Original Article

Comparison of clinical outcomes between “heads-up” 3D viewing system and conventional microscope in macular hole surgeries: A pilot study

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Purpose: To compare clinical outcomes of patients undergoing macular hole surgery with heads-up three-dimensional (3D) viewing system and conventional microscope. **Methods:** In all, 50 eyes of 50 patients with stage 3 or 4 macular hole were randomized and macular hole surgery [inverted internal limiting membrane (ILM) flap technique] was performed in 25 eyes using 3D viewing system and 25 eyes using conventional microscope. All surgeries were performed by a single surgeon. Patients were followed up for a period of 3 months. Logarithm of the minimum angle of resolution (logMAR) visual acuity, macular hole index, intraoperative parameters such as total surgical time, total ILM peel time, number of flap initiations, duration of Brilliant Blue G dye exposure, illumination intensity, postoperative logMAR visual acuity, and macular hole closure rates were recorded and compared between the two groups. **Results:** The mean age was 67.92 ± 7.95 and 67.96 ± 4.78 years in both groups, respectively ($P = 0.98$). Gender ($P = 0.38$) and right versus left eye ($P = 0.39$) were also comparable. Preoperative and postoperative best-corrected visual acuity ($P = 0.86, 0.92$), macular hole index ($P = 0.96$), total surgical time ($P = 0.56$), total ILM peel time ($P = 0.49$), number of flap initiations ($P = 0.11$), and macular hole closure rates ($P = 0.61$) were not statistically significant when compared between the two groups. Illumination intensity of microscope (100% vs 45%) and endoillumination (40% vs 13%) were significantly less in the 3D viewing system. **Conclusion:** The clinical outcomes of macular hole surgery using 3D viewing system are not inferior to that of conventional microscopes, and it has the added advantages of better ergonomics, reduced phototoxicity, peripheral visualization, magnification, and less asthenopia, and it serves as a good educational tool.

Key words: 3D heads-up viewing system, digitally assisted vitreoretinal surgery, macular hole

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Digitally assisted vitreoretinal surgery (DAVS) is the latest and the most intriguing advancement in the field of vitreoretinal surgeries. The “heads-up” three-dimensional (3D) viewing system [Fig. 1] for retinal surgeries offers many technical advantages[1,2] to surgeons which include performing surgeries in a more physiologically comfortable position. It allows high-definition visualization of the retinal periphery with better magnification, presence of filters to enhance visualization of different anatomical structures, and lower illumination levels.[3] It also serves as an efficient teaching tool as both the surgeon and the audience view the same 3D display using passive polaroid glasses.

With advancing technologies in the field of ophthalmology, there is a trend towards improved success rates of various surgeries. To the best of our knowledge, there is no study in literature comparing the outcomes of “heads-up” 3D vision system with conventional microscopes in vitreoretinal surgeries. This is the first study comparing the functional and anatomical outcomes of macular hole surgery done using 3D system with those done using conventional ocular microscopes.

Methods

This prospective, randomized, comparative study was approved by the Institutional Ethics Committee and was performed in accordance with the tenets of Declaration of Helsinki. A single surgeon performed all surgeries within 3 months duration. In all, 50 patients with idiopathic macular holes were scrutinized and were equally randomized into two groups. Patients with macular hole stages 3 and 4 (according to Gass classification) and those who consented for surgery were included in the study. Patients with macular hole secondary to trauma, myopia, or other causes, patients with other ocular comorbidities, and those not willing to follow-up were excluded from this study. The first group underwent surgery using DAVS (group 1) and the second group underwent surgery using conventional microscope (group 2). Pars plana vitrectomy with multilayered inverted internal limiting membrane (ILM) flap technique and 20% SF6 tamponade was the universal procedure in all cases [Fig. 2].

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Figure 1: Surgeon taking the "'heads heads-up' up" position while using digitally assisted vitreoretinal surgery

For each patient, we documented age, gender, duration, preoperative best-corrected visual acuity on (LogMAR) acuity chart, and macular hole indices. Intraoperative data included total surgical time, time taken for ILM peeling, number of flap initiations, illumination levels used in microscope and endoillumination, time taken to stain ILM with Brilliant Blue G dye (BBG), and surgeries that required repeat staining with BBG dye.

Postoperative evaluation was carried out at first day, first week, first month, and third month. A minimum of 3 months follow-up was considered mandatory for all patients. Postoperative data recorded were best-corrected visual acuity at each follow-up and type of macular hole closure. Preoperative and postoperative swept source optical coherence tomography [Figs. 3 and 4] and fundus photography were taken at all follow-ups. Data were analyzed using IBM SPSS 23 software, and significance level was set at less than 0.05.

Results

Demographic profile

We carried out the study in 50 patients out of which 25 patients underwent macular hole surgery using "heads-up" retinal surgery and 25 patients underwent surgery using traditional ocular microscope. The mean age was 67.92 ± 7.95 years in the first group and 67.96 ± 4.78 years in the second group. The mean age was comparable between the two groups (*P* = 0.98). There was also no difference with respect to gender (*P* = 0.38) and right versus left eye (*P* = 0.39) in both the groups.

Best-corrected visual acuity, as measured by logMAR, showed no significant difference between the two groups at the time of examination (*P* = 0.86) and at the end of 3 months (*P* = 0.92). The preoperative macular hole index was also comparable between the two groups (*P* = 0.96) [Table 1].

Intraoperative parameters

Illumination levels, total surgical time, ILM peel time, number of flap initiations, and duration of BBG exposure were recorded and compared between the two groups. The mean illumination power of microscope was 45% in group 1 and 100% in group 2. The mean endoillumination was 13% in group 1 and 45% in group 2. The total surgical time was 30.32 ± 3.66 min in the first group and 29.6 ± 4.92 min in the second group. The difference in the duration of surgery was not statistically significant between the two groups (*P* = 0.56). The time taken for ILM peel was 308.48 ± 56.53 s in the first group and 298.04 ± 48.36 s in the second group. The difference between the two groups was not significant (*P* = 0.48). The number of ILM flap initiations was 15.84 ± 3.37 in the first group and 14.52 ± 2.2 in the second group and the difference was not significant (*P* = 0.11). The duration of BBG exposure in group 2 was 120 s in all patients, whereas the duration was only 90 s in group 1. In spite of the longer duration in group 2, we had to restain ILM with BBG in two patients, whereas none of the patients in group 1 had to be restained.

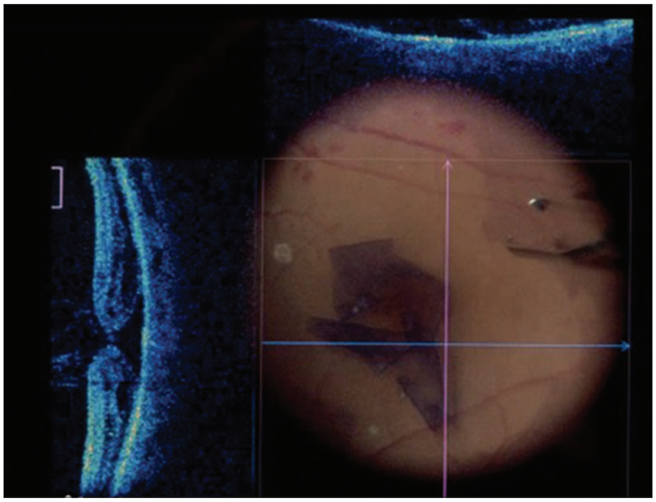

Figure 2: Intraoperative OCT grab showing successful inverted internal limiting membraneILM flap technique on digitally assisted vitreoretinal surgery

Table 1: Demographic and clinical outcomes between two groups

Variable	3D viewing system (*n*=25)	Conventional microscope (*n*=25)	*P*
Age (years)	67.92±7.95	67.96±4.78	0.98
Gender, *n* (%)			
Male	11 (44)	8 (32)	0.38
Female	14 (56)	17 (68)	
Eye, *n* (%)			
Right	12 (48)	15 (60)	0.39
Left	13 (52)	10 (40)	
Preoperative (logMAR)	1.108±0.35	1.093±0.23	0.86
2 Months (logMAR)	0.6132±0.27	0.621±0.27	0.92
MHI	0.424±0.1	0.422±0.09	0.96
Surgical time	30.32±3.66	29.6±4.92	0.56
ILM peel time	308.48±56.53	298.04±48.36	0.49
Number of flap initiations	15.84±3.37	14.52±2.2	0.11
BBG dye exposure (s)	90	120	0.02
MH closure, *n* (%)			
Type 1	23 (92)	22 (88)	0.61
Type 2	2 (8)	3 (12)	

3D: Three-dimensional, logMAR: Logarithm of the minimum angle of resolution, MHI: Macular hole index, ILM: Internal limiting membrane, BBG: Brilliant Blue G dye, MH: Macular hole

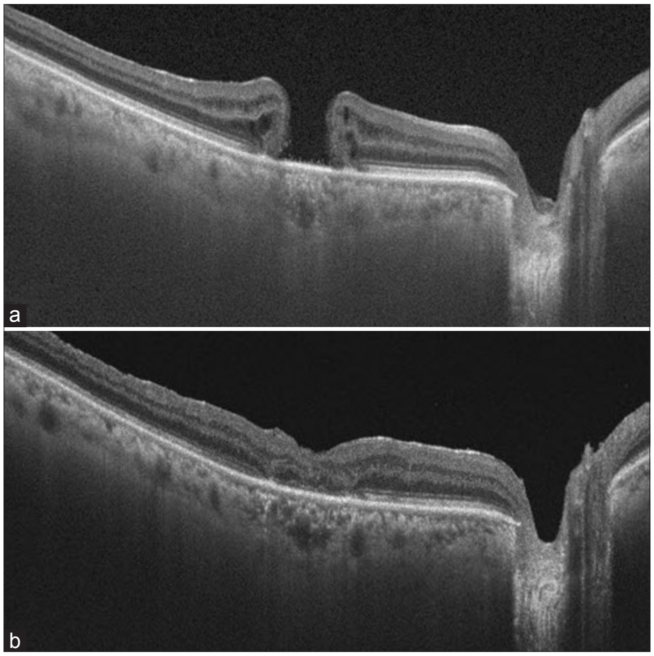

Figure 3: (a) Preoperative OCT image of a patient with stage 4 macular hole. (b) Postoperative OCT image. (Group group 1)

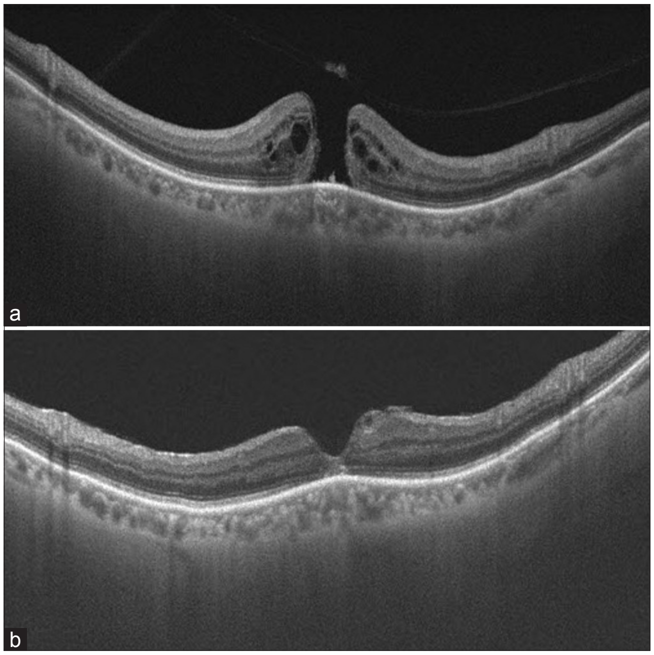

Figure 4: (a) Preoperative OCT image of a patient with stage 3 macular hole. (b) Postoperative OCT image. (Group group 2)

Postoperative outcomes

Postoperative BCVA was compared between the two groups. The final BCVA in the first group was 0.6132 ± 0.26 logMAR and it was 0.6212 ± 0.27 logMAR in the second group. The results were comparable between the two groups ($P = 0.92$). Both the groups had a significant improvement of vision from baseline to final visual acuity at 3 months follow-up ($P = 0.01$). However, comparing the improvement between the two groups was comparable.

Of the 25 patients in group 1, 23 patients had type 1 macular hole closure and 2 patients had type 2 closure; whereas in group 2, 22 patients had type 1 closure and 3 patients had type 2 closure. The results were not significant ($P = 0.608$).

Discussion

The "heads-up" 3D viewing system has provided a new dimension of viewing experience to ophthalmic surgeons and has offered several advantages compared with conventional system. The setup entails three major components: two 1080p cameras mounted on the microscope in place of the oculars; a central processing unit that processes the images and also has an operating system with preinstalled video recording and editing software; and a 55-inch 4K OLED display screen that is positioned at the foot end of the patient about 6 feet from the surgeon. The surgeon and observers wear passive polaroid glasses to get a 3D view of the surgery. There is very minimal relay time between the steps of surgery and the video projected on the screen. The surgeon takes a heads-up position while performing the surgery. A novel feature is the introduction of color filters to enable visualization of specific anatomical structures. A yellow filter may theoretically decrease exposure time and concentration needed to stain ILM with BBG dye. A blue filter shows up the vitreous better when tagged with triamcinolone acetonide. A green/red free filter helps with visualization in cases of vitreous hemorrhage. Digital image processing allows magnification without loss of resolution and has the potential to eliminate flat lens use for macular surgery. It also allows enhanced visualization of the periphery up to the ora serrata with very good magnification.

Regarding all novel systems, this system too has a learning curve which was evident with increased duration of surgery and ILM peel time with the first few cases, which dropped significantly with subsequent surgeries.

Benefits

Many theoretical benefits have been postulated. A heads-up position allows the surgeon to straighten his or her back and even rest on the back rest. A survey of English ophthalmologists has revealed that 50% suffer from back pain.[4] Improved ergonomics of the system would help lower the incidence of back pain.

Retinal phototoxicity is a rare but proven risk with vitreoretinal surgery.[5,6] Digital image enhancement helps reduce illumination power to a considerable degree, decreasing the phototoxicity to retinal pigmented epithelium cells. This could be explained in our study as patients who underwent macular hole surgery with 3D viewing system attained better postoperative visual acuity compared with those who underwent surgery using conventional microscope although the comparison was not significant.

Color filters reduce the quantity and the duration of dye exposure, decreasing the toxicity[7] and enabling the surgeon to have a better view of intraocular structures.

Enhanced depth of field and better stereopsis enable the surgeon to focus on the point of interest while allowing wider view of different planes. It also reduces glare of the instruments while providing even image brightness. Less asthenopia is an advantage as the surgeon does not accommodate while viewing through the eyepiece for a long time as 3D systems do not require near vision. Because all the observers in the operating room can put on polaroid glasses and view exactly the same image as the surgeon with minimal relay time, teaching is enhanced.[8]

Conclusion

With all the postulated benefits to the surgeon and noninferiority established in clinical outcome, we conclude that 3D system opens up an initial step in digital evolution of surgical visualization of vitreoretinal surgeries, both as an operative and an educational tool. However, the major drawback is the cost factor which becomes indispensable with the progress in the field of ophthalmology in modern era.

This study reflects the initial experience of 3D viewing system in a single center. In our experience, the 3D viewing system appears to as safe and effective as the conventional microscope with the added advantage of surgeon comfort and teaching experience.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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