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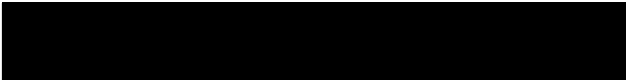
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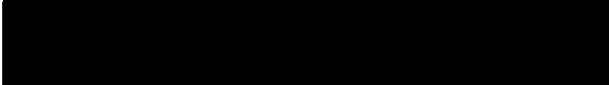
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Use of the Microscope in Endodontics: A Questionnaire Based Study

Andrew R. Steidley, DMD, Daniel D. Kersten, DDS, Steven Delgado, DDS, Pete Mines, DDS, Thomas A. Beltran, BA

Abstract

The primary purpose of this study was to determine the frequency of dental operating microscope (DOM) use among endodontists and compare current utilization to historical trends. Secondly, we sought to determine if the incorporation of image capture technology (ICT) with the DOM has changed the daily practice of endodontics and what effect market size may have on their utilization. A web-based survey regarding the DOM, with ten questions, was sent to 4042 active members of the American Association of Endodontics (AAE). Data collected from 1174 participants, a response rate of 29%, indicated that 96.2% of all endodontists have access to and use the DOM in their practice and 73.8% reported no limitations to use. Among those who use the DOM, 61.1% reported using ICT. The greatest limitation to ICT was increased time requirements. Via a chi-square test and binary logistic regression, our results indicate that market size has no effect on the use of the DOM or ICT ($P=0.21$). The most common reason for ICT was documentation, with 67.9% participants reporting that they use captured images for this purpose. The majority of respondents, 61.6%, indicated that they agreed with the statement "The ability of others to see what I see with the microscope has greatly improved my endodontic practice." In conclusion, we found that the use of the DOM by endodontists has increased to 96.2%, and that image capture technology has improved the ability of others to appreciate the intricacies of endodontics.

Key Words

Endodontics, camera, use, operating microscope, usage, utilization, web survey Dental Operating Microscope, image capture, assistant viewing, buddy scope

The increased usage of the dental operating microscope (DOM) in the field of endodontics has led to a reported increase in both clinical efficiency and proficiency, as well as a decrease in iatrogenic related events [1, 2, 3]. The first documented use of the DOM within the dental field can be traced to 1907 by Bowles [4]. In 1998 the Commission on Dental Accreditation (CODA) incorporated the DOM into its proficiency standards for all post graduate endodontic residencies. Since that time, the DOM has become an integral part of

the endodontic profession with a steady increase in usage, from 52% in 1999 [2] to 90% in 2008 [3].

Various studies have demonstrated the clinical effectiveness of the DOM in improving the success of different endodontic procedures. For example, it has been shown to increase the probability of finding additional canals in maxillary molars [5, 6, 7]. Furthermore, with the advent of the DOM, surgical endodontic therapy experienced improved outcomes [8, 9]. A study published by Bowers et al in 2010 demonstrated that fine motor skills were significantly improved with the DOM and that using the DOM was an acquired skill which improved proficiency over time [10].

Constant advancements in technology and many new innovations have led to expanded use of the DOM. The use of image capture technology (ICT) and assistant viewing binoculars in combination with the DOM were first described by Dr. Carr in 1992. His review of this topic included the science behind the DOM along with potential uses for these new technologies [11]. In 2009 a review of the basic components needed for image capture technology concluded that it is an ever-changing field with constant advancements and innovations [12]. As time has passed ICT has experienced an increase in quality with a decrease in cost. Further, ICT has become directly incorporated into the DOM and is therefore more convenient for clinical use.

Various authors have cited instances in which the addition of a camera to a dental practice can enhance diagnosis, treatment planning, patient education, dentolegal documentation, insurance verification, marketing, and communication with the dental team [13, 14]. However, there is little evidence in the literature regarding the utilization of ICT with the DOM and the usage of the DOM for assistant observation.

Thus, the aim of this study was to determine the frequency of DOM use among endodontists, and to compare current and historical utilization trends. Secondly, we sought to determine if the incorporation of either assistant observation or ICT has been widely incorporated into the endodontic practice. We hypothesized that DOM utilization has increased since 2008 and that both ICT and assistant microscopic observation would be widely adopted within the specialty.

<p>1) How many years has it been since you finished your residency training?</p> <p>a. 0-5yrs b. 6-10yrs c. 10-15yrs d. 16-20yrs e. >20yrs</p> <p>2) Which of the following best characterizes your current practice?</p> <p>a. Academia b. Resident c. Federal Service d. 1-2 providers e. >2 providers</p> <p>3) Which best describes your market size?</p> <p>a. Small (</=50,000) b. Mid-sized (50,000-300,000) c. Large (>300,000)</p> <p>4) Do you use the dental operating microscope as much as anticipated?</p> <p>a. Yes b. No c. I do not use the dental operating microscope *end of survey*</p> <p>5) What are your significant limitations to microscope usage? (please mark all that apply)</p> <p>a. Maintenance problems b. Initial cost/availability c. Restricted field d. Positional difficulties e. Inconvenience f. Increased treatment time g. Lack of auxiliary support h. Not applicable, I use the microscope without limitations i. Other i. [explain] _____</p> <p>6) Does your assistant utilize the microscope to observe treatment in any capacity?</p> <p>a. Yes b. No</p>	<p>7) Do you use your microscope for image capture as much as you anticipated?</p> <p>a. Yes b. No c. I do not use the dental operating microscope to capture images *end of survey*</p> <p>8) What are your limitations to microscope image capture? (Mark all that apply)</p> <p>a. Increased time requirements b. Difficulty with image capture or storage c. Not applicable, I use the camera without limitations d. Other i. [explain] _____</p> <p>9) How often do you use your microscope to capture images for the following?</p> <table border="0" style="width: 100%;"> <tr> <th></th> <th>Never</th> <th>Rarely</th> <th>Sometimes</th> <th>Often</th> <th>Always</th> </tr> <tr> <td>Patient Education</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> </tr> <tr> <td>Referral</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> </tr> <tr> <td>Documentation</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> </tr> <tr> <td>Insurance</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> </tr> <tr> <td>Professional Education</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> </tr> </table> <p>10) To what extent do you agree with the following statement "the ability for others to see what I see with the microscope has greatly improved my endodontic practice."</p> <table border="0" style="width: 100%;"> <tr> <th>Strongly Disagree</th> <th>Disagree</th> <th>Neither Agree or Disagree</th> <th>Agree</th> <th>Strongly Agree</th> </tr> <tr> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> <td style="text-align: center;">●</td> </tr> </table>		Never	Rarely	Sometimes	Often	Always	Patient Education	●	●	●	●	●	Referral	●	●	●	●	●	Documentation	●	●	●	●	●	Insurance	●	●	●	●	●	Professional Education	●	●	●	●	●	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	●	●	●	●	●
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Table 1. Sample Survey

Materials and Methods

A QuestionPro.com survey was created to answer the study questions. It was designed so that each question required an answer. The 10-question survey [Fig 1.] was initially sent to 7 endodontic residents as a pilot study. Final adjustments were made, and the survey was sent to 4042 active members of the American Association of Endodontics (AAE) on 7 August 2017. The survey was open for 6 weeks with reminders sent at weeks 1, 3, and 5. All responses were recorded for every completed survey; incomplete surveys were excluded. Multiple comparisons were accomplished using the Kruskal-Wallis test with Dunn-Bonferroni post-hoc comparisons used to elucidate significant results. A chi-square test was used for pairwise comparisons. Binary logistic regression analysis was used to examine the potential relationship between market size and use of a dental operating microscope for image capture. Significance was declared at $P < 0.05$ for all tests. All data was analyzed by using SPSS version 23.0.

Results

A total of 1174 AAE members responded to the email request by initiating the survey (an overall response rate of 29%). Of this number, 1132 members completed the survey. Forty-three respondents (3.8%

of those who completed the survey) indicated that they do not use a DOM. Thus, the current utilization rate for the DOM is 96.2%, a 44.2% increase from 1999 and a 6.2% increase from 2008 [2, 3] [Fig 4.]. The 1089 respondents who both completed the survey and indicated some use of a DOM were retained for analysis. Among those who use the DOM only a small portion ($N=86$, 7.6%) reported that they didn't use it as much as they had anticipated. Further analysis of this question revealed no difference with regard to market size between respondents who did not use the DOM as much as anticipated and those who did ($P=0.75$).

In regard to practice type or setting for respondents (Academia, Resident, Federal Service, 1-2 Providers, or >2Providers) the majority ($N=938$, 87.0%) of respondents reported being in private practice. Practice type did not differ based on respondents' time since residency completion ($P=0.90$), but did differ with market size ($P<0.001$).

Two homogenous subsets were found among DOM use data with regard to experience. Respondent experience (as measured by time since residency completion) shows a clear distinction in DOM use between respondents with 15 years or less and those with greater than 15 years. The latter reported less use of the DOM ($P<0.001$). Self-reported DOM use did not differ based on respondents' practice type ($P=0.06$).

The most common limitation to the DOM was reported to be positioning difficulties (N=153, 14.0%). However, the majority of respondents, 73.8% (N=804), indicated that they have no significant limitation to DOM usage [Table 2].

Table 2. Significant Limitations to Microscope Usage

	N	%
Maintenance Problems	16	1.5
Initial Cost / Availability	66	6.1
Restricted Field	56	5.1
Positional Difficulties	153	14.0
Inconvenience	54	5.0
Increased Treatment Time	51	4.7
Lack of Auxiliary Support	28	2.6
Other	47	4.3
N/A, No Limitations	804	73.8

When asked if an assistant utilizes the DOM to observe treatment, most respondents (N=917, 84.2%) indicated “No”. Thus, a surprisingly low 15.2% of endodontic assistants are observing treatment with the aid of magnification.

As for image capture technology usage, 61.1% of respondents indicated that they have access to and use ICT [Fig. 2]. Of those who use ICT, 29.7% (N=321) stated that they use this technology as much as anticipated while 31.5% (N=340) indicated that they did not. No significant relationship was found between market size and use of the dental operating microscope for image capture ($P=0.21$). The most commonly reported limitations to ICT use was found to be “increased time requirements” (N=218, 18.6%) followed by “difficulty with image capture” (N=209, 17.8%). When respondents were allowed to write in a response their most common answer revolved around the added expense associated with ICT. Reasons for using the microscope to capture images are shown at the bottom of this page [Table 3]. The greatest reported reason for ICT was documentation.

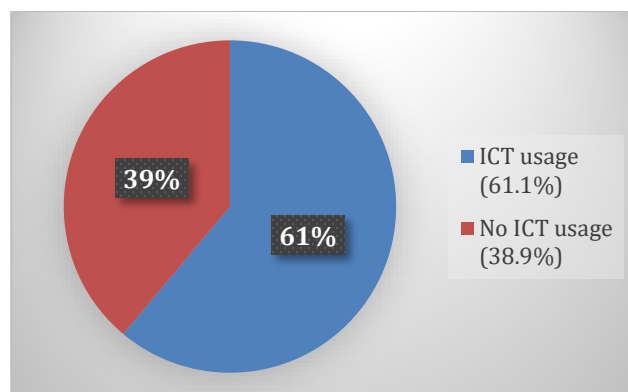


Figure 2. Endodontist utilization rate of image capture technology

Finally, when asked to rate the statement “The ability of others to see what I see with the microscope has greatly improved my endodontic practice”, the majority of respondents (61.6%) indicated that they either agreed (N=237) or strongly agreed (N=157) with the assertion [Fig 3]. In contrast, only 12.2% of respondents selected “Strongly Disagree” (N=29) or “Disagree” (N=49).

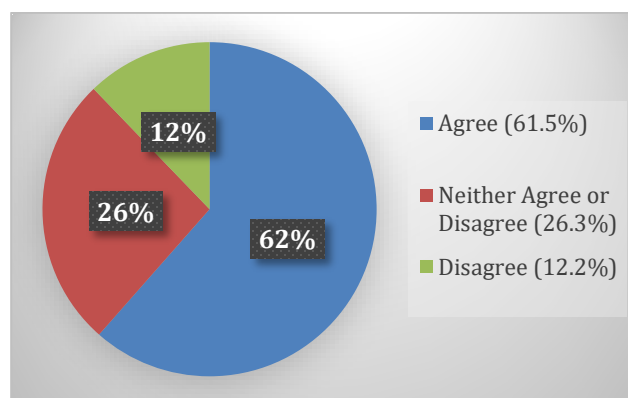


Figure 3. Does ICT improve the ability of others to appreciate endodontics?

Discussion

Since the addition of the DOM to the clinical proficiency requirements of CODA, this technology has

Table 3. Reasons for Microscope Image Capture, N (%)

	Never	Rarely	Sometimes	Often	Always
Patient Education	121 (10.3%)	124 (10.6%)	239 (20.4%)	115 (9.8%)	41 (3.5%)
Referral	115 (9.8%)	104 (8.9%)	228 (19.4%)	135 (11.5%)	58 (4.9%)
Communication	95 (8.2%)	95 (8.1%)	214 (18.2%)	160 (13.6%)	75 (6.4%)
Documentation	355 (30.2%)	173 (14.7%)	75 (6.4%)	25 (2.1%)	12 (1.0%)
Insurance	138 (11.8%)	116 (9.9%)	209 (17.8%)	127 (10.8%)	50 (4.3%)
Professional Education / Lecture					

become widely adopted within endodontics [Fig. 4] [2, 3]. The DOM has been shown to improve the clinician's ability to locate additional canals as shown in a 2017 study that demonstrated an improved ability to locate 2nd mesio-buccal canals in maxillary molars [7].

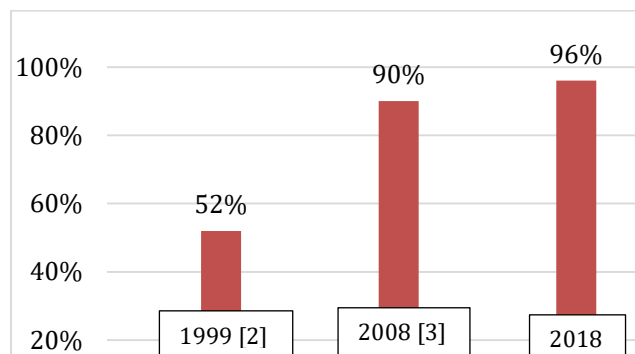


Figure 4. DOM use through the years

In 2008 a study similar to ours found that 59% of clinicians reported significant limitations to use of the DOM [3]. A study published in 2010 found that there is a learning curve to DOM usage [10]. However, our study indicated that there has been a decrease in limitations, as 73.8% of those surveyed reported no impediments to the usage of the DOM [10]. Thus, through the years DOM usage has increased while limitations to its use have decreased, an important trend that we speculate will continue. These two findings are contributing to the continued rise of DOM use within the profession.

Not surprisingly there was a slight increase in DOM utilization among younger clinicians, which could easily be explained by the addition of DOM usage to CODA standards in 1998.

Dental assistants currently are not utilizing assistant-side microscopic observation as frequently as we had anticipated. This could be due to either a lack of dental assistant training or a lack of acceptable technology for their visualization. As we had hypothesized, the majority of clinicians who use the DOM have incorporated ICT into their practice. The purpose of these images was relatively evenly distributed amongst the answer choices, with the exception of insurance. Furthermore, we discovered that the limitations to ICT were relatively evenly spread across the answer choices. Those who use ICT in some manner overwhelmingly indicated that this added feature had improved the ability to communicate with others about treatment.

The fact that most clinicians consider ICT to have improved their communication, and therefore their clinical practice, is a significant finding. This allows us to extrapolate that ICT will continue to become adopted within the endodontic community. We were slightly surprised that assistant microscopic

observation of treatment is not being more readily utilized due to the potential to increase clinical proficiency.

There is no question that the DOM's utilization within endodontics has improved the daily clinical practice of endodontists. A 2017 study compared maxillary first molars that had undergone NSRCT either with or without the DOM. This study found that when the DOM was utilized a 2nd mesio-buccal canal was located in 62% of cases compared to 19% for those cases completed without the DOM. Further, this study found that when the DOM was not used, periapical radiolucencies were found associated with 73% of the MB roots. This is in contrast to 26% of the MB roots when the DOM was used [7]. Monea et al took these studies one step further and attempted to relate outcomes to DOM usage. This study discovered that the DOM improved endodontic outcomes over the non-DOM group as follows: 81% versus 62% at 6 months, and 89% versus 82% at 18 months [5].

As we shift towards a more conservative approach to endodontics, the use of the DOM is going to become more crucial for dentin-sparing preparations and shapes while maintaining adequate disinfection. The importance, and need, for this shift was demonstrated in a recent study in which the authors found that teeth prepared with traditional accesses had lower fracture resistance compared to those prepared with conservative accesses [15]. This push towards conservative endodontics has also been presented by Dr. David Clark and Dr. John Khademi who provide an excellent review of the need to transition to more conservative endodontics in order to improve long-term endodontic, as well as restorative, outcomes. They state that the DOM can be considered one of the 5 major catalysts that will influence endodontic access and coronal shaping as we make this transition [16].

Based on the trend of continued utilization of the DOM within endodontics, we anticipate that within the next decade the usage rate will near 100%. As we approach this moment, we must ask ourselves: When will the DOM finally be considered the standard of care for endodontic treatment?

Conclusion

This is the first study to evaluate the utilization rates of ICT and assistant microscopic observation within the field of endodontics. The DOM has become widely adopted among endodontists, reaching a current utilization rate of 96.2%. Only 15.2% of assistants are observing endodontic therapy utilizing microscopic magnification despite its potential to increase clinical efficiency. A total of 61.1% of endodontists who use the DOM also use ICT at least

occasionally. Endodontists who use ICT reported that it has significantly improved their daily clinical practice, indicating that this technology will become more prevalent in the future. The increased usage of the DOM, along with various studies indicating significantly improved outcomes when the DOM is utilized, seems to indicate that the DOM may become the standard of care for all molar endodontic procedures in the foreseeable future.

Acknowledgements

The opinions or assertions contained herein are the private ones of the authors and are not to be construed as official or reflecting the view of the DOD or the USUHS.

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