3D (Three Dimensional) Picture in Picture (PIP) HDMI Versus 2D (Two Dimensional) Endoscopic Viewing System in IOL Drop

Hanspal BHİNDER[1]

ABSTRACT

Purpose: Purpose of this study is to compare the use of 2d endoscopic procedure system with 3D-PIP-HDMI Visualization system and evaluate its effect on orientation of the monitor, Loss of hand eyes coordination, Field of view, Error in grasping the IOL due to lack of stereopsis and frequent head turning which is a great problem in using the endoscope in a microsurgical environment as the surgeon has to switch from the microscope ocular view to the endoscope monitor view or vice versa. The aim of the study is to evaluate a novel 3D-PIP-HDMI endoscopic viewing system and observe its role.

Material and Methods: Five cases out of 10 (Cases number 1,3,5,7,9) of IOL drop were operated using standard 2D endoscopy system and rest five cases (Cases number 2,4,6,8,10) were operated using 3D-PIP-HDMI endoscopic visualization system. After each procedure, surgeon completed oxford grading assessment of various parameters (Table 1,2).The cases were subjected to statistical analysis.

Results: 3D-PIP-HDMI endoscopy viewing system improved the orientation of the video monitor, hand eyes coordination, quality of picture, correct picking up of Dropped IOL, stereopsis in all the cases which was highly statistical significant (P<0.0024).

Conclusion: 3D-PIP-HDMI Visualization system provides both the real time 3d videos from endoscope and surgical Microscope which is projected in a single LED, monitor Panel at the same time. It helped us to overcome the limitation related to the standard 2d endoscopy procedures.

Key Words: Endoscope, vitrectomy, three dimensional endoscopy, 3D endoscope, 3D-PIP-HDMI visualization system, Picture in picture, IOL drop, stereopsis.

INTRODUCTION

The standard Endoscopic procedures have been used in ophthalmology since 1934, when Thorpe first described the use of an endoscope within the vitreous cavity.[1]

There are numerous advantages of ophthalmic endoscopy like viewing far peripheral retina inside retinal tear, underneath the iris and facilitates removal of hidden cortical fragments or membrane growth over the ciliary body which is not possible with best biome or wide angle vitrectomy lens. Standard 2d Endoscopy has been used in various ocular procedures [2-14] But there are few important limitations of this system such as lack of stereopsis,[15-18,20,21] a relatively steep learning curve.[17-19] television monitor control 1517, difficulty in hand eyes coordination[19] and low resolution image quality.[18,19]

The objective of this study is to combine the microscope and the endoscope views in the same setting, through 3D-PIP-HDMI visualization imaging system and to overcome the limitations associated in intraocular standard 2D endoscopic procedures.

1- M.D. Associate Professor, Guru Gobind Singh International Eye Centre&Eye Bank Delhi/INDIA
BHINDER H., visioncareindia@gmail.com

Geliş Tarihi - Received: 31.10.20154
Kabul Tarihi - Accepted: 10.03.2015
Ret-Vit 2015;23:301-307

Yazışma Adresi/Correspondence Adress: M.D., Associate Professor, Hanspal BHINDER
Department Of Retina Guru Gobind Singh International Eye Centre& Eye Bank
31, Defence EnclaveVikasMarg, New Delhi - 110092, INDIA

Phone: +91 999 016 01 60
E-mail: visioncareindia@gmail.com

In this study, we evaluate the view provided by a novel 3D-PIP-HDMI endoscopic viewing system and a traditional 2d endoscopic viewing system during the performance of a standard procedural paradigm, assessing worldwide limitations like orientation of the monitor, loss of hand eyes coordination, field of view, quality of images, quality of images during head movement, lack of stereopsis, error in grasping the IOL due to lack of stereopsis and frequent head turning to see microscopic view then switching over to see endoscopic view in the monitor.

MATERIALS AND METHODS

We evaluated 3D-PIP-HDMI endoscopic visualization system and standard 2d endoscopy with particular focus on various limitations like orientation of the monitor, hand eyes coordination, field of view, quality of images (color/contrast), quality of images during head movement, stereopsis (depth perception),error in grasping the IOL due to the lack of stereopsis and the head turning in total 10 consecutive cases of dropped IOL managed at Guru Gobind Singh International Eye Centre during the period May 2013-April 2014. Cases were taken alternately for 3D-PIP-HDMIendoscopic visualization system and standard 2d endoscopy.

Inclusion Criteria: All cases of IOL drop and dislocation were included in the study however vitreous hemorrhage, endopthalmitis or any retinal pathology were excluded from the study. The protocol was approved by the Institution Review board. All the patients or their legal representatives signed an informed consent form. All the ten cases of IOL drop were operated by single surgeon. Five cases (Cases number 1,3,5,7,9) of IOL drop were operated using standard 2d system and rest five cases (Cases number 2,4,6,8,10) were operated using 3D-PIP-HDMI endoscopic visualization system. After each procedure, surgeon completed oxford grading assessment from grade 1 to grade 4 (Grade1-Excellent; Grade 2: Good; Grade 3: Moderate and Grade 4:poor) as given in Table 1 for standard 2d endoscopic system and Table 2 for 3D-PIP-HDMI endoscopic visualization system.

3D-PIP-HDMI Visualization System

There are four primary hardware components to our endoscopic system station as described in Figure 1,2.

1. An image generation platform 3D-PIP-HDMI (picture in picture/Zoom) visualization system (MPZ-2000, Medicalproductzone) with a remote control.

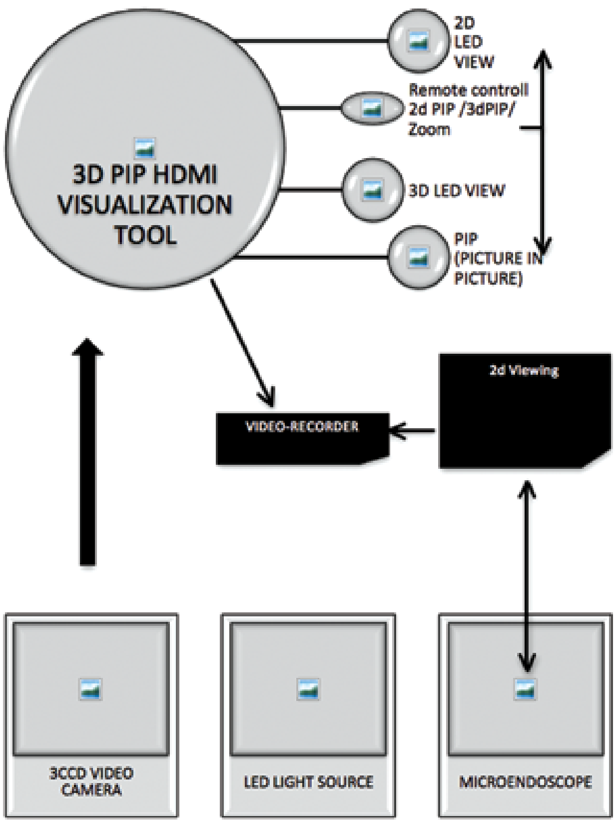

Figure 1: *Diagrammatic view of 3d PIP HDMI visualization system and standard 2D Endoscopy system.*

Figure 2: *3D PIP HDMI endoscopic visualization System. Black arrow 1:3D (Three Dimensional) PIP (picture in picture) Endoscopic Visualization System. Black arrow 2: It is a Video recorder. Black arrow 3: It is a Remote Control for 3d PIP HDMI visualization system. Black arrow 4: LED Monitor. Black arrow 5: Endoscopic Unit.*

2. Polarize glasses that allow the surgeon and assistant to see the 3d view of endoscopic procedure in LED, Monitor panel.
3. LED, Monitor panel with HDMI port/S-video port.
4. The fourth component required for this application is Micro endoscope system (Endooptiks Inc), which consist of 19 gauge micro endoscope, with a light source, video camera and video recorder.

The integration of video images from microscope and endoscope, is accomplished by capturing both the real time videos from endoscope and surgical Microscope which is projected in a single LED, monitor Panel at the same time (Figure 3), with the help of a specially designed 3D-PIP-HDMI visualization system(MPZ-2000, Medicalproductzone) which generates two halves on the left and right, with the entire frame for the left eye scaled down horizontally to fit the left half of the frame, and the entire frame for the right eye scaled down horizontally to fit the right side of the frame with Picture in Picture (PIP) technology. These pictures are processed and superimposed by 3D PIP visualization system hardware which is best viewed by wearing polarized glasses. Viewing angled of the monitor and the surgeon was kept less than 15 degree with distance of 5 feet for 22 inch LED, monitor.

The viewing displayed, could be switched between real time 2D or 3D video along with PIP (Picture in Picture) along with zoom feature with the help of a wireless remote control which enables the surgeon to view both the images.3D-PIP-HDMI Visualization System is exclusively designed to provide more clear images of micro endoscope. It furthers, helps to eliminate honeycombing layer digitally without any time lag and no complicated setting is required, as it has preset function.

Surgical Technique

All surgeries were performed at one institution by a single surgeon between May 2013-April 2014. Briefly, it was performed as follows: All the procedures were performed using peribulbar anesthesia under monitored anesthesia care. Two small, localized peritomies were created supero temporally, supero medially. Self maintaining 20 gauge infusion line was placed followed by two[19] gauge sclerotomies which were created 3.5 mm posterior to the surgical limbus one for micro-endoscope another for vitrector. The 19 gauge micro-endoscope probe was checked before placing it in the eye and a clinically adequate image was obtained with the probe before its insertion into the eye (Figure 3). Vitrectomy was done using 20 gauge vitrector. In all the cases just before grasping the IOL, irrigation infusion line was stopped.[20] gauge microforcep was used to grasp IOL in all the cases. Dislocated IOL was placed in the ciliary sulcus. After the procedure sclerotomies sites were closed with 7 o vicryl suture.

Statistical Analysis

All statistical data was recorded on a spreadsheet and analyzed using Microsoft Excel (Office 2007) and Statistica (StatSoft) the various limitation factors were compared in all cases of standard 2d endoscopy and 3d endoscopy by using the K-Means Hierarchical Clustering, Joining Test (Table 3 and Figure 6).

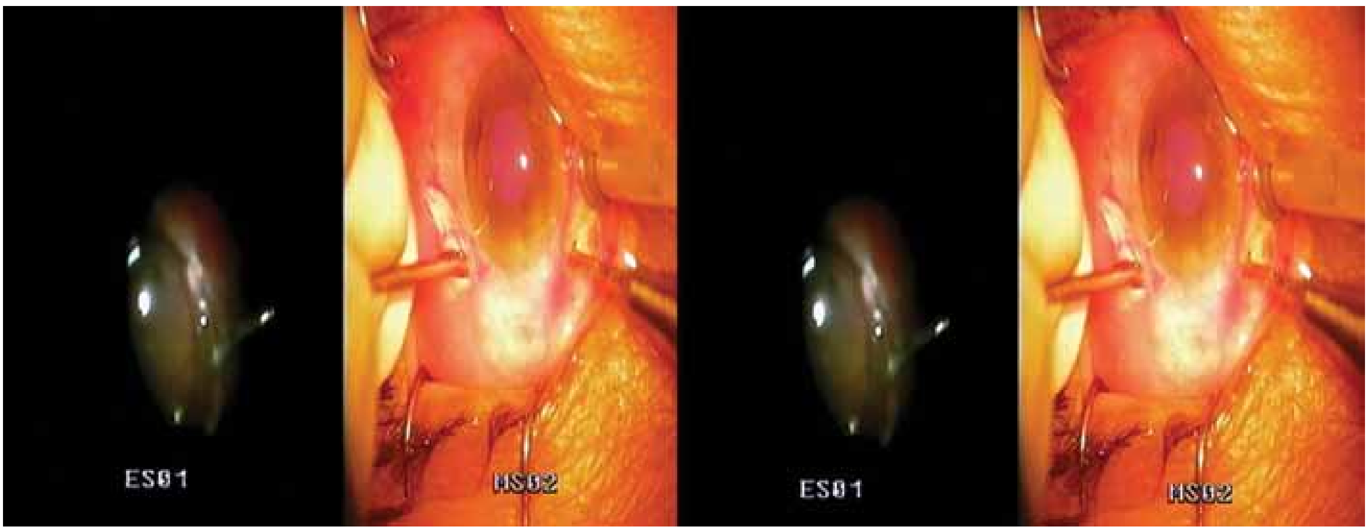

Figure 3: *Set of Endoscopic view (ES01) and microscopic view (MS01) for the Right&left eye (Side by side view). In (ES01) IOL is grasped by the microforcep; In (MS01) microscopic view endoscope shaft, microforcep and infusion line can be seen.*

RESULTS

In present study evaluation of eight (8) limitations were done using oxford Grading system in 2d viewing system (Table 1) and 3D-PIP-HDMI visualization endoscopic system (Table 2) in all the cases, which are summarized in table 1, 2, and figure 4, 5. Further, all the statistical data was compared by using the K-Means Hierarchical Clustering, Joining Test (Table 3 and Figure 6).

3D-PIP-HDMI visualization endoscopic showed excellent orientation of monitor, hand eye coordination, stereoscopic vision, quality of image, error in grasping the IOL, head turning as compared to standard 2d endoscopy viewing system cases which was highly statistical significant (P<0.0024). However the study did not show any statistical significant relation in regards to field of view and Quality of Image during Head movement in both 2D and 3D endoscopic viewing systems.

DISCUSSION

It is well established that while doing standard 2d endoscopic procedure one loses stereopsis.[15-18,21] It has been established in previous studies[17-19] that there is definitely a learning curve for the surgeon due to lack of stereopsis in the 2D endoscopy system. The single screen video monitor does not provide any stereoscopic information.

The surgeon could only accurately place the video monitor in space; as the location of the original image is an unknown. The resultant image on the monitor contains no spatial information of microscopic view, and no concept of hand eyes coordination.

Even with the use of a high-resolution monitor by some authors[22] failed to overcome the limitations of 2d endoscope system as steep learning curve, limited field of view, lack of stereopsis. However the role of 3D PIP-HDMI visualization system has helped to see both stereo-endoscopic as well as microscopic view in the same monitor in the present study.

Table 1: *Standard 2D endoscopy system result.*

Cases No.	Orientation of the monitor	Hand eyes coordination	Field of view	Quality of images (color/ contrast)	Quality of images during head movement	Stereopsis	Error in grasping the IOL	Head turning
1	4	4	2	3	3	4	4	3
3	4	4	2	3	3	4	4	3
5	4	4	2	3	3	4	4	3
7	4	4	2	3	3	4	4	3
9	4	4	2	3	3	4	4	3

Oxford grading assessment 1-4 (1; Excellent, 2; Good, 3; Moderate 4; poor).

Abbreviation	**Explanation**
2D	Two Dimensional.

Table 2: *3D PIP HDMI endoscopic system result.*

Cases No.	Orientation of the monitor	Hand eyes coordination	Field of view	Quality of images (color/ contrast)	Quality of images during head movement	Stereopsis	Error in grasping the IOL	Head turning
2	1	1	2	1	3	2	1	1
4	1	1	2	1	3	2	1	1
6	1	1	2	1	3	2	1	1
8	1	1	2	1	3	2	1	1
10	1	1	2	1	3	2	1	1

Oxford Scoring 1-4 (1; Excellent, 2; Good, 3; Moderate 4; poor).

Abbreviation	**Explanation**
3D	Three Dimensional
PIP	Picture in Picture
HDMI	High-Definition Multimedia Interface

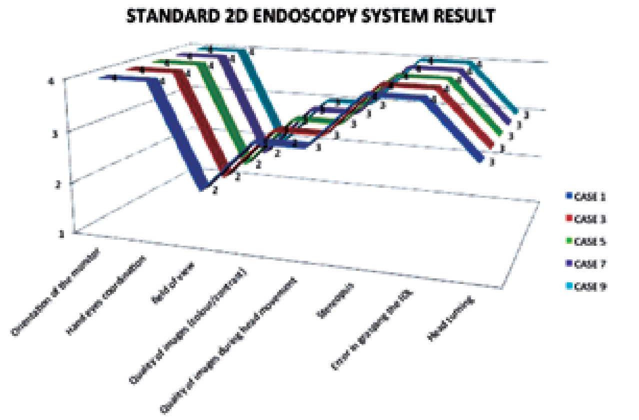

Figure 4: *Line chart showing various parameters results in cases 1,3,5,7,9 with standard 2d endoscopy system result. Oxford Grading system was distributed as follow: Grade 1;Excellent, Grade 2; Good, Grade 3; Moderate and Grade 4; poor.*

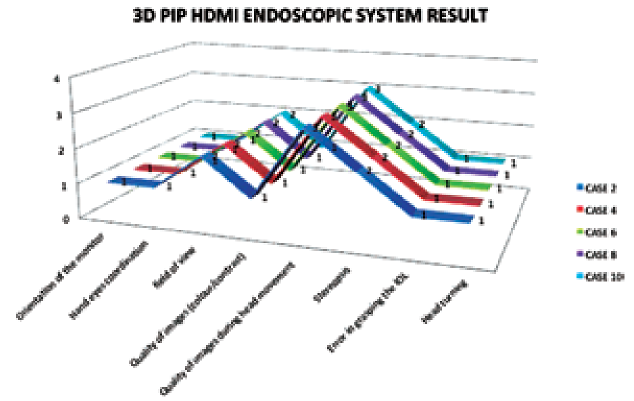

Figure 5: *Line chart showing various parameters results in cases 2, 4, 6, 8,10 with 3D PIP HDMI endoscopic system .Oxford Grading system was distributed as follow: Grade 1; Excellent, Grade 2; Good, Grade 3; Moderate and Grade 4; poor.*

To the best of our knowledge this is the first study on the 3D-PIP-HDMI endoscopy viewing system incorporated in endoscopic IOL Drop management and it overcomes the problems related to the standard 2D endoscopy procedures.

This study furthers evaluated 3D-PIP-HDMI endoscopic visualization system and standard 2D endoscopy in ten cases since May, 2013 and April 2014. Our oxford grading assessment in present study demonstrated the advantages of 3D over 2D visualization system. 3D-PIP-HDMI endoscopic visualization system improved the performance and visualization of the surgeon and solved the worldwide limitations 15-21 of standard 2D endoscopy, which are listed in the table 1, 2, 3 and Figure 4-6. In a present study, we noted that the grading was consistent in all the cases for each limitation as limitations were independent of patient factor which was highly statistical significant (P<0.0024).

In 2D endoscope viewing system surgeon has to switch from the microscope view to the endoscope monitor view or vice versa as the result of which orientation of the monitor and hand eye coordination is poor (Grade 4) in all the cases but there was excellent improvement (Grade 1) in orientation of the monitor, hand eyes coordination with 3D-PIP-HDMI endoscopic visualization system. The surgical orientation during surgery was enhanced because of the visualization of both endoscopic and microscope view at the real time, in a single display, which was possible with the help of the 3D-PIP-HDMI endoscopic visualization system. Because this, the advantages of both the devices can be exploited simultaneously. This allowed us to use the endoscope as an assistant to the microscope in an efficient way.

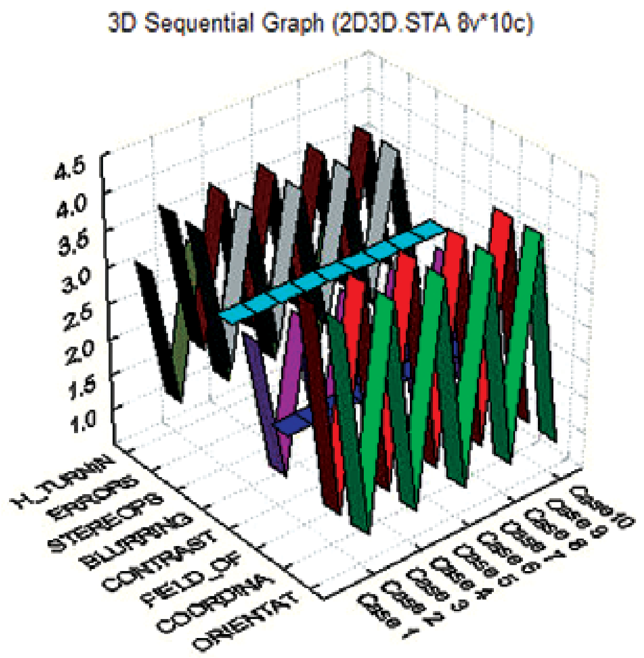

Figure 6: *3D Sequential graph of all cases.*

To get the best and most realistic 3D experience, surgeon would match viewpoint and viewing angle to that of the monitor as closely as possible. In our study viewing angle of Monitor and surgeon was kept less than 15 degree with distance of 5 feet for 22 inch LED, monitor because, as surgeon start to move farther from the screen, the 3D image will look the little strange to the surgeon as brain tries to make sense of the images it is receiving. This is because the brain expects to see a side view or angled perspective of the 3D scene when it is viewing it at an angle. Instead, it still perceives the head-on view (or the camera view) while viewing the display and the 3D scene at an angle. This results in an uncomfortable and less realistic 3D experience to the surgeon. Therefore, we minimized the viewing angle to less than 15 degrees in 3D-PIP-HDMI endoscopic visualization system.

Table 3: *K-means hierarchical clustering joining results.*

[10 cases with 8 variables] 2D Endoscopic system (Cases 1, 3, 5, 7, 9) 3D Endoscopic system (Cases 2, 4, 6, 8, 10)									Signif. P value		Standard
	ORIEN-TAT	COORDI-NA	FIELD_OF	CONT-RAST	BLUR-RING	STERE-OPS	ERRORS	H_TUR-NIN	P < 0.05	Mean	Deviatn.
Case 1	4	4	2	3	3	4	4	3	0.670412064	3.5	0.577350259
Case 2	1	1	2	1	3	2	2	1	0.00245234	1	0
Case 3	4	4	2	3	3	4	4	3	0.670412064	3.5	0.577350259
Case 4	1	1	2	1	3	2	2	1	0.00245234	1	0
Case 5	4	4	2	3	3	4	4	3	0.670412064	3.5	0.577350259
Case 6	1	1	2	1	3	2	2	1	0.00245234	1	0
Case 7	4	4	2	3	3	4	4	3	0.670412064	3.5	0.577350259
Case 8	1	1	2	1	3	2	2	1	0.00245234	1	0
Case 9	4	4	2	3	3	4	4	3	0.670412064	3.5	0.577350259
Case10	1	1	2	1	3	2	2	1	0.00245234	1	0

Oxford Scoring 1-4 (1; Excellent, 2; Good, 3; Moderate 4; poor).

Abbreviation	Explanation
1: ORIENTAT	: Orientation of the monitor
2: COORDINA	: Hand eye coordination
3: FIELD_OF	: Field of view
4: CONTRAST	: Quality of images (colour/contrast)
5: BLURRING	: Quality of images during head movement (Blurring/Focusing)
6: STEREOPS	: Stereopsis
7: ERRORS	: Number of errors due to Stereopsis
8: H_TURNIN	: Head turning

In this study it was evaluated that the field of view was same in both 2d and 3d viewing system. It depends on the distance between the target and tip of the endoscope, if you go closer to the target, field of view decreases if go away or keep it near sclerotomy site the field of view increases (panoramic view).Further with inbuilt zoom function in 3D-PIP-HDMI viewing system we could zoom image with the help of remote control whenever necessary during the procedure. 3D-PIP-HDMI system improved the normal displays with respect to color and contrast of the image.

Blurring is one of the most frequent distortions in endoscopic images. It is of two types, one is; focus blurring which is mainly caused by a wrong distance of the camera to the intraocular tissue which can be controlled by the focusing knob. Second types is, motion blurring, which is either caused by rapid movement of the endoscope or during head movement or head turning. In our study, we found blurring of the images during head movement was moderate in all the cases in 3D because of Polarized glasses eye strain. Blurring of Images in 2D view was also noted to be moderate (Grade3) during head movement because of frequent head turning to see microscopic view then switching over to see endoscopic view in the monitor.

Some authors[21] reported that viewing a remote monitor may be foreign, which can be adapted with practice and appropriate bedside positioning of the monitor, which minimizes the head turning. However in our study with the help of 3D PIP (Picture in Picture) HDMI visualization system, there was hardly any head turning as, both endoscopic view and microscopic view are projected in a single LED monitor in 50:50 ratio whereas in 2D viewing method which lacks microscopic view in the screen, head turning was more frequent.

3D-PIP-HDMI endoscopic visualization system significantly improved the stereoscopic vision (Grade 2) whereas there was lack of stereopsis (Grade 4) in 2D endoscopic viewing system. In other study[23] the author grasped the dislocated IOL and repositioned it in the ciliary sulcus under endoscopic control due to lack of stereopsis perfluorocarbon liquids (PFCL) was used to prevent any injury or hand errors but in this present study 3D-PIP-HDMI system helps to achieve Correct grasping of Dropped IOL over retina or laterally hanging IOL over pars plana as stereopsis was excellent where, as in 2D endoscopic viewing system, there were more errors to grasp the IOL with the microforcep due to lack of stereopsis. Further we noted that Instrument positioning or handling was excellent in 3D PIP mode.

The main advantage of the endoscopic techniques include clear visualization of the anterior retropupillary and peripheral intraocular anatomy like iridocapsular and intercapsular spaces, ciliary sulcus, peripheral retina, and vitreous base unmatched by other methods.[24] The detailed and magnified views of the peripheral intraocular structures provided by 3D endoscopy allow a precise repositioning of the haptics of the dislocated IOL under direct visualization. In addition, the endoscope enables rapid detection of small lens fragments or entangled IOL haptic underneath iris or iridociliary angle which is not possible with standard pars plana surgery using best biome or wide angle vitrectomy lens.

CONCLUSION

3D PIP HDMI Visualization system provides real-time, high-resolution binocular Depth perception. Excellent orientation of monitor, hand eye coordination, stereoscopic vision, quality of image, error in grasping the IOL, head turning were obtained which were highly statistical significant ($P<0.0024$) in 3D PIP HDMI visualization system as compared to standard 2D endoscopy viewing system.

REFERENCES/KAYNAKLAR

1. Thorpe H. Ocular endoscope: An instrument for the removal of intravitreous non magnetic foreignbodies.Transactions of the American Academy of Ophthalmology and Otolaryngology 1934;39:422-4.
2. Shields MB. Intraocular cyclophotocoagulation. Trans Ophthalmol Soc U K.1986;105:237-41.
3. Joos KM, Shen JH. An ocular endoscope enables a goniotomy despite a cloudy cornea. Arch Ophthalmol 2001;119:134-5.
4. Bayraktar S, Koseoglu T. Endoscopic goniotomy with anterior chamber maintainer: surgical technique and one-year results.Ophthalmic Surg Lasers 2001;32:496-502.
5. Mizota A, Takasoh M, Kobayashi K, et al. Internal sclerostomy with the Er:YAG laser using a gradient-index (GRIN) endoscope. Ophthalmic Surg Lasers 2002;33:214-20.
6. Leon CS, Leon JA. Microendoscopic ocular surgery: a new intraoperative, diagnostic andtherapeutic strategy. Part I: endoscopic equipment/ methodology applied to cataract surgery with intraocular lens implantation. J Cataract Refract Surg 1991;17:568-72.
7. Althaus C, Sundmacher R. Endoscopically controlled optimization of trans-scleral suturefixation of posterior chamber lenses in the ciliary sulcus.Ophthalmologe 1993;90:317-24.
8. Tsunoda K, Migita M, Nakashizuka T, et al. Treatment of anterior vitreous beforesuturing an intraocular lens to the ciliary sulcus. J Cataract Refract Surg 1996;22:222-6.
9. Jurgens I, Lillo J, Buil JA, et al. Endoscope-assisted transscleral suture fixation of intraocular lenses. J Cataract Refract Surg 1996;22:879-81.
10. Terasaki H, Miyake Y, Awaya S. Fluorescein angiography of peripheral retina and parsplana during vitrectomy for proliferative diabetic retinopathy. Am J Ophthalmol 1997;123:370-6.
11. Hammer ME, Grizzard WS. Endoscopy for evaluation and treatment of the ciliary body in hypotony. Retina 2003;23:30-6.
12. Norris JL, Cleasby GW, Nakanishi AS, Martin LJ. Intraocular endoscopic surgery. Am J Ophthalmol 1981;91:603-6.
13. Norris JL, Cleasby GW. Intraocular foreign body removal by endoscopy.Ann Ophthalmol 1982;14:371-2.
14. Sandler NA, Carrau RL, Ochs MW, et al. The use of maxillary sinus endoscopy in the diagnosis of orbital floor fractures. J Oral MaxillofacSurg 1999;57:399-403.
15. Uram M. Ophthalmic laser microendoscopeendophotocoagulation. Ophthalmology 1992;99:1829-32.
16. Uram M. Laser endoscope in the management of proliferative vitreoretinopathy. Ophthalmol. 1994;101:1404-8.
17. Jacobi PC, Dietlein TS, Krieglstein GK. Microendoscopic trabecular surgery in glaucoma management. Ophthalmology 1999;106:538-44.
18. Lee SM, Kim MK, Oh JY, et. al. Endoscopic vitrectomy improves outcomes of Seoul-typekeratoprosthesis exchange in rabbit model. Investigative Ophthalmol and Vis Sci 2008;49:4407-11.
19. Chun D, Colyer M, Wroblewski K. Visual and anatomic outcomes of vitrectomy with temporary keratoprosthesis or endoscopy in ocular trauma with opaque cornea. Ophthalmic Surg Lasers Imaging Retina 2012;43:302-10.
20. Kawashima M, Kawashima S, Dogru M, et al. Endoscopy guided vitreoretinal surgery following apenetrating corneal injury. Clinical Ophthalmology 2010;4:895-8.
21. Kyle V M, Yoshihiro Y, et al. Indications and techniques of endoscope assisted vitrectomy. J Ophthalmic Vis Res 2013;8: 282-90.
22. Sabti KA, Raizada S. Endoscope-assisted pars planavitrectomy in severe ocular trauma. Br J Ophthalmol 2012;96:1399-403.
23. Boscher C, Lebuison DA, Lean JS, et al. Vitrectomy with endoscopy for management of retained lens fragments and/or posteriorly dislocated intraocular lens. Graefes Arch Clin Exp Ophthalmol 1998;236:115-21.
24. Chan CK, Lin SG. Modified sulcus fixation technique for dislocated PCIOL by temporary extemalization of haptics, [poster #132]. The Vitreous Society 17th Annual Meeting. Rome, Italy, Sept. 21-25, 1999.