Comparison of optical performance among three dental operating microscopes: A pilot study

Poorya Jalali, Charles Kim, Karl F. Woodmansey
Departments of Endodontics, Texas A and M College of Dentistry, Dallas, Texas, USA

Abstract

Introduction: Two important aspects of the dental operating microscope (DOM) that factor into its overall effectiveness are resolution and depth of field. Therefore, the objective of this study was to evaluate and compare the resolution and depth of field of DOMs from three well-known manufacturers using standardized test targets.

Materials and Methods: A resolution test, using the 1951 USAF Hi-Resolution Target (Edmund Optics, Barrington, NJ), and a depth of field test, using the Depth of Field Target 5-15 (Edmund Optics, Barrington, NJ), were performed by two calibrated observers. Three DOM systems such as Seiler IQ (Seiler Instrument Inc., St. Louis, USA), Global G-Series 6 step (Global Surgical Corp., St. Louis, USA), and Zeiss Extaro 300 (Carl Zeiss Meditec AG, Oberkochen, Germany) were used to compare the resolution and depth of field.

Results: The Zeiss Extaro 300 showed the highest maximum resolution and maximum DOF (64 lp/mm and 17 mm, respectively). The Seiler IQ showed the lowest maximum resolution and maximum DOF (35.9 lp/mm and 11 mm, respectively).

Conclusion: Within the limitations of this study, the Zeiss Extaro 300 was superior in terms of resolution and depth of field as compared to the other two DOMs.

Keywords: Dental operating microscope; depth of field; endodontics; resolution

INTRODUCTION

The dental operating microscope (DOM) enhances the visualization of the tooth and its anatomic substructures during endodontic procedures. Numerous clinicians have noted its ability to improve treatment.[1-9] Resolution and depth of field are two important aspects that factor into the effectiveness of the DOM. Resolution is defined as the measure of the sharpness of an image or the ability to distinguish the individual parts of an object.[10] The unaided human eye can generally distinguish between two parallel lines that are 0.2 mm apart. If they are closer together, they appear as a single line.[2] Consequently, resolution (or limiting resolution) is most often measured by and reported as the minimum distance between line pairs (lp/mm) where they are still observed as a pair.

Depth of field, on the other hand, refers to the visible zone of clarity and focus. This is a pure function of the optics and is measured without the use of any focusing adjustments. An operating dental microscope should have a high resolution with a large depth of field to provide the best optical performance.

Zeiss, Seiler Instrument Inc., Global Surgical Corp., and Carl Zeiss Meditec AG are well-known manufacturers of DOMs. A convenience sample of one microscope from each of those manufacturers was utilized for this study. The goal of this study was to measure differences in resolution and depth of field among the DOMs from these manufacturers. To the best of our knowledge, no prior study has quantitatively investigated and compared various DOMs in terms of optical performance.

Address for correspondence:
Dr. Poorya Jalali, Department of Endodontics, Texas A and M College of Dentistry, Dallas, Texas, USA.
E-mail: jalali@tamu.edu

Date of submission : 05.05.2020
Review completed : 19.07.2020
Date of acceptance : 14.08.2020
Published: 16.01.2021

How to cite this article: Jalali P, Kim C, Woodmansey KF. Comparison of optical performance among three dental operating microscopes: A pilot study. J Conserv Dent 2020;23:374-6.
MATERIALS AND METHODS

A resolution test, using the 1951 USAF Hi-Resolution Target (Edmund Optics, Barrington, NJ), and a depth of field test, using the Depth of Field Target 5-15 (Edmund Optics, Barrington, NJ), were performed by two observers [Figure 1]. Three DOM systems such as Seiler IQ (Seiler, St. Louis, USA), Global G-Series 6 step (Global, St. Louis, USA), and Zeiss Extaro 300 (Zeiss, Oberkochen, Germany) were used to compare the resolution and depth of field. All the tested DOMs were equipped with a light-emitting diode light source.

The two observers were calibrated using two 45-min pilot sessions by evaluating and reviewing their findings. In addition, short calibration sessions were conducted before testing each DOM to ensure maintaining interobserver agreement throughout the study. Each examiner conducted an initial setting of the DOM by adjusting the interpupillary distance and the eyepieces. Then, an individual microscope adjustment (Parfocaling) was conducted as previously described.[11] During the study, each examiner performed the tests independently. If there was a disagreement between their findings, the tests were repeated and reviewed together until an agreement on findings was reached.

Depth of field test

The depth of field test was performed using the Edmund Optics Depth of Field Target at normal incidence. To ensure that the maximum depth of field was recorded, it was important to make sure that the top of the target recorded one end of the depth of field. The top of the field was focused into view before decreasing the working distance just enough to get it out of focus. Then, it was adjusted slightly so that it would barely come back into focus. To record the depth of field, the 5 lp/mm was used, and the distance, at which the focus was lost, was recorded.

Resolution Test

The resolution test involved distinguishing two sets of three bars, with one set being horizontal and the other being vertical. Being able to distinguish higher group numbers meant that the microscope was able to distinguish smaller objects, which were then further divided into elements within each group. However, it was important to be able to distinguish all objects at groups and elements lower than that of the smallest object. The group and element, at which the smallest object was distinguishable, were noted.

RESULTS

The magnification, resolution, and DOF for the three DOMs are presented in Table 1.

The end magnification was from ×3.4 to ×21.25 for the Zeiss Extaro ×300, 2.1 to ×19.2 for the Global G series, and ×4.2 to ×11 for the Seiler IQ.

The Zeiss Extaro 300 showed the highest maximum resolution and maximum DOF (64 lp/mm and 17 mm, respectively). The Seiler IQ showed the lowest maximum resolution and maximum DOF (35.9 lp/mm and 11 mm, respectively).

DISCUSSION

Three DOMs from different manufacturers were tested and compared with regard to resolution and depth of field. High-precision test targets were used to quantitatively measure the imaging characteristics of the three DOMs.

The Zeiss Extaro 300 and Global G series showed to have a wide range of magnification, with the latter having the smallest minimum end magnification (×2.1). The minimum magnifications, due to their wide field of view, could provide

| Table 1: Resolution, depth of field, and end magnification results for the three dental operating microscopes |
| --- |
| DOM | End magnification | Resolution (lp/mm) | DOF (mm) |
| Zeiss Extaro 300 | ×3.4 | 12.7 | 17 |
| | ×5.1 | 17.96 | 11 |
| | ×8.5 | 35.9 | 6 |
| | ×13.6 | 50.8 | 4 |
| | ×21.25 | 64 | 2 |
| Global G-Series 6 step | ×3.2 | 10.08 | 13 |
| | ×5.1 | 12.7 | 12 |
| | ×8 | 20.16 | 7 |
| | ×12.8 | 35.9 | 6 |
| | ×19.2 | 40.3 | 3.5 |
| Seiler IQ | ×4.2 | 14.25 | 11 |
| | ×7 | 22.63 | 5 |
| | ×11 | 35.9 | 2.5 |

DOM: Dental operating microscope, DOF: Depth of field.
comfort and confidence in performing certain procedures that require the visualization of a large area of the mouth. For example, in intraoral injections, rubber dam placement, and suturing, the minimum magnification proved to be more suitable than the higher magnifications.\cite{2,12} Therefore, having the smallest minimum end magnification may be an advantage of the Global G series compared to the other two DOMs.

In endodontics, high-resolution DOMs are strongly demanded for precision visualization and procedure. In this study, the Zeiss Extaro 300 showed to have the highest maximum resolution (64 lp/mm), which was significantly higher than the Global G series and Seiler IQ’s maximum resolution (40.3 lp/mm and 35.9 lp/mm, respectively). However, further studies are needed to determine whether these differences in maximum resolution have any clinical significance and whether they could result in improved performance. A study by Bowers et al. showed a significant improvement in fine motor skills with the use of DOM compared with loupes and unaided vision.\cite{6} Therefore, it is reasonable to assume that a higher resolution may result in better clinical performance. Furthermore, it is important to note that resolution and magnification are independent quantities. In other words, higher magnification does not necessarily result in a higher resolution, which is in accordance with the findings of this study. For example, the results of this study showed that, in Global G series, no changes in the resolution are noted when the end magnification was increased from \( \times 12.8 \) to \( \times 19.2 \). Furthermore, the Zeiss Extaro 300 at \( \times 13.6 \) showed a higher resolution than Global G series at \( \times 19.2 \).

Depth of field of a DOM is of utmost importance in endodontics. This feature allows the clinician to clearly visualize different levels of the internal root canal anatomy.\cite{2} In other words, in a DOM with a high depth of field, different levels of the root canal system can be maintained into focus without moving the patient, DOM, or adjusting the fine focus. In this study, the Zeiss Extaro 300 showed the highest maximum DOF (17 mm), followed by Global G series (13 mm). As expected, DOF decreases as the magnification of DOM increases for each DOM.

To the best of our knowledge, this is the first study of its kind that quantitatively evaluated and compared various DOMs in terms of optical performance. However, this study had a number of limitations. First, the study could have benefited from including more observers for measuring the imaging characteristics. However, using the test targets was a subjective method of evaluation, and a very significant amount of time was utilized to make the two observers adequately calibrated. Adding more observers into the study, potentially, could have resulted in less accurate and reliable findings. Second, the limited number of DOMs evaluated could also be considered a limitation, and the results of this study should not be generalized to the other products of these manufacturers. However, it is reasonable to assume that, within each manufacturer, different models may have very similar lens quality and optical performance. Third, the observer-dependent measurements used in this study introduced subjectivity in the results. However, the risk of subjectivity was minimized by calibrating the observers and using standardized targets. However, it is still important to note that these methods are subjective, and the resolution and depth of field scores presented in this study are not absolute findings. Therefore, using the test target, the observations may vary among individuals. Nevertheless, using these methods, the results would be meaningful, providing the observers are calibrated with each other, and the findings are used for comparison purposes only.

**CONCLUSION**

Within the limitations of this study, among the three tested DOMs, Zeiss Extaro 300 showed to be the superior DOM in terms of resolution and depth of field. Further studies needed to evaluate whether these differences in optical performance could result in improved clinical performance.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Carr GB. Microscopes in endodontics. J Calif Dent Assoc 1992;20:55-61.
2. Carr GB, Murgel CA. The use of the operating microscope in endodontics. Dent Clin North Am 2010;54:191-214.
3. Tibbetts LS, Shanelec D. Periodontal microsurgery. Dent Clin North Am 1998;42:339-59.
4. van As GA. Magnification alternatives: Seeing is believing, Part I. Dent Today 2013;32:82-7.
5. Stropko JJ. Canal morphology of maxillary molars: Clinical observations of canal configurations. J Endod 1999;25:446-50.
6. Bowers DJ, Glockman GN, Solomon ES, He J. Magnification’s effect on endodontic fine motor skills. J Endod 2010;36:1135-8.
7. Al Shaikhly B, Harrel SK, Umorin M, Augsburger RA, Jalali P. Comparison of a dental operating microscope and high-resolution videoscope for endodontic procedures. J Endod 2020;46:888-93.
8. Biswas M, Mazumdar D, Neyogi A. Non surgical perforation repair by mineral trioxide aggregate under dental operating microscope. J Conserv Dent 2011;14:83-5.
9. Schmidt BS, Zaccara IM, Reis So MV, Kuga MC, Palma-Dibb RG, Kopper PM. Influence of operating microscope in the sealing of cervical perforations. J Conserv Dent 2016;19:152-6.
10. Mualla F, Aubreville M, Maier A. Microscopy. In: Maier A, Steidl S, Christlein V, Hornegger J, editors. Medical Imaging Systems: An Introductory Guide. Ch. 5, Cham (CH): Springer; 2018. Available from: https://www.AQ479.ncbi.nlm.nih.gov/.
11. Setzer F. The dental operating microscope. In: Kim S, Kratchman S, editors. Microsurgery in Endodontics. 1st ed. Hoboken: Wiley Blackwell, 2018. p. 1-7.
12. Low JF, Dom TNM, Baharin SA. Magnification in endodontics: A review of its application and acceptance among dental practitioners. Eur J Dent 2018;12:610-6.