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Current trends in the use of guided technology in surgical endodontics: A web-based survey

ABSTRACT:
Introduction: The use of guided technology is emerging in the practice of surgical endodontics. 3-dimensionally–printed surgical guides (3DSGs) and dynamic navigation systems (DNS) are two of these guided techniques. The purpose of this study was to assess the level of exposure of endodontists and endodontic residents to guided surgical techniques and their incorporation of these techniques into their surgical practice. **Materials:** A 30-question web-based survey was distributed via email to 6,510 members of the American Association of Endodontists. Responses were collected over a period of two months and descriptive statistics were analyzed. **Results:** Data was obtained from 552 respondents (404 actively practicing endodontists, 107 in academia) for an overall response rate of 8.5%. 78% of members in the private practice setting reported doing fewer than 10 surgeries a month, and most of them do not perform surgeries on palatal roots of maxillary molars (52%) or mandibular second molars (73%). For these teeth, the most common treatment recommendation is extraction or performing a second retreatment. Only 6% of practicing endodontists currently report using 3DSGs (primarily for endodontic surgery) and 2% report using DNS (primarily for locating calcified canals). While the interest level in guided technology appears high (77% of practicing endodontists are at least somewhat interested in the use of guided technology for endodontic surgery), most (60%) report being unwilling to invest more than $5,000 in new technology. Most residencies (62%) are not teaching either guided surgical technique. **Conclusions:** While interest level appears high, guided endodontic microsurgery has not yet become mainstream in endodontic practice.

INTRODUCTION

Endodontic surgery has evolved immensely over the years, with technological advances in surgical adjuncts. This has included the introduction of cone-beam computed tomography (CBCT), surgical operating microscope (SOM), improved illumination, and microinstrumentation techniques. Furthermore, additional progress was made with the introduction of ultrasonics for retropreparation and the advent of bioceramics for improved biocompatibility of root-end filling material (1, 2). With this, endodontic microsurgery (EMS) has success rates similar to that of initial therapy and marked improvement in success over traditional root-end surgery (3, 4).
Guided surgery is emerging as an approach allowing for more accurate and predictable outcomes. Pinsky et al introduced the concept of using CBCT and computer-aided design/computer-aided manufacturing (CAD/CAM) technology to fabricate an acrylic surgical guide (6). Strbac et al described a similar protocol, using 3-dimensionally–printed surgical guides (3DSGs) to plan and execute the most ideal bone perforation site, and in 2017 Giacomino et al introduced targeted EMS (TEMS), which added the use of a guideport to the 3DSG and a trephine bur (7, 8). TEMS utilizes CBCT imaging and implant-planning software to pre-determine the location and angulation of the osteotomy. This information is used to design the guideport, and a modified trephine bur is used to complete the osteotomy, root-end resection and biopsy acquisition occur in one step (8). This method allows for more accurate and efficient completion of the osteotomy and resection (9).
Another form of guided surgery that has manifested in recent years involves the use of a dynamic navigation system (DNS) to perform EMS (10). Navident (ClaroNav, Toronto, Ontario,

Canada) and X-Guide (X-Nav Technologies, LLC, Lansdale, PA) are two such systems that utilize the information gathered from a CBCT, paired with an optical positioning device guided by overhead tracking cameras. The system directs the practitioner's bur in real-time along a pre-determined surgical path and angulation. Unlike TEMS, surgery performed using the DNS does not require the fabrication of a surgical guide. Similar to TEMS, DNS is purported to reduce the risk of unintentional iatrogenic incidents and lead to more accurate and predictable surgical outcomes (11). Additionally, guided techniques allow the operator to perform root-end surgeries in anatomically complex areas (i.e, palatal roots of first and second maxillary molars and roots of mandibular second molars) that previously were unattainable and may have required extraction (8, 10).

While a guided protocol theoretically removes much of the "guesswork" associated with a surgical procedure, it remains unclear if endodontists today are aware of this novel approach and if so, to what extent the technology is being incorporated into the standard endodontic practice. Additionally, no information currently exists concerning the level of education regarding guided surgical techniques being provided in residency training programs to enable the next generation of endodontists to utilize these techniques. Therefore, the purpose of this survey is to investigate the amount of training, education and familiarity with guided endodontic surgery and the incorporation of guided techniques into endodontic private practice and residency training programs.

MATERIALS AND METHODS:

A SurveyMonkey link to a survey consisting of 30 layered questions was e-mailed to active members of the American Association of Endodontists (AAE). The e-mail stated that the survey is being conducted as part of an ongoing resident research project and included an introductory paragraph briefly describing the two primary guided surgical techniques that were being investigated (3DSGs and DNS). The same email was re-sent one month later as a follow-up, and the survey remained open for one additional month. To ensure completion of all survey questions, the survey could not be submitted without 100% completion, and a reminder message would appear to instruct the participant to complete the missed response prior to submission. Questions were limited to a multiple choice answer format to prevent an uncontrolled variety of responses.

Survey Design: The survey was designed in such a way that specific responses to questions directed the participant to a unique set of additional questions. An initial demographic question distinguished between respondents identifying themselves primarily as private practitioners (both endodontists and general dentists) and those primarily serving in education (either as educators or current endodontic residents).

For all participants that considered themselves primarily in private practice, the following additional information was gathered: number of years in practice and current practice location. Regarding their specific practice, these respondents were asked to estimate on average, how many endodontic surgeries they are performing a month and whether or not they perform surgeries on palatal roots of maxillary molars and mandibular second molars. The remainder of the questions were used to gain information about the respondents' current knowledge and interest levels regarding guided surgery. The questions inquired on their level of familiarity with guided surgical techniques, including both 3DSGs and DNS and their level of interest in continued education relative to guided surgeries. For respondents that stated they are very familiar with the technology, they were asked if they are currently utilizing the technology in their practice and if they are, for which cases they primarily use it. If they responded that endodontic microsurgery is the primary use of the technology, the respondents were asked more specifically about the cases for which they use it (nearly all root-end surgeries, or only cases with difficult access of in close approximation to vital anatomy). Finally, this group of respondents was asked about the likelihood that they will continue to utilize this technology in their future practice.

All respondents that indicated their primary role is in education (whether as educators or as current residents), were asked, on average, how many root-end surgeries residents in their program perform prior to graduation and whether or not they routinely perform surgeries on palatal roots of maxillary molars, and mandibular second molars. They were also asked which surgical treatment is preferential for cases involving the palatal root of maxillary molars and roots of mandibular seconds molars. For questions specifically addressing guided surgery, the participant was asked which guided techniques are being taught in their program and the primary use of that technology (endodontic microsurgery, locating calcified canals, minimally invasive access, or implant placement). Those responding that endodontic microsurgery is the primary use of the technology, were asked about which cases they primarily use it for and how likely they are to continue to utilize this technology in their future practice.

If at any point during the course of the survey the respondents indicated a low level of interest in or a lack of a desire to incorporate guided endodontic surgery either into their individual practice or in their residency program, they were asked to identify the reason(s) for their diminished interest as well as indicate how much they would be willing to financially invest into a guided surgical system.

Data Analysis: Data were exported from the survey platform as a Microsoft Excel and formatted to allow analysis using SPSS software (SPSS Inc, Chicago, IL). Descriptive statistics were analyzed.

RESULTS

All registered AAE members with e-mail addresses were invited to participate in the study. A total of 6,510 members were sent an email link to the survey, and 552 completed surveys were collected for a response rate of 8.5%. 41 respondents indicated that they are not actively practicing clinical dentistry in any capacity, and their surveys were terminated at that time. 404 respondents indicated they are currently in private practice, and 107 were affiliated with academia.

With regards to the members currently in private practice, the following information was obtained: 46% have been in practice for >20 years, 10% in practice 16-20 years, 14% in practice 11-15 years, 13% in practice 6-10 years and 17% in practice 0-5 years; 85% of respondents are currently practicing in the United States; 58% report performing fewer than 5 surgeries/month, 20% perform 6-10 surgeries/month, and 13% do not perform any surgeries. With regards to treatment of palatal roots of maxillary molars, 52% do not perform surgeries on these roots, and 17% stated they will only perform the surgery if the palatal root is accessible from the facial aspect. Rather in the treatment of persistent apical periodontitis of these roots, 36% would elect to perform a second retreatment (NS-RETX), 35% would refer for extraction, and only 20%

would opt to treat with root-end surgery. With regards to the treatment of persistent apical periodontitis in mandibular second molars, 73% of respondents do not perform surgeries on these teeth, but rather 39% stated they refer these teeth for extraction, 30% would choose to perform a second NS-RETX, and 17% said they would recommend intentional replantation.
Although most private practitioners have had some form of exposure to guided technology, either reading a published article or attending a lecture on the topic, (79% have been exposed to 3DSGs, 68% have exposure to DNS) only 6% and 2% are using 3DSGs and DNS, respectively, in their practices. Only 15% of respondents stated they were extremely interested in guided endodontic surgery, affirming they want to add the technique to their current practice. The majority (62%) were somewhat interested, but need more evidence of viability prior to adding the technology to their practice. Finally, 23% reported being not at all interested in guided surgical techniques, the majority of which cited the expense of investing in a new system and the pre-surgical planning time as the primary barriers to adding the technology to their practice. More than half (55%) of the private practitioners that responded reported that they are willing to spend no more than $5000 on new technology.
Overall, 107 survey respondents identified themselves as involved in academia (57 faculty, 50 current residents). When answering the same questions about treatment of choice for palatal roots of maxillary molars with persistent apical periodontitis, 41% said they would perform root-end surgery, while 38% would elect to perform a second NS-RETX. Concerning preferred treatment options for mandibular second molars, 44% would elect intentional replantation if possible and only 19% would perform root-end surgery on these teeth. Based on the responses received, 62% reported that neither form of guided surgical techniques (3DSGs or DNS) are being incorporated into their respective curricula.

DISCUSSION

Over the last 2 decades, endodontists have reported incorporating more surgery into their clinical practices. A survey conducted in 2009 reported that 91% of responding endodontists were performing root-end surgeries, and nearly 90% were utilizing an operating microscope and ultrasonic instrumentation (5). The results of this survey were similar, as 87% of private practice endodontists report performing at least one root-end surgery per month. However, guided surgical techniques have not been as readily adopted, as only 6% report using 3DSGs and 2% report using DNS.
While the concept of guided procedures may be novel in the field of surgical endodontics, it is by no means new to dentistry. Application of surgical guides for the placement of dental implants is widespread (12, 13) and more recently there has been increased interest in the use of dynamic navigation software for improved precision and accuracy in the placement of implants (14-17). Furthermore, guided technology has newly been applied to nonsurgical procedures within endodontics. Reports demonstrating use of both 3DSGs guides as well as DNS to aid in locating calcified canals (18-20), preparing minimally invasive and precise access cavities (21, 22), and delivery of intraosseous anesthesia (23) have been published.
Interestingly, of the 24 respondents that said they use 3DSGs in their private practice, 13 (54%) use them for EMS. On the contrary, only 9 respondents reported having DNS in their office, and 6 of those 9 (67%) use the system for locating calcified canals.

The primary limitation of this study is the response rate of 8.5%, which is lower than that seen in other surveys in this area of study. One explanation for this is that the survey was sent to all active members of the AAE, which included a large population of individuals retired from the practice or endodontics or those involved in non-clinical areas of the specialty. Since these members were included, the first question of the survey removed all respondents who answered, "I no longer practice clinical dentistry," and did not affiliate with any of the previous responses. Despite this, several hundred individuals included in the original sample likely declined to complete the survey at all, thus decreasing the response rate. Another possibility is that the survey was sent out immediately following the first-ever virtual AAE Annual meeting. While this decision was strategic at first, the situation may have been such that individuals were very recently inundated with professional emails and yet another email requesting their electronic participation was not well-received.

The small sample size further diminished the results obtained from the study due to the design of the survey itself. While there were 30 questions in total, the most any given person would answer was less than 15, in order to keep the survey as brief as possible. The survey was designed in such a way that participants would be directed to the next question based upon how they answered the previous question. As a result, some questions resulted in fewer than 20 total responses, and therefore were not included in the results.

The technology available to dentists today is truly remarkable. The introduction of guided surgical techniques in endodontic microsurgery will give clinicians the necessary means to treat difficult cases with a higher degree of confidence and clinical success. Perhaps guided surgery will become a common practice in the endodontist office of the future.

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