Digitally assisted vitreoretinal surgery: A unique surgical teaching tool for beginners

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Purpose: To study the role of digitally assisted vitreoretinal surgery (DAVS) as a learning and teaching tool compared to that of the standard binocular side-scope of the conventional analog microscope (CAM).

Methods: This was a cross-sectional, observational study conducted at a tertiary eye care center and teaching institute in South India. Postgraduate residents and clinical fellows observed a predecided set of retinal surgical procedures using both DAVS and CAM. A detailed questionnaire was used to compare the participants’ subjective scoring of both the platforms in terms of level of comfort, clarity of image and stereopsis, level of understanding, and overall impression. Results: Thirty-six participants, including 20 residents and 16 fellows, took part in this study. DAVS obtained a higher score for all 15 questions compared to CAM and the differences were statistically significant. DAVS obtained a mean score of 4.80 (median: 5) whereas CAM obtained a mean score of 3.14 (median: 3) on a grading scale of 1–5 with regard to the overall experience of surgical viewing through either platform (P < 0.01). Conclusion: DAVS is a better learning and teaching tool compared to the side scope of the CAM from a learner’s perspective. Thus, DAVS can help beginners in the field of vitreoretinal surgery obtain a better understanding of the surgical steps prior to the initiation of hands-on training.

Key words: DAVS, learning tool, surgical viewing platform, teaching tool, vitrectomy

Learning and mastering surgical techniques is a highly challenging yet rewarding aspect of any surgical specialty, including ophthalmology. Retina surgery requires even more systematic and intense training because of the need of handling delicate tissues. Apart from sound theoretical knowledge, careful observation of surgeries being performed by experienced surgeons forms the mainstay of learning. Observing surgical steps through the binocular side scope of the conventional operating microscope continues to be the standard method of surgical observation by learners. Despite being a time-tested method, this has several disadvantages: only a single observer can view the surgery at any point in time, and the sitting posture of the observers becomes difficult and they are prone to developing physical discomfort and strain while viewing for long durations.

Digitally assisted vitreoretinal surgery (DAVS) platform has become available as a new state-of-the-art technology in retina surgery visualization. This technology enables three-dimensional visualization of the surgical field on a high-definition monitor not only for the surgeon but also for the assistants and observers, obviating the need for a side scope. Several studies have looked at the level of comfort and ergonomics of this system from the surgeon’s point of view[1–4]; however, the role of DAVS as a learning tool by trainees in the field of vitreoretinal surgery has not been studied in detail.

This study aimed to look at the role of DAVS as a learning and teaching tool compared to that of the standard binocular side-scope of the conventional analog microscope (CAM).

Methods

This was a cross-sectional, observational study conducted at a tertiary eye care center and teaching institute in South India after obtaining approval from the institutional review board. The study adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from each participant before inclusion into the study.

The participants included postgraduate residents who had completed at least one year and clinical fellows in the Department of Vitreous and Retina who were willing to be a part of the study. All the study participants observed a predecided set of retinal surgical procedures using both viewing systems (DAVS and CAM). All surgeries were performed by a single surgeon proficient in vitreoretinal surgery with teaching experience of more than 20 years. The surgeon was well-versed with the DAVS platform and had more than two years of experience using it.

Each study participant watched a minimum of five surgeries on each of the two platforms. The five surgeries observed on

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each platform included all three of the following categories: pars plana vitrectomies followed by the appropriate steps for a) retinal detachment, b) proliferative diabetic retinopathy, and c) idiopathic macular hole. Participants viewed the surgeries on both platforms in a random manner; DAVS was not always preceded by CAM and vice versa. The surgical microscope and wide-angle viewing system used for the study were OPMI Lumera T and RESIGHT 500 (ZEISS, Oberkochen, Germany), respectively. DAVS platform used was NGenuity 3D Visualization System (Alcon, Forth Worth, Texas, USA) along with TrueVision Visualization System (Santa Barbara, California, USA). The eyepiece of the microscope was replaced by a high-dynamic-range (HDR) camera wired to a central processing unit (CPU). A stereo image of the surgical field was projected on a 55-inch monitor and was viewed by the operating surgeon and all assistants and observers with the aid of passive polarized 3D goggles. Both the surgeon and the observers wore similar 3D goggles with the same specifications provided by the manufacturer of the DAVS system and there were no qualitative differences. Multiple observers could comfortably view the surgical procedure at the same time. Both the systems were randomly used by the surgeon based on the availability of the systems.

At the end of viewing all the surgeries, each participant was asked to fill a questionnaire. The predesigned questionnaire was designed by experienced retina surgeons and was tested on 10 observers who were similar in experience to the study participants. A principal component analysis was performed with the replies from the validation cohort to look for correlation among the items of the questionnaire. The items that were very strongly correlated and would essentially convey the same idea to the observers were clubbed and made into a single question. The final questionnaire included a total of 15 items under four sections, namely level of comfort, clarity of image and stereopsis, level of understanding, and overall impression. Replies to each question were arranged in a Likert scale from 1 to 5, with 1 being “Strongly disagree,” 5 being “Strongly agree,” and 3 being a neutral response. Each participant observed surgeries on separate days on both platforms. To ascertain anonymity, the participants were asked to fill in details in the questionnaire without using their identity.

Data analysis

Data were entered into a Microsoft Excel spreadsheet and analyzed using SPSS software (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0, Armonk, NY: IBM Corp.). Replies to the questionnaire items were categorized as a “Yes” for a reply of 4 or 5 and a “No” for a reply of 1 or 2. Data were expressed as mean ± SD for parametric variables and median for nonparametric variables, and differences between groups were determined using t test and Mann–Whitney U test for parametric and nonparametric data, respectively. P < 0.05 was considered as the level of statistical significance.

Results

A total of 36 participants were recruited in the study, which included 20 ophthalmology postgraduate residents in their second or third year of training who had not had vitreo-retina exposure previously and 16 ophthalmologists in the first 6 months of clinical fellowship in vitreous and retina. There were 17 males and 19 females, and their ages ranged from 26 to 43 years with a mean of 29.64 years. In DAVS, the overall median score for each question was 5 whereas it was 3 in the case of CAM.

Comfort

Twenty-one (58.3%) participants felt that they had a considerable amount of physical discomfort while viewing the surgeries through the CAM whereas only one (2.78%) participant experienced discomfort while using the DAVS. Thirty-one participants (86.11%) felt that they could freely communicate with the surgeon while using the DAVS, whereas only 13 (36.11%) felt so using the CAM. While using the DAVS, 33 (91.67%) participants said that their seating posture was comfortable and only 5 (13.89%) felt comfortable using the CAM.

Image quality

Thirty-one (86.11%) participants were able to perceive a stereoscopic image with good depth perception using the DAVS and only 21 (58.33%) had a similar feeling while using the CAM. Only 18 (50%) participants felt that the magnification using the CAM was sufficient, whereas 33 (91.67%) felt that their field of view was adequately magnified in the DAVS. All but one participant (97.22%) felt that they were able to view the orientation of the surgical field similar to the surgeon using the DAVS, while only 8 (22.22%) felt so using the CAM. Nineteen participants (52.78%) had difficulty in focusing on images during the course of the surgery using the CAM, but only 2 (5.56%) had such focusing issues while using the DAVS.

Understanding of surgery

All participants could clearly visualize the initial steps including port making using the DAVS while only 22 (61.11%) could do so using the CAM. Triamcinolone staining and vitrectomy were clearly viewed and understood by 35 (97.22%) participants using the DAVS whereas only 24 (66.67%) could get a clear view and understanding using the CAM. Internal limiting membrane peeling was visualized well by 35 (97.22%) participants on the DAVS and by only 22 (61.11%) on the CAM. Similarly, laser procedures were clearly viewed and understood by 35 (97.22%) participants using the DAVS in contrast to only 8 (22.22%) who felt so using the CAM.

Surgical viewing platform preference

The fourth section of the questionnaire assessed the overall impression and surgical viewing platform preference of the participants. Thirty-four (94.44%) participants preferred to watch further surgeries using the DAVS, and only 8 (22.22%) preferred to do so using the CAM. Thirty-three (91.66%) participants felt that the DAVS had helped them enhance their knowledge and understanding of the surgical procedure, whereas only 17 (47.22%) felt so about the CAM. Thirty-five (97.22%) participants said that they would recommend DAVS as the preferred learning tool for vitrectomy surgeries for trainees, whereas only 11 (30.56%) had this opinion about the CAM. When asked to grade the overall experience of surgical viewing through either platform, 5 being the best and 1 being the worst, DAVS obtained a mean score of 4.80 (median: 5) whereas CAM obtained a mean score of 3.14 (median: 3). The scores obtained by DAVS were higher than those obtained by CAM for all 15 questions and the difference was statistically significant (P < 0.01) in all of them [Table 1].
Table 1: Comparison of participants response between DAVS and CAM

| Question                                                                 | DAVS | CAM | P     |
|--------------------------------------------------------------------------|------|-----|-------|
| 1.1 There was no physical discomfort while viewing the surgical procedure.| 1 0 0 10 25 5 1 (2.8%) 32 (97.2%) | 5 16 11 3 1 2 21 (58.3%) 4 (11.1%) | <0.001 <0.001 |
| 1.2 I was able to freely communicate with the surgeon during the surgery.| 1 1 3 11 20 5 2 (5.6%) 31 (86.1%) | 6 6 11 9 4 3 12 (33.3%) 13 (36.1%) | 0.003 <0.001 |
| 1.3 My seating posture was comfortable.                                  | 0 0 3 14 19 5 0 33 (91.7%) | 6 15 10 4 1 2 21 (58.3%) 5 (13.9%) | <0.001 <0.001 |
| 2.1 I was able to get a clear binocular stereoscopic view of the surgical field. | 0 1 4 9 22 5 1 (2.8%) 31 (86.1%) | 0 3 12 14 7 4 3 (8.3%) 21 (58.3%) | 0.31 0.008 |
| 2.2 I was able to get a good magnified view.                            | 0 0 3 10 23 5 0 33 (91.7%) | 1 8 9 14 4 3.5 9 (25%) 18 (50%) | <0.001 <0.001 |
| 2.3 The orientation that I could view was the same as the surgeon's view. | 1 0 0 11 24 5 1 (2.8%) 35 (97.2%) | 5 13 10 4 4 2.5 18 (50%) 8 (22.2%) | <0.001 <0.001 |
| 2.4 There were no focusing issues during the course of the surgery.     | 0 2 3 10 21 5 2 (5.6%) 31 (86.1%) | 4 15 6 9 2 2 19 (52.8%) 11 (30.5%) | <0.001 <0.001 |
| 3.1 I could visualize the initial steps including port making clearly.  | 0 0 0 2 34 5 0 36 (100%) | 2 3 9 14 8 4 5 (13.9%) 22 (61.1%) | <0.001 <0.001 |
| 3.2 I could visualize triamcinolone staining and vitrectomy clearly.    | 0 0 1 6 29 5 0 35 (97.2%) | 1 4 7 15 9 4 5 (13.9%) 24 (66.7%) | <0.001 <0.001 |
| 3.3 I could visualize ILM staining/peeling clearly.                      | 0 0 1 7 28 5 0 35 (97.2%) | 0 3 11 15 7 4 3 (8.3%) 22 (61.1%) | <0.001 <0.001 |
| 3.4 I could visualize the laser procedures clearly.                     | 0 0 1 8 27 5 0 35 (97.2%) | 8 14 6 5 3 2 22 (61.1%) 8 (22.2%) | <0.001 <0.001 |
| 4.1 I would prefer to watch further surgeries using this same modality. | 0 0 2 1 33 5 0 34 (94.4%) | 1 10 17 7 1 3 11 (30.5%) 8 (22.2%) | <0.001 <0.001 |
| 4.2 I felt that this surgical viewing mode has helped enhance my knowledge and understanding of the surgical procedure. | 0 1 2 3 30 5 1 (2.8%) 31 (97.7%) | 2 7 10 16 1 3 9 (25%) 17 (47.2%) | <0.001 <0.001 |
| 4.3 I would recommend this as the preferred teaching tool in our institution for vitrectomy surgeries. | 0 1 0 4 31 5 1 (2.8%) 35 (97.2%) | 4 10 11 10 1 3 14 (38.9%) 11 (30.5%) | <0.001 <0.001 |
| 4.4 Grade your overall experience of surgical viewing through this system, 5 | 0 0 1 5 30 5 0 35 (97.2%) | 1 7 16 10 2 3 8 (22.2%) 12 (33.3%) | <0.001 <0.001 |

being the best and 1 being the worst.
Discussion

Three-dimensional digitally assisted vitreoretinal surgery system (DAVS) is one of the latest innovations in the field of vitreoretinal surgery. Advantages previously described by surgeons are better stereopsis, better depth of field, enhanced field of view, better resolution, and improved ergonomics.\textsuperscript{[1,3,5,6]}

Previously, studies have described the reduction in physical stress and neck pain among surgeons operating the DAVS in a “heads-up” position compared to the conventional operating microscope.\textsuperscript{[7,8]} However, this is the first-of-a-kind study to evaluate the perceptions of a nonoperating observer during vitreoretinal surgeries. CAM has several disadvantages compared to DAVS. Only one observer can view the surgical steps at any point in time, thereby making mass learning difficult. Straining to view through the side scope has also been reported to induce physical stress and discomfort for the viewer. While switching between observers, the interpupillary distance and focus of the observing scope need to be changed each time, which can cause considerable disturbance to the operating surgeon. Many a time, the side scope may not be fitted with an image inverter and thereby the observer does not get to visualize the surgical field in the same orientation as the surgeon. A beam splitter with a pre-set proportion of light-split is used to direct a part of the light emerging from the microscope into the side scope. Thus, the amount of light that the observer views is, by default, always lesser than what the surgeon views, thereby compromising the quality of the image viewed by the trainee.\textsuperscript{[9]} Moreover, during endolaser, an additional laser filter needs to be fitted to the side scope. The abovementioned points make mass surgical viewing and learning challenging with CAM.

However, DAVS provides a stereoscopic view of the surgical field on a large monitor that can be viewed by multiple individuals simultaneously, including the surgeon, assistants, and observers.\textsuperscript{[10]} Goggles can be provided to all the observers during a single surgery, which overcomes the problem faced during mass teaching using CAM.

In our study, the participants’ response clearly shows that the level of physical discomfort was much lesser while viewing the surgeries using DAVS compared to the CAM. These can be attributed to the fact that in DAVS, the viewers did not have to crane over to look into the binocular side scope and could assume any comfortable seating position while viewing the surgery on the monitor. Absence of such physical concerns also facilitated them to freely communicate with the surgeon. Hence, DAVS provided better ergonomics not only to the surgeon but also to the observer.

Studies have demonstrated the perceived superiority of DAVS over CAM in terms of image magnification and image clarity to the operating surgeon.\textsuperscript{[2-10]} In our study too, the observers felt that DAVS was better than CAM in image clarity and stereopsis. They felt that DAVS provided a better magnified stereoscopic view of the surgical field with good depth perception compared to the CAM. The operating surgeon could easily point toward retinal structures; this aided in teaching the observers regarding tissue handling during surgeries. The need for an additional image inverter for the side scope was also alleviated while using the DAVS. Similarly, an additional laser filter that needs to be fitted to the side scope of the CAM is not necessary while using the DAVS.

Overall, the level of surgical step visualization and understanding were better in the DAVS than in the CAM. This was possibly because of the better magnification, clarity, and contrast provided by the DAVS, and the ease with which the instructor could demonstrate surgical steps.

The overall score obtained by DAVS was higher than that obtained by CAM, and participants indicated that they would prefer DAVS as their learning tool of choice for observing vitreoretinal surgeries. It must be understood that retina surgical techniques and visualization platforms have been evolving exponentially since the 1970s.\textsuperscript{[11-14]} Surgery using conventional microscopes has been the norm across the globe not only for posterior segment surgeries but also for anterior segment surgeries; surgeons have been using these quite efficiently. However, with the advent of the DAVS platform, surgeons have been pushed into a newer world of surgical visualization, which both experienced surgeons and fresh graduates are slowly getting oriented to. DAVS offers ergonomic and other practical benefits that are not available while using CAM. Maybe because of this reason, fresh graduates and beginners in retina surgery in our study who did not have orientation of retina surgeries through the CAM might have perceived DAVS as a much better platform. This study does not endeavor to minimalize the importance of CAM. However, it puts forward the scenario in a comparative manner; hence, the CAM scores might have been low.

There are a few limitations in our study. All items in our questionnaire were given equal weightage. Moreover, the items of the questionnaire were prepared based on the opinion of retina surgeons experienced in using the DAVS platform. Although we do agree that there may be variability in the choice of questions according to the perception of observers, this is a first-of-a-kind study and may serve as a basis for future such study designs. Further, this study has just evaluated the role of DAVS as a teaching tool by observation. However, the perception of DAVS as a hands-on surgical platform and its role in the training curve of young retinal surgeons also needs to be evaluated in a separate study.

Conclusion

This study is, to the best of our knowledge, the first in India to assess the role of DAVS as a tool to aid visualization and learning of steps of vitreoretinal surgical procedures by observation. It demonstrates that DAVS is a better learning and teaching tool compared to the side scope of the CAM from a learner’s point of view. DAVS can prove to be a gamechanger in vitreoretinal surgical training, delivering an overall better understanding of the surgical steps and procedures to the trainees and hence making the learning experience more holistic and complete.

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Conflicts of interest
There are no conflicts of interest.
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