USE OF THREE-DIMENSIONAL ENDOSCOPY IN ENDONASAL AND ANTERIOR SKULL BASE SURGERY

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Abstract

Objectives: The three dimensional (3D) endoscope is considered as a new surgical tool which used in different approaches in intranasal and anterior skull base surgical procedures. There are many advantages of the 3D endoscopy over the two dimensional (2D) one that have been demonstrated along clinical applications, surgical training and different experimental studies. Our study aimed to show the difference between using the 3D & 2D endoscopes during endonasal and anterior skull base surgery and its importance specially when used by novice users. Design: Our study is divided into two phases (clinical & cadaveric phases).In the clinical study we have done 52 endonasal & anterior skull base surgical procedures (26 study cases and 26 control cases).We recorded accuracy, duration and intraoperative complication for each case. The cadaveric study was performed on three cadavers, difference in accuracy and dissection time were recorded using 3D & 2D endoscopy for each side chosen by randomization. Results: In the clinical study, the cases done by 3D endoscope were significantly faster and more accurate with less intraoperative complications compared to cases done using 2D endoscope. In cadaveric dissection while using 3D endoscope there was better depth of perception regarding the anatomical landmarks compared to 2D endoscope. Conclusion: 3D endoscopy is an advanced instrument that allows better training for the coming generation of ENT surgeons. Both clinical and cadaveric studies offer a promising outcomes in both endonasal and anterior skull base surgery.

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Conclusion: 3D endoscopy is an advanced instrument that allowmay better training for the coming generation of ENT surgeons. Both clinical and cadaveric studies offer a promising outcome in both endonasal and anterior skull base surgery.

Summary:

- In this study, the 3-dimensional endoscopes were compared to the 2-dimensional endoscopes The study included clinical and cadaveric phases we also used the need to use surgical navigation systems as a new parameter to compare the accuracy of the 2D and 3D endoscopic procedures.
- Navigation systems were needed less frequently with 3D endoscopes. The difference between the 2 groups was statistically significant.,
- The duration of surgical procedures was significantly shorter when the 3-D endoscopes were used.
- Fewer intraoperative complications were reported during 3D endoscopic procedures but the difference between the 2 groups was not statistically significant.
- The cadaveric study revealed better depth perception and better identification of anatomic landmarks with the 3D endoscopes. On the other hand, there was no significant difference between the 2 groups regarding the dissection time.

Keywords: 3D, 2D, endoscopy, Skull base, three-dimensional, two-dimensional

Objectives:

Despite advancement in new equipment and surgical instruments, it is only recently that three-dimensional (3D) endoscopes have been used in endonasal and anterior skull base surgery. Previous publications have shown the importance, advantages and limitations of three dimensional endoscopy either in endonasal or skull base surgical approaches.[1, 2] The endoscopes used in this study incorporate dual 'chip-on-the-tip' technology in which two video chips create two different digital images which are displayed onto a 3D screen. Polarising glasses are worn to project a different image to each eye.[3]

Extended endoscopic endonasal approaches are increasingly applied in the management of various intracranial and cranial base pathologies. On one end of the complexity spectrum, lie lesions such as pituitary adenomas and encephaloceles of the cribriform plate, which can be more easily approached through the endonasal corridor.[4-6]

There are many advantages of endoscope however, it does not achieve the binocular vision. The monocular endoscopes create a 2D image during the operative view which lack the depth of perception, size orientation and hand –eye coordination.[7, 8] Human kinematic studies proved that the longer movement times are required by monocular cues to estimate the distance between variable surgical landmarks.[9]

Many binocular cues are essential to gain the depth of perception like convergence, stereopsis and vertical disparities which are the main features of the three dimensional technology. To achieve stereopsis it requires two meticulously different retinal images obtained from different angles and directions and then the human cortex superimposes these two images to give the stereopsis. Like the majority of stereoscopic systems which give the 3D display of the surgical field by production of minimally different images, then displayed separately to each eye, so the generated two images are the concept of stereopsis which named the dual channel and the shutter mechanism technologies.[7]

Design

This study has been performed in two phases: clinical and cadaveric parts:

A- Clinical study:

The clinical study was a prospective one. The study was performed on patients admitted to "blinded for review" along one calendar year. All patients gave informed consent after the nature of the research has been fully explained to them and the research was approved by Institutional Review Board of the faculty according to Helsinky declaration (ethical research number 0201021). We used the Karl Storz second generation 3D HD endoscope that utilizes the 'dual chip-on-the-tip' technology with two lenses on the tip of the endoscope, Medtronic navigation system and Panasonic 3D polarizing glasses which filter less light than conventional polarizing glasses, so the operating room was not required to be dark. The 3D polarizing glasses fit over normal glasses worn by surgeons. This phase was performed on 52 endonasal and anterior skull base cases (26 control cases using 2D endoscope and 26 study cases using 3D endoscope (Figures 1 and 2). Duration of surgery, accuracy (frequency of navigation system use), intraoperative complications, and surgeon discomfort were recorded.

B-Cadaveric study:

The cadaveric study was a randomized study. Choosing to start each side by using 2D or 3D scope was achieved by randomization (flipping coin). The study was performed on three fresh frozen cadavers (six sides in total) using Karl Storz 2nd generation 3D HD endoscope to dissect the different anatomical landmarks and regions in advanced endonasal and anterior skull base surgery. We used this endoscope for both 2D and 3D visualization using different settings on the endoscope, and this ensured minimal influence from optical variables that could arise from using two different endoscopes, making the intervention purely 3D and thus resulting in a more controlled design.

Time was recorded in each side from first touching the vestibule of the nose until completing the sphenoidotomy & entering the sphenoid sinus cavity in the cadavers (uncinectomy, middle meatal antrostomy, ethmoidectomy and sphenoidotomy were done on each side). Also, identification of various intranasal dissection sites and anatomical landmarks were done for illustrative, educational, and training purposes (figure 3).

The data that support the findings of this study are available from the corresponding author upon reasonable request

Results:

A range of operative procedures undertaken using 2D and 3D endoscope was performed. The majority of cases in the two groups were pituitary adenomas, (12 cases in each group 46.2%), followed by recurrent pituitary adenomas 6 cases in each group as shown in table (1).

In the clinical study the operative time was recorded for each case starting from touching the skin of patient till the end of the operative procedure of each. The mean operative time in the 2D group was 2.92±1.51 hours, while in 3D was 1.88±0.65 hours. Comparing the two groups regarding the operative time, there was a highly significant increase in operative time in 2D group compared to 3D group ($p < 0.05$) as shown in table (2).

Regarding the frequency of navigation system use intraoperatively, the mean frequency of using the navigation system in 2D group was 5.0±3.31, while in 3D group was 2.50±2.04. Consequently, there was a highly significant increase in number of navigation system utilization in 2D group more than the 3D group ($p < 0.05$) as demonstrated in table (3).

The incidence of intraoperative complications during use of the 2D endoscope was higher than intraoperative complications while using the 3D endoscope which was not statistically significant. The most common complications reported in 2D group were cavernous bleeding in 11 cases (42.3%) followed by C.S.F. leak in 6 patients (23.1%), while in 3D group were 7 cases (26.9%) followed by cavernous bleeding in 5 patients (19.2%).

There was no reported discomfort to the surgeon while using 2 D endoscope however, 3 surgeons reported headache/ migraine while using the 3D endoscope. This was not statistically significant ($p > 0.05$).

In the cadaveric study, the mean time while using 2D endoscopy was 19.67±1.53 minutes, while in 3D endoscope it was 21.33±4.93 minutes. This did not reach statistical significance.

Discussion

Endoscopic sinus surgery is considered the gold standard for the management of most sinus pathology. Improvements and updates in image quality and angled scopes have resulted in advances in endoscopic sinus surgery (ESS) with the expansion of use of the endoscopic approach in skull base surgical interventions.[10]

The three dimensional (3D) endoscopes have been utilized for endonasal surgery, and recent publications have shown the advantages and a number of limitations in using 3D endoscopes in endonasal sinus surgery or skull base surgical approaches.[2] In these reports, 3D images were reconstructed from multiple 2D images obtained using special lenses that imitate the compound eye of bees, from various angles.[11] This is a different technology to the 3D HD storz endoscopes that were used in this study.

In our clinical study, the mean operative time in the 2D group was significantly higher than the 3D group. This is also shown by Castelnuovo et al., (2012), while studying the utilization of the 3D endoscope in resection of anterior skull base malignancy, they found a statistically significant reduction of both operative time and error rates by using the new stereoscopic endoscope[12], which require the passive polarizing three dimensional display[13] compared to two dimensional endoscope. Also they recorded low[14] or absent surgeon discomforts with the novel stereoscopic systems.[15] Moreover Barkhoudarian et al., reported that there is a strong evidence for 3D allowing a 30-minute reduction in pituitary adenoma resection operating time.[16] A shorter operative time decreases the risk of postoperative complications in endoscopic pituitary surgery.[17]

In our study, the frequency of using the surgical navigation system showed that there was a highly significant increase in frequency of navigation system use in the 2D group more than the 3D group. There are no similar studies in the literature to compare to our study but these results are in keeping with the hypothesis that 3D endoscopy gives improved depth of perception hence a reduction in the need to use navigation to confirm anatomy.

In our 2D group there was no surgeon discomfort during all operative cases while 3 operative cases in the 3D group resulted in the surgeon reporting discomfort (headache/migraine); there was no significant difference between the two studied groups. Other authors in clinical and experimental studies reported similar results. Moreover a small number of surgeons in multiple studies recorded user side effects and discomforts like dizziness, eye strain, fatigue, migraine and headaches in 3D endoscope users.[18]

Minimally invasive surgery is the standard of patient care in many institutions [19]. However, incidents of increased complication rates among inexperienced surgeons have been reported and a detailed study of these claims demonstrates that the surgical learning curve plays a vital role in the rate of complications.[20]

Regarding intraoperative complications, the incidence of complication in our 2D group was higher than 3D group, however it was statistically not significant. The most common complication in our 2D group was cavernous bleeding in 11 cases (42.3%) followed by C.S.F leak in 6 patients (23.1%), while in 3D group there were 7 cases of C.S.F leak (26.9%) followed by cavernous bleeding in 5 patients (19.2%).

For endoscopic pituitary surgery, the Southern Surgeons club noted that 90% of complications happened in the first 30 patients of the learning curve, with the initial risk being tenfold of that after 50 operations.[21] They were using 2D endoscopy and a number of explanations were given including: loss of depth perception (stereopsis), ergonomic difficulties of using an endoscope, and issues with training.[20, 21]

Regarding our cadaveric study, the mean dissection time for both sides of the cadavers using 2D endoscope was 19.67±1.53 minutes while in using 3D endoscope was 21.33±4.93 minutes which was not statistically significant ($p > 0.05$). It is possible that if we had chosen a more complicated index longer operation to compare then we might increase the likelihood of repeating the same results as seen in the clinical study with 2D taking longer than 3D.

The cadaveric study describes only a qualitative comparison of various approaches and anatomical landmarks using 3-dimensional endoscopy as a new learning tool and technique. Future studies should focus on more detailed quantitative comparisons of field exposure and surgical limitations.

Conclusion:

3D endoscopy is an advanced technology that allows better training for the coming generation of ENT surgeons. Both clinical and cadaveric studies offer promising outcomes in both endonasal and anterior skull base surgery.

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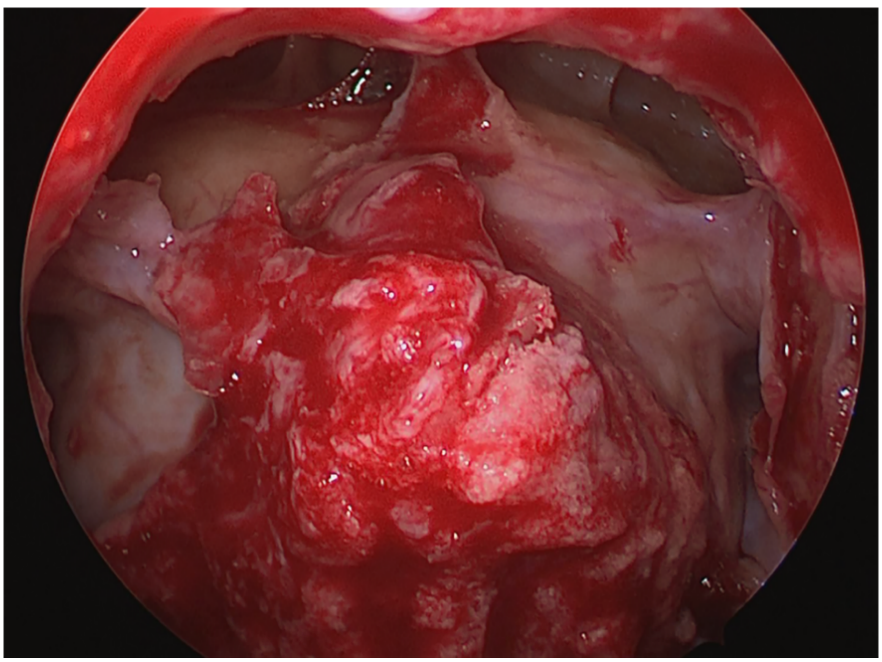
Figures



Figure(1): 2D endoscopic view of anterior skull base tumour

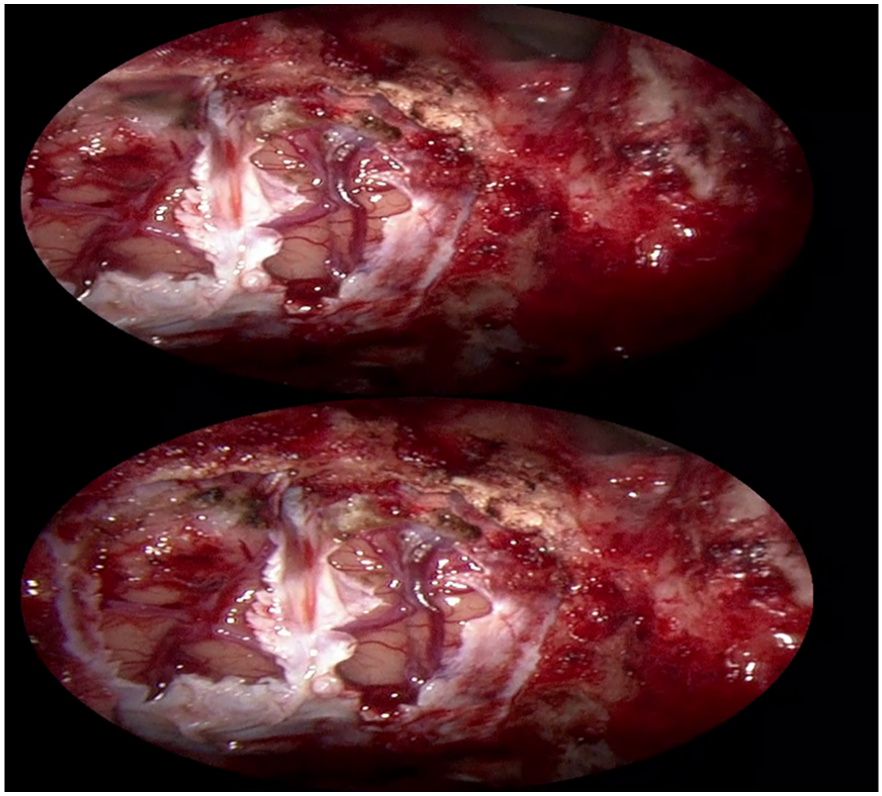


Figure (2): 3D intra-operative view after resection of anterior skull base tumour (the double images created by 3D endoscope)

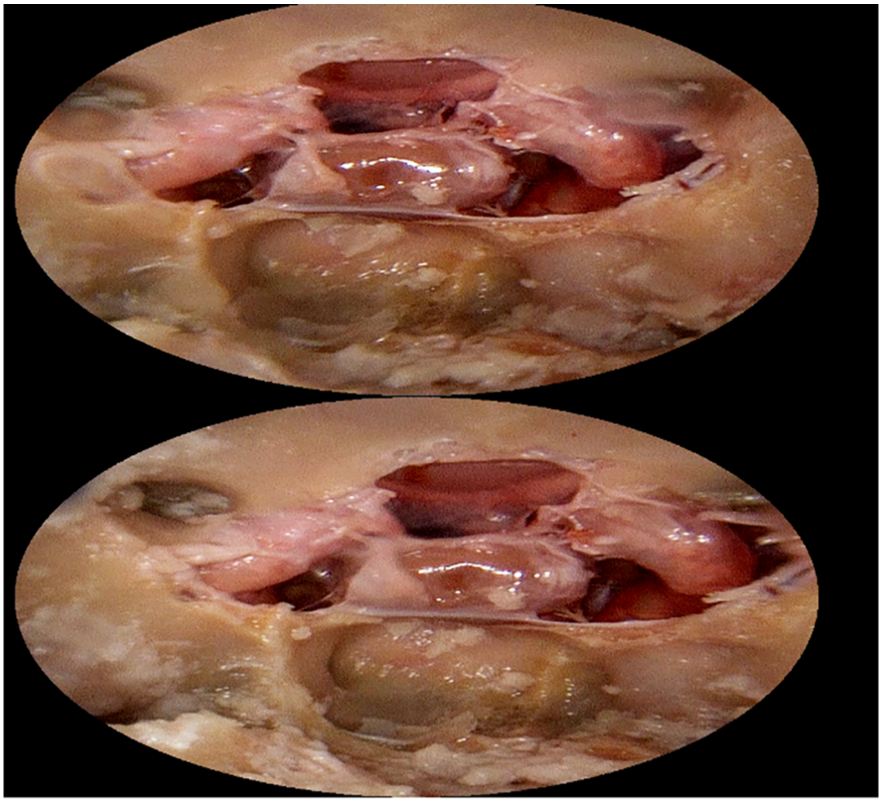


Figure (3): 3D cadaveric view inside sphenoid sinus after removal of bone over pituitary gland, planum sphenoidale and both carotid arteries

Table 2: Comparison between the studied groups according to operative time

	2-D endoscope (n = 26)	3-D endoscope (n = 26)	U	p
Operative time (hours)				
Min. – Max.	0.75 – 7.43	0.50 – 2.95	145.50*	<0.001*
Mean ± SD.	2.92 ± 1.51	1.88 ± 0.65		
Median(IQR)	2.49(2.35 – 2.92)	2.02(1.48 – 2.18)		

U: Mann Whitney test

p: p value for comparing between the studied groups

*: Statistically significant at p [?] 0.05