The Effects of Magnification and Operator’s Experience on the Quality of Preclinical Dental Procedures

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Authors’ contributions

This work was carried out in collaboration among all authors. Author PPNSG designed the study and wrote the protocol. Authors PPNSG and JMP performed the statistical analysis. Author DW managed the analyses of the study, the literature searches and wrote the first draft of the manuscript. Author DW and JMP conducted the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study evaluated the effect of magnification on the quality of preclinical class I cavity preparations according to operator’s experience.

Methodology: This was an experimental laboratory study. The response variable was the quality of Class I cavity preparations evaluated by the Class I Cavity Preparation Assessment - COCA. Class I cavity preparations were performed in all artificial first molars under four conditions: unaided visualization, using a simple loupe, using a Galilean loupe, and using a Keplerian loupe (N=640). The two-factor analysis of variance was performed (α=0.05).

Results: No interactions between operator’s experience and magnification device were found (p>0.05). Although, higher quality scores were given to cavity preparations in tooth #36 using the Galilean loupe compared to naked eye (p<0.01). The more experienced operator received higher quality scores for tooth #46 regardless of the magnification system used (µexperienced=7.0±2.3 and µinexperienced=5.4±2.4).

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Conclusion: The use of magnification devices did not influence the quality of class I cavity preparations performed on tooth #16, 26, 46. Galilean loupes were associated with improved quality of the cavity preparation performed on tooth #36, and the operator’s experience influenced the quality of the preparation on tooth #46.

Keywords: Dental education; lenses; dental cavity preparation; dentistry.

1. INTRODUCTION

The use of magnification devices in dentistry has increased in recent years, with the most common devices being monocular or binocular loupes [1]. Monocular loupes contain simple, low-cost lenses. Though binocular loupes often require a greater investment, they stand out because of the lens systems that they offer. Galilean devices contain concave lenses and provide up to 3.5x magnification [2]. Keplerian devices contain convex ocular lenses and prisms, thus providing greater (up to 4x) magnification [2].

Regardless of the system used, magnification seems to have a positive influence on the quality of dental work: it increases the size of the dental structure and improves professionals’ access to the tissues being treated [3,4]. Though these benefits are possible, the effect of magnification on dental procedures may vary due to differences in operators’ experience and magnification systems [5,6].

The amplification of the operating field provided by magnification does not change the dental structure, which maintains its true dimensions, thus resulting in disproportions between the visual field and the movement of the operator’s hands [7,8]. These disproportions may influence operators’ abilities to perceive fine detail, a skill which is extremely important for the success of dental treatments [9]. Furthermore, an operator with greater clinical experience may not feel such a great effect from the use of magnification on the quality of the procedures, since his developed skill may already allow for better cavity preparations.

Dental procedures require manipulation of anatomical structures and the use of cutting instruments [10]. These procedures performed with increased visibility result in less wear on dental structures and provide improved margins for cavity preparation and restorations [11].

Thus, the effects of visual field magnification on the quality of dental work are a very important topic of investigation, and research on this subject is particularly useful if it considers both experienced professionals and dentists still enrolled in training programs. However, the literature provides little scientific evidence to objectively demonstrate the effect of magnification on the quality of dental procedures [12,13].

Therefore, the objective of this study was to evaluate the effect of magnification on the quality of preclinical class I cavity preparations performed by individuals with and without clinical experience.

2. MATERIAL AND METHODS

2.1 Study Design

This study was approved by the Research Ethics Committee of the São Paulo State University (UNESP), School of Dentistry, Araraquara (CAAE Registry No. 4753816.9.0000.5416). The operators provided an informed consent.

This is a laboratory-based experimental study. The dependent variable was the quality of class I cavity preparations in restorative dentistry procedures as evaluated by the Class I Cavity Preparation Assessment – COCA [14]. The independent variables were the magnification system under four conditions (unaided visualization, the use of a simple loupe, the use of a Galilean loupe, and the use of a Keplerian loupe) and operator’s experience under two conditions (inexperienced or experienced operators). For the inexperienced and experienced operator, undergraduate and graduate students were selected respectively.

The sample unit was the teeth, and the minimal sample size was determined using data from a pilot study, a power of 80% and a significance level of 5%. This resulted in 20 teeth in each experimental condition. Tooth and loupes were randomized so that 20 cavity preparations of each tooth were carried (16, 26, 36, 46) out with each of the magnifying loupes (n=320) and operator (N=640).
2.2 Magnification Devices

The simple loupe selected (BioArt – São Carlos, São Paulo State, Brazil) provided 3.5x magnification. The Galilean device selected was purchased from the Ymarda Optical Instrument Factory (Nanjing - China), which also provided 3.5x magnification. The Keplerian device used in the study was also purchased from the Ymarda Optical Instrument Factory (Nanjing - China) and provided 4.0x magnification.

2.3 Cavity Preparations

Class I cavity preparations were performed for composite resin on tooth numbers 16 (right maxillary first molar), 26 (left maxillary first molar), 36 (left mandibular first molar), and 46 (right mandibular first molar).

The cavity preparation procedures were performed according to cited by Wajngarten et al. [15]. This technique was standardized and followed the recommendations suggested by Baratieri and Monteiro Jr [16]. A diamond bur (Kg Sorensen Model 1014 – Cotia, São Paulo State, Brazil) was used on low rotation. The preparation needed to exhibit rounded internal line angles to support the force of mastication and a depth/width corresponding to 1 to 1.5 burs.

A MOM-brand dental mannequin (Marília, São Paulo State, Brazil), which has artificial resin teeth specific for cavity preparation at the preclinical level, was used in the procedures. As the teeth were prepared, they were removed and replaced by intact resin teeth so that new preparations could be performed. The mannequins were placed in dental chairs to simulate a clinical setting.

2.4 Method for Evaluating Cavity Preparations

The method used was the Class I Cavity Preparation Assessment (COCA), developed by Wajngarten et al. [14]. Cavity preparation quality was evaluated by a calibrated researcher ($\rho=1.0$) with direct observation of the teeth and light standardization.

The aspects of the preparations that were considered were design, mesiodistal length, buccolingual axis length, depth and roundness of the internal angles. Each of these items was classified as adequate, partially adequate, or inadequate based on the ideal anatomical characteristics for each parameter. Each item received a score based on its classification: two points were given to adequate items, one point was given to partially adequate items, and zero points were given for inadequate items.

2.5 Statistical Analysis

This step was performed independently for each tooth (numbers 16, 26, 36, and 46) in order to determine any differences between the magnification systems and operators' levels of experience.

The assumptions of normality ($Sk=0.453-0.857$; $Ku=0.367-1.187$) and homoscedasticity ($p=0.064-0.345$) were met. For this reason, the two-factor analysis of variance was performed. The significance level adopted in this study was 5%.

3. RESULTS AND DISCUSSION

3.1 Results

Table 1 presents the means and standard deviations of the final scores given for the quality of the preparation of tooth numbers 16, 26, 36, and 46 organized by magnification, operator's experience, and ANOVA summary.

For maxillary teeth, no significant difference was observed between "magnification device" and "operator's experience", nor for these factors when considered separately. In the evaluation of the mandibular teeth, no significant difference was found between "magnification device" and "operator's experience." However, in the case of tooth number 36, a significant difference was found between the magnification systems. In the case of tooth number 46, a significant difference was found between the operators with different levels of experience.

Figs. 1 and 2 present the confidence interval for the final scores given for the quality of the cavity preparations for tooth numbers 36 and 46, respectively.
Table 1. Means and standard deviations of the final scores given for the quality of the preparation of tooth numbers 16, 26, 36, and 46 organized by magnification, operator's experience, and ANOVA summary

<table>
<thead>
<tr>
<th>Tooth number</th>
<th>Magnification</th>
<th>Operator’s Experience</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Experienced</td>
<td>6.50 ±1.88</td>
<td>5.87 ±2.33</td>
<td>4.73-22.93</td>
<td>1-3</td>
<td>4.73-7.64</td>
<td>0.93-1.32</td>
</tr>
<tr>
<td></td>
<td>Inexperienced</td>
<td>7.87 ±1.86</td>
<td>6.50 ±2.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Simple Loupe</td>
<td>6.25 ±2.62</td>
<td>6.50 ±2.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Keplerian Loupe</td>
<td>6.50 ±2.61</td>
<td>6.87 ±1.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Naked Eye</td>
<td>5.12 ±2.50</td>
<td>5.62 ±1.96</td>
<td>0.31-25.94</td>
<td>1-3</td>
<td>0.10-8.65</td>
<td>0.02-1.51</td>
</tr>
<tr>
<td></td>
<td>Simple Loupe</td>
<td>5.12 ±2.62</td>
<td>5.60 ±1.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Galilean Loupe</td>
<td>6.00 ±2.64</td>
<td>5.35 ±3.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Keplerian Loupe</td>
<td>5.75 ±2.93</td>
<td>5.31 ±2.47</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Naked Eye</td>
<td>5.87±3.09</td>
<td>5.12±2.36</td>
<td>5.81-88.82</td>
<td>1-3</td>
<td>5.81-29.60</td>
<td>0.92-4.69</td>
</tr>
<tr>
<td></td>
<td>Simple Loupe</td>
<td>5.47±2.66</td>
<td>5.62±2.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Galilean Loupe</td>
<td>6.25±2.36</td>
<td>6.75±1.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Keplerian Loupe</td>
<td>6.37±2.36</td>
<td>5.00±2.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Naked Eye</td>
<td>6.12±2.36</td>
<td>5.25±2.28</td>
<td>11.37-37.54</td>
<td>1-3</td>
<td>3.79-37.54</td>
<td>0.67-6.60</td>
</tr>
<tr>
<td></td>
<td>Simple Loupe</td>
<td>6.00±2.74</td>
<td>5.00±2.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Galilean Loupe</td>
<td>7.25±1.97</td>
<td>5.50±2.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Keplerian Loupe</td>
<td>6.25±2.07</td>
<td>6.00±2.49</td>
<td></td>
<td></td>
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</tbody>
</table>
Fig. 1. The 95% confidence interval (CI95%) for the mean of the final scores given to the cavity preparations performed on tooth number 36 (results organized by magnification device)

Fig. 2. The 95% confidence interval (CI95%) for the mean of the final scores given to the cavity preparations performed on tooth number 46 (results organized by operator’s experience)
Higher quality scores were given to cavity preparations performed using the Galilean loupe than those performed under the naked eye.

The more experienced operator received higher quality scores regardless of the magnification system used.

3.2 Discussion

The objective of this study was to observe the effect of magnification on the quality of class I cavity preparations. No significant difference was found between the magnification system used and operator’s experience in the evaluations of any of the teeth. In the evaluation of the maxillary teeth, the independent variables were considered individually and were not found to influence the quality of the cavity preparations (p>0.05). Similar results were found by Donaldson et al. [17] and Lussi et al. [18].

In the procedures performed on the upper dental arch, the head of the mannequin was laid back in accordance with ergonomic posture recommendations [19-21]. In this position, it is possible that tooth numbers 16 and 26 were closer to the operator’s eyes and that appropriate visibility was therefore obtained without the need for the magnification provided by the loupes.

In the procedures performed on the mandibular teeth, one independent variable was found to influence the quality of the cavity preparations for each of the teeth considered. This result may be associated with the angle of visibility obtained. During procedures performed on the mandible, the head of the mannequin or patient must be facing forward [19-21]. This position causes the angular relationship between the occlusal plan of the teeth and the operator’s line of sight to differ. For this reason, both the magnification system used and the operator’s experience may aid in the establishment of an ideal angle of visibility.

In the case of tooth number 36, the Galilean loupe was found to have a positive influence on the quality of the cavity preparations and to affect the quality of the preparation, regardless of the use of magnification. A lack of experience on the part of the operator requires greater dexterity during clinical procedures. Thus, procedures performed on the dental arch closest to the operator’s dominant hand allow the operator to maintain his or her arm next to his or her body, resulting in greater hand control and stability. This region also offers greater visibility and access to the tooth being treated. In this study, the inexperienced operator was left-handed and therefore worked farther away from tooth number 46, which may have increased his difficulty in performing the preparation on this tooth.

Overall, the quality of class I cavity preparations was not found to be influenced by magnification. Donaldson et al. [17] argue that visibility of small details provided by magnification devices may not be as effective in more basic preparations such as those performed in the current study.

The low scores that both operators received for their cavity preparations may also be influenced by the material of the artificial tooth. Artificial teeth are made using plastic material, which is less resistant to wear and tear than natural dental tissues. Therefore, artificial teeth are more susceptible to the effects of burs, a factor which may result in less conservative and less anatomical preparations.

One of the limitations of this study was the fact that an operating microscope was not included as one of the magnification devices in the independent variable “magnification system”. Pascotto and Benetti [10] report that high (8x) magnification provided by the use of this microscope allows for the creation of better margins on the preparation, which itself helps to prevent cavities from returning. These authors also defend the use of microscopy for restorative procedures, since these microscopes improve visualization and reproduction of details, thus resulting in improved restoration quality.

This study sought to provide information that was lacking in research on magnification systems in dentistry by presenting scientific data on the influence of these systems on the quality of preclinical cavity preparations. The method developed herein to evaluate cavity preparations was also found to be reliable and easy to apply; it is therefore a strong candidate for implementation in educational programs.
Because cavity preparations are only the first step in restorative procedures, it is recommended that future studies consider devices that provide greater magnification (such as operating microscopes) be compared to other loupes used in dentistry. The quality of restorations in the different quadrants can also be evaluated in future studies.

4. CONCLUSION

Thus, the authors could conclude that the use of magnification devices did not influence the quality of class I cavity preparations performed on tooth numbers 16, 26, or 46. The Galilean loupes was associated with improved quality of the cavity preparation performed on tooth number 36, and the operator's experience influenced the quality of the preparation performed on tooth number 46.

CONSENT

All authors declare that written informed consent was obtained from the participants for publication of this study.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki (CAAE Registry No. 4753816.9.0000.5416).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES


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