Surgeon perspectives of three-dimensional endoscopy in pediatric otolaryngology: A qualitative study

Brendan D. McNeely[1], Nick Fitzpatrick[2], Katharina Leitmeyer[2], Julie Pauwels[2], and Neil Chadha[1]

[1]The University of British Columbia Faculty of Medicine
[2]BC Children's Hospital

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Abstract

KEY POINTS 1. This is the first study to use a qualitative methodology to assess the potential advantages and disadvantages of the application of 3D endoscopes in pediatric otolaryngology surgery. 2. Open-ended, structured interviews were conducted with six pediatric Otolaryngologist operating at a tertiary pediatric centre, with a minimum one year of experience using a 3D endoscopy system. 3. Thematic analysis of the surgeon's responses identified 3D endoscopy to provide improved surgical field visualization which thus served as a valuable teaching tool. 4. The surgeons interviewed found 3D endoscopy to improve surgical outcomes in pediatric airway surgery, particularly in surgeries involving the larynx. 5. Further quantitative evaluation of patient outcomes could delineate the precise clinical role 3D endoscopy may hold in future pediatric Otolaryngology practice.

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2. Open-ended, structured interviews were conducted with six pediatric Otolaryngologist operating at a tertiary pediatric centre, with a minimum one year of experience using a 3D endoscopy system.
3. Thematic analysis of the surgeon's responses identified 3D endoscopy to provide improved surgical field visualization which thus served as a valuable teaching tool.
4. The surgeons interviewed found 3D endoscopy to improve surgical outcomes in pediatric airway surgery, particularly in surgeries involving the larynx.
5. Further quantitative evaluation of patient outcomes could delineate the precise clinical role 3D endoscopy may hold in future pediatric Otolaryngology practice.

INTRODUCTION

Three-dimensional (3D) endoscopy has emerged as a surgical tool to improve visualization and stereoscopic vision in Otolaryngologic surgery. The diameter of 3D endoscopes has been reduced to 4 mm, thereby allowing surgeons to better navigate narrow anatomy while continuing to reliably provide images of high quality and resolution. Early peer-reviewed evaluations of the novel surgical technique have not yielded a definitive consensus on 3D endoscopy's utility in Otolaryngology. Three-dimensional endoscopy was found to provide enhanced visualization of the laryngeal structures which improved surgical excision[1]. In contrast, other reports have found no difference in clinical outcomes when using 3D over 2D endoscopy in sinus or middle ear surgeries, although 3D endoscopy provided notably improved anatomic visualization[2,3]. Despite the discordance, such quantitative research has been confined to experimental settings or specific clinical presentations, and has largely failed to evaluate 3D endoscopy use in regular clinical practice. This is the first study to use a qualitative methodology to assess the potential advantages and disadvantages of 3D

endoscope use in pediatric Otolaryngology surgery as experienced by surgeons with regular access to 3D endoscopic technology.

METHODS

A qualitative study design was employed to obtain an in-depth and broad understanding of Otolaryngologists' experiences with 3D endoscopy, focussing on clinical advantages and challenges that they faced when using the novel surgical equipment. A Karl Storz TipCam (Karl Storz GmbH & Co, Tuttlingen, Germany) second generation 3D-high-definition, 4mm endoscopy system (0 degree, 30 degree, 45 degree) was used by all participants with 3D glasses and appropriate personal protective equipment. The study was approved by the Research Ethic Board at British Columbia Children's Hospital (BCCH). Written informed consent was obtained from all interview participants prior to their study participation. The study followed Standards for Reporting Qualitative Research (SRGR) guidelines.

Participants

The research team conducted structured interviews with 6 Otolaryngologists operating at BCCH. The participating surgeons included 4 senior consultants and 2 surgical fellows. The sample size was limited due to the number of surgeons who had regular access and experience with the 3D endoscopy equipment. Previous research has demonstrated that a qualitative sample size is best determined by the nature of individual study rather than a power calculation[4–6].

Procedure

The structured interviews for qualitative data collection were conducted over Zoom (Zoom Video Communication Inc., San Jose, California), recorded, and transcribed for research purposes. The open-ended questions were prepared in advance and were consistent across all participants (Appendix 1). The questions were prepared to encompass varied and clinically-relevant components 3D endoscopic surgery. Moreover, particular attention was paid to contrast 3D endoscopy to conventional surgical technology, including 2D endoscopy and the surgical microscope.

Data Analysis

The authors analysed the interviews for recurrent themes once all interviews were completed. The interview responses were compiled and examined through modified thematic analysis using open and axial coding. The data coding was independently reviewed and interpreted by three authors. Using validated grounded theory, open coding is the deconstruction of information into common groups based on shared ideas, and axial coding involves organizing information into overarching themes[7]. Due to our novel research methodology on this topic, the aim was exploratory to elucidate original and recurrent themes.

RESULTS

All six surgeons invited to participate in the study completed full interviews. Five of the six participants were male (83%). All surgeons had at minimum one year of experience with the 3D endoscopy system.

Thematic analysis

Seven over-arching themes were identified from the data and categorized into advantages or disadvantages of the 3D endoscopy system, or additional themes, as described in Table 1. The identified themes are discussed in more detail as follows.

Improved stereoscopic vision when using 3D endoscopy was a recurring point of discussion for all six participants.

"When using a 2D scope, [surgeons] have learned to simulate depth perception by moving the endoscope frequently to generate a 3D map in their mind. With the 3D endoscope, you have 3D perception immediately and you appreciate the relationship of different structures in different dimensions very quickly." (Participant #1)

"You gain the feeling of moving through space to better appreciate the anatomy rather than just looking at the anatomy." (Participant #4)

This improved visualization had clinical applicability to better discriminate laryngeal anatomy, thus facilitating laryngeal surgery. This was identified by four of the six participants.

"The main benefit [of 3D endoscopy] is ability for more precision due to the depth perception. This was particularly noticeable for laryngeal papillomatosis, where a fraction of a millimeter counts to get rid of disease and retain the normal structure." (Participant #5)

Moreover, 3D endoscopy was found to be a valuable teaching tool due the more detailed visualization of anatomical structures.

"In surgical training, [3D endoscopy] gives you a better perspective to advise trainees on how to improve their technique, but also to recognize that techniques are being done safely and appropriately. I feel more confident that I can see exactly what they are doing." (Participant #1)

This teaching benefit of 3D endoscopy was pervasive in all interviews.

"When there is an opportunity to teach, I would like to use [3D endoscopy] in almost every case." (Participant #6)

In contrast, all participants found 3D endoscopy to require additional set-up time and careful equipment positioning; however, the surgeons found that this resolved with increased device use and familiarity.

"The [support] staff must know what they are doing during set-up... there are no problems with the equipment itself." (Participant #3)

Two participants found impaired utility of 3D endoscopy compared to other surgical techniques in clinical scenarios when the width of the instrument did not allow for access to the surgical site.

"In the smallest babies, the scope is likely too big." (Participant #3)

DISCUSSION

Our qualitative investigation of pediatric Otolaryngologist experience in 3D endoscopic surgery found this innovative technology to improve visualization thereby facilitating surgical and anatomical teaching. Moreover, 3D endoscopic technology was found to be particularly effective in laryngeal surgery, although the endoscope's width can limit its utility in certain clinical scenarios.

Three-dimensional endoscopy as a teaching tool

All participants commented that 3D endoscopy could be effective to facilitate teaching. The 3D endoscopy system provides a more complete projection of complex anatomical structures including the vocal cords and surrounding topography of the larynx. Three-dimensional imaging of such structures allowed trainees to better understand anatomical relationships ultimately targeted to improve their surgical precision. Moreover, 3D endoscopy allowed supervising surgeons to more precisely follow surgical movements of trainees, thus improving the senior surgeons' confidence that maneuvers were conducted in a safe manner.

Implications for practice

Appreciable image enhancement using 3D endoscopy translated into the surgeons' ability to better delineate anatomical relationships. Notable pediatric clinical scenarios in which such delineation improved surgical experience was the larynx. In the instance of laryngeal papillomatosis, surgeons felt they could more safely perform an extensive resection of tissue and minimise airway traumatization due to improved confidence of the exact margin of disease. This thorough resection was found to double the interval between recurrent respiratory papillomatosis procedures. This finding builds upon previously defined benefits of 3D endoscopy for surgical treatment of laryngomalacia and subglottic cysts[1,8]. Similarly, three surgeons noted they were better able to visualize the borders of vocal cords in medialization procedures. In contrast, the current 3D

endoscope technology is limited to 4 mm in diameter which restricted its use in narrow spaces including certain neonatal airways and pediatric middle ear spaces. Anecdotally, two surgeons noted the stereoscopic vision was lost when the camera lens was frequently soiled during sinus surgery. This finding contrasts previous reports of a well-defined role for 3D endoscopy in endonasal surgery, albeit in adult patients[9].

Subjective surgeon experience of 3D endoscopy was improved with increased use. In particular, the initial technical challenges such as increased set-up time and equipment positioning optimization were overcome with experience. This is further evidenced by Moore and Bennett, who found 90% of endoscopic surgical complications to occur in the first 30 patients on the learning curve[10]. No adverse physical side effects were encountered by surgeons to limit their ability to perform the procedures in a safe and efficient manner. Altogether, the above findings encourage the continued use of 3D endoscopy, particularly in pediatric Otolaryngology airway surgery.

Strengths and Limitations

Our study is confined to a single institution due to the novel technology and related resource limitations, however, all pediatric Otolaryngologists interviewed in our study had substantial clinical experience with the 3D endoscopic technology. Our study offers new and diverse insight as the first to evaluate 3D endoscopy use in regular pediatric Otolaryngology practice. With increased 3D endoscopy resource access, quantitative evaluation of patient outcomes can serve to further clarify the precise role of 3D endoscopy in pediatric Otolaryngology surgery. Moreover, a subsequent cost analysis of 3D endoscopy use could better elucidate the innovative technology's role in publicly funded healthcare models.

Advantages of 3D Endoscopy	Disadvantages of 3D Endoscopy	Additional Themes
1. Improved stereoscopic vision including accurate depth perception, visualization of complex structures, and enlarged field of view.	1. Technical difficulties included precise surgeon positioning, eye wear, and increased set-up time.	1. Initial technical challenges were resolved with increased 3D endoscope use and experience.
2. Improved surgical outcomes and patient experience for procedures that involved laryngeal structures or pathology.	2. Minimal role in narrow anatomical areas (< 4mm in diameter) that do not allow for endoscope access.	2. No physical side-effects were encountered by surgeons using the 3D system.
3. Teaching was facilitated through better anatomical visualization allowing learners to safely operate more extensively.		

Table 1. Themes identified from data analysis.

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APPENDIX

Interview Questions

1. Can you describe your overall experiences with 3D endoscopy in pediatric airway procedures?
2. Tell us about the benefits you perceive of 3D endoscopy compared to other techniques (like 2D endoscopy and the microscope).
3. Tell us about the limitations of 3D endoscopy compared to other techniques.
4. How would you describe the visualization provided by the 3D endoscope system?
5. What technical difficulties did you encounter?
6. Did you notice any physical side effects after using the 3D system?
7. What role do you think 3D endoscopy could play in teaching?
8. Did it seem to have any effect on the speed of surgery or patient outcomes?
9. Were there any clinical scenarios where it was particularly useful or detrimental?
10. What proportion of pediatric airway cases would you use it in going forward?
11. Any other comments?

Appendix 1. Standardized participant interview questions.