($p = 0.0001, 0.036, 0.001,$ and $0.001,$ respectively)</p> <p>Time students spent in each successfully completed preparation module (less is better): Class I, class II, class III, and class V preparations, loupes < no loupes ($p = 0.001, 0.021, 0.0001, 0.028,$ respectively)</p> <p>Mean number of computer-aided assistance and computer-generated evaluations (less is better): Class II and class III preparations, loupes < no loupes ($p = 0.001$ and $0.001,$ respectively), class I and class V preparations had no statistical difference ($p = 0.551$ and $0.119,$ respectively)</p> <p>Time spent interpreting computer-generated assistance and evaluations per module (less is better): Class I, class II, and class III preparations, loupes < no loupes ($p = 0.002, 0.0001,$ and $0.001,$ respectively). Class V preparations had no statistical difference ($p = 0.088$)</p>

Study	Risk of bias domains					Overall
	D1	D2	D3	D4	D5	
Braga after et al. 2021	-	+	+	+	+	-
Eggman after et al. 2022	+	+	+	+	+	+
Narula after et al. 2015	+	+	+	-	+	-
Pazos after et al. 2020	X	+	-	+	-	X
Carpentier after et al. 2019	+	+	+	+	+	+
Maggio after et al. 2011	-	+	+	+	-	+

Domains:
D1: Bias arising from the randomization process.
D2: Bias due to deviations from intended intervention.
D3: Bias due to missing outcome data.
D4: Bias in measurement of the outcome.
D5: Bias in selection of the reported result.

Judgment
X High
- Some concerns
+ Low

FIGURE 2 Risk of bias domains.

(Designs for Vision). Maggio et al.¹⁷ demonstrated significantly better performance with students using loupes. Students using loupes had a more significant number of successfully prepared tooth preparation procedures per module ($p = 0.001$), less time spent in each successfully completed module ($p = 0.0001$), the lower mean number of computer-aided assistance and computer-generated evaluations ($p = 0.001$), and less time spent interpreting computer-generated assistance and evaluations per module ($p = 0.001$).¹⁷

3.2.6 | Class V preparation

Class V preparations were performed in one study,¹⁷ comparing a cohort of students using no loupes with a cohort of students using 2.5× through-the-lens magnification loupes (Designs for Vision). Maggio et al.¹⁷ demonstrated significantly better performance with students using loupes. Students using loupes had a more significant number of successfully prepared tooth preparation procedures per module ($p = 0.001$) and less time spent in each successfully completed module ($p = 0.028$). However, no significant difference was observed in the mean number of computer-aided assistance and computer-generated evaluations ($p = 0.119$), and no significant difference was observed in time spent interpreting computer-generated assistance and evaluations per module ($p = 0.088$).¹⁷

3.3 | Risk of bias (quality assessment)

Three papers^{8,16,17} had low risk of bias and two papers^{1,14} had some concerns of bias (Figure 2). Pazos et al.¹⁵ study

was deemed to have a high risk of bias due to only having a singular participant in the study.

4 | DISCUSSION

Dentistry is a visually and physically demanding profession. The use of magnification allows dentists to visualize tiny details that might not be visible to the naked eye due to the limits of human vision.⁵ This systematic review highlights that the use of loupe magnification provides a more detailed view of tooth structure and enhances cavity preparation for undergraduate students. Four of the six included studies^{1,8,14,17} revealed a positive significant statistical difference in improved performance on cavity preparations. In addition, most of these papers had a “good” or “fair” risk of bias, which is pertinent in assessing current research reliability. To the best of our knowledge, this is the first systematic review that specifically examines the effects of dental magnification on the performance of undergraduate dental students on cavity preparation. Therefore, there is reason to consider using dental loupe magnification as an integral part of dental education and training.

From the included studies, the majority^{8,14–16} utilized a cross-sectional study design which typically provides greater insights into the effects of dental magnification on the performance of cavity preparations. The individuals participating in the study are able to provide data for both variables and consequently, researchers gain a deeper understanding of how dental loupes affect performance and how it may be assessed. A limitation of the Pazos et al.¹⁵ study was cohort selection since they used a single student as the sample size for their experiment. Although multiple teeth were prepared for comparison, the cohort

size encompassed only one third-year student, rendering it insufficient to represent the broader population of undergraduate dental students.

Another limitation in the reviewed studies was poor cohort description. Eggmann et al.⁸ and Narula et al.¹⁴ failed to specify the exact year levels used as their cohorts. This prevents reviewers from effectively analyzing whether the required tasks align appropriately with the students' skill levels. The students' year and experience levels are also important as less experienced individuals may need to develop prerequisite fine motor skills prior to gaining the true benefits of magnification. It must also be noted that early prescription of loupes may alter students' performance and possibly cause overdependence prior to acquiring baseline skills. Previous studies have shown that magnification loupes have a positive impact on the prevention of musculoskeletal disorders.¹⁸ However, conflicting data can still be found in the literature regarding performance per se in different dental procedures at both graduate and postgraduate level.^{6,10,19} This is significant in considering and assessing the best time to commence dental loupes usage. Consequently, reviewers may question the efficacy of dental loupes in enhancing performance once foundational skills have been adequately established.

Furthermore, Narula et al.¹⁴ did not clearly specify the number of students used in the study. Although the title of the study suggests that final-year BDS students and dental interns were involved, there is no direct statement provided in the article. The total number of participants is important to evaluate the reliability of research projects. The authors¹³ also added more variables since the prepared teeth used by students varied. Tooth number 36 (FDI) was prepared using loupes and tooth number 46 Fédération Dentaire Internationale (FDI) was prepared without loupes. The utilization of differing quadrants within the dentition introduces additional variables that necessitate consideration. Individuals may display specific strengths and weaknesses depending on the quadrant of work, influenced primarily by working posture and their dominant hand. The consistency in assessing student performance is therefore diminished, as all variables should ideally remain constant except for the introduction of dental loupes.

Eggmann et al.⁸ employed acrylic blocks as the primary medium for students to perform cavity preparations. This method of assessing student performance does not simulate clinical dental procedures closely. This is a significant methodological flaw, as the evaluation of student performance in dentistry should closely imitate real-world clinical procedures. This would be the most accurate means of assessing the benefits of dental magnification and student ability.

Another issue encountered across the studies was examiner bias. In three of the articles, this was not explicitly addressed.^{14,15,17} Notably, these studies did not provide information about the use of blinded examiners.^{14,15,17} The incorporation of examiner bias could potentially affect the validity of the studies' findings. In addition, there is a lack of information regarding visual acuity examination in participants not using dental loupes. Across all studies, there was heterogeneity regarding the magnification amount and loupe brand utilized. The amount of magnification may also alter the performance of students, thereby skewing results in certain papers over others.

This study acknowledges that it does not cover all the variables related to assessing the advantages of dental magnification for undergraduate dental students. Dentistry, being a vast profession, involves numerous factors that can potentially benefit from dental loupes. This review did not address factors like comfort, postural changes, or satisfaction rates of the dental students who used loupes.

Although the review provides insights into the positive outcomes of utilizing loupe magnification, the scarcity of articles meeting the stringent inclusion criteria and their highly varying methodologies problematizes the ability to draw a definitive conclusion for this review. This limitation underscores the need for additional research in this area to provide more comprehensive insights. Future researchers should aim to minimize as many controllable variables as possible and utilize standardized criteria, such as using the same loupes, magnification amount, visual acuity test for all participants, dental procedures, typodonts, and marking criteria.

There is also potential for a review focusing on the integration of magnification into dental education. However, the suitable year level to introduce dental loupes requires further consideration and investigation since factors such as the overdependence of dental loupes should be assessed. There is also the need to assess the long-term effects of dental loupes on the speed of skill progression and quality of clinical work.

5 | CONCLUSION

The findings of this systematic review indicate that incorporating loupe magnification in dental education curricula may enhance the performance of undergraduate dental students in cavity preparations. However, it is crucial to carry out more studies with consistent methodologies to reinforce the current literature and furnish additional evidence for incorporating loupe magnification in dental teaching programs.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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