Efficacy of Three-Dimensional Endoscopy for Ventral Skull Base Pathology: A Systematic Review of the Literature

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Key words
- Endoscope
- Extended endonasal
- Parasellar
- Sellar
- Skull base surgery
- Three-dimensional
- Transsphenoidal

Abbreviations and Acronyms
2D: Two-dimensional
3D: Three-dimensional
HD: High-definition
SD: Standard-definition

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OBJECTIVE: **The three-dimensional (3D) endoscope is a novel tool that provides stereoscopic vision and may allow for improved dexterity and safety during surgical resection of ventral skull base lesions. We describe here the cumulative experience available in the neurosurgical literature.**

METHODS: **A PubMed literature review was performed to identify and analyze all studies pertaining to 3D endoscopic endonasal skull base surgery.**

RESULTS: **We identified 26 articles: 14 clinical articles, 5 simulated environment studies, 5 human cadaveric studies, and 2 expert opinions. In all the clinical studies, 262 patients were treated for the following 257 pathologies listed in the articles: 190 suprasellar/parasellar lesions (73.9%), 41 ventral skull base lesions (16.0%), 19 sinonasal pathologies (7.4%), and 7 cerebrospinal fluid leak repairs (2.7%). Complication rates, operative time, length of hospital stay, and extent of tumor resection were equivalent between two-dimensional (2D) and 3D endoscopy. However, all studies reported that subjective depth perception and spatial orientation were markedly improved with 3D technology. In 3 studies (11.5%), it was concluded that there was no clinically significant surgical benefit in switching from 2D to 3D endoscopy. All cadaveric studies and expert opinions concluded that 3D endoscopy improved the identification of key anatomical structures and was superior to 2D endoscopy. Simulated environment studies demonstrated that 3D endoscopy improved speed and accuracy of endonasal tasks, more so in novice surgeons.**

CONCLUSIONS: **Our findings suggest that 3D endoscopy provides improved surgical dexterity by affording the surgeon with depth perception when manipulating tissue and maneuvering the endoscope in the endonasal corridor.**

INTRODUCTION

Since the initial description of the transsphenoidal approach in 1907 by Schloffer, poor illumination and visualization of critical neurovascular structures in the endonasal corridor limited its adoption.[1] Cushing abandoned the transsphenoidal approach in the late 1920s, citing superior visualization, lower recurrence rates, and better visual outcomes afforded by the transcranial route. The introduction of the operating microscope by Hardy in 1967 signaled a major leap forward for endonasal skull base surgery: High magnification and illumination afforded by the microscope allowed surgeons to better identify critical neurovascular structures to avoid iatrogenic injury and to better dissect tumor from normal gland, resulting in preserved pituitary function. The popularization of the fully endoscopic controlled approach by Jho et al.[2] in 1997 proved to be a second leap forward: The endoscope provided a wider field of view and angled viewing to inspect the cavernous sinus and suprasellar elements, as well as higher magnification, internal illumination, and image resolution to differentiate normal pituitary gland from tumor.

Several skull base centers transitioned from a microscope-driven approach to a fully endoscopic technique largely as a result of the superior visualization provided by endoscopy. Numerous surgical series have demonstrated the improved efficacy and safety of this technique versus traditional microscopic or open surgical approaches for various sellar and parasellar lesions.[3] Nonetheless, a major drawback cited by critics has been the loss of depth perception when transitioning from a three-dimensional (3D) microscopic view to a two-dimensional (2D) endoscopic view. Recent technological advancements allowed for the development of 3D endoscopes with high-definition (HD) images and a smaller endoscopic profile. Proponents suggest that this tool may signal the next major technological advancement in skull base surgery. To understand the impact of this new surgical adjunct further, we performed a systematic review of the literature to identify all reports of 3D endoscopes in the modern neurosurgical era. To our knowledge, this is the first such comprehensive review on this subject in the literature.

MATERIALS AND METHODS

A systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines to identify studies that assessed the surgical efficacy of 3D endoscopic endonasal skull base surgery. An extensive literature search was performed on May 17, 2015, using PubMed (National Library of Medicine) with the key word "three dimensional endoscopy." No restrictions existed regarding year of publication. Two investigators (H.A.Z. and A.Z.) independently performed the initial search to identify all relevant articles by screening titles and abstracts, then collated the final selection of studies to be included in the systematic review after examining the full-text articles. The reference lists of included articles were reviewed to identify any additional articles relevant to our analysis. Original, peer-reviewed articles, including opinion-based commentaries, studies performed in a clinical setting, studies performed in a simulated environment, and cadaveric studies assessing the surgical efficacy of 3D endoscopic endonasal skull base surgery were chosen. Non–English language articles; articles describing nonhuman studies; and articles examining 2D endoscopy, laparoscopy, or robotic surgery were excluded.

Two investigators (H.A.Z. and A.Z.) independently extracted the following data from clinical studies: year of publication, type of study, surgical technique, number of participants and their level of training, total number of patients, mean patient age, outcomes measured, surgical indications, equipment used, perioperative and postoperative outcomes, results, and conclusions. Data extracted from nonclinical studies included year of publication, surgical technique or tasks performed for laboratory-based studies, number of participants and their level of training, number of specimens for cadaveric studies, equipment used, outcomes measured, results, and conclusions. For opinion-based commentaries, advantages and disadvantages were included.

RESULTS

There were 2621 articles identified from the online database. After filtering articles that contained human subjects only and English language publications, 2168 articles were available for review (Figure 1). Of these 2168 articles, 2129 were eliminated because they were not relevant to 3D endoscopic surgery. An additional 16 articles were excluded because they were not related to 3D endoscopy of the skull base. Of the remaining 23 articles, 3 were excluded because they did not address a ventral skull base approach, and 1 additional article was excluded because it was a general endoscopy review article. Examining the reference lists of included articles, we identified 7 additional 3D endoscopic skull base surgery articles. Thus, 26 articles were included in the final analysis: 14 clinical studies, 5 human cadaveric studies, 5 simulated environment studies, and 2 expert opinion commentaries.

Clinical Studies

There were 14 clinical studies included: 7 retrospective studies, 5 prospective studies, 1 cohort study, and 1 case report (Table 1).[4-17] A comparison with 2D endoscopic surgery was presented in 12 of the 14 articles. All procedures were performed via an endonasal route to the sinus and skull base, with 1 study combining a transcranial approach.[17] There were 262 patients with an a mean age of 51.6 years treated by 34 experienced surgeons and 5 novice surgeons. Pathologies for 257 patients were available in the article text for analysis. Pathologies included 190 suprasellar/parasellar lesions (73.9%), 41 ventral skull base lesions (16.0%), 19 sinonasal pathologies (7.4%), and 7 cerebrospinal fluid leak repairs (2.7%). All studies used a standard-definition (SD) 3D Visionsense endoscope (Visionsense, Ltd., Petach-Tikva, Israel) rather than HD 3D endoscope. The endoscope was used in conjunction with either 0° or 30° angled tips and 4.7-mm-diameter rigid endoscope for visualization. Only 1 study reported using 3D HD technology (Shinko Optical Co., Ltd., Tokyo, Japan), which was directly compared with a 2D HD system.[10] The remaining studies used 3D SD visualization systems.

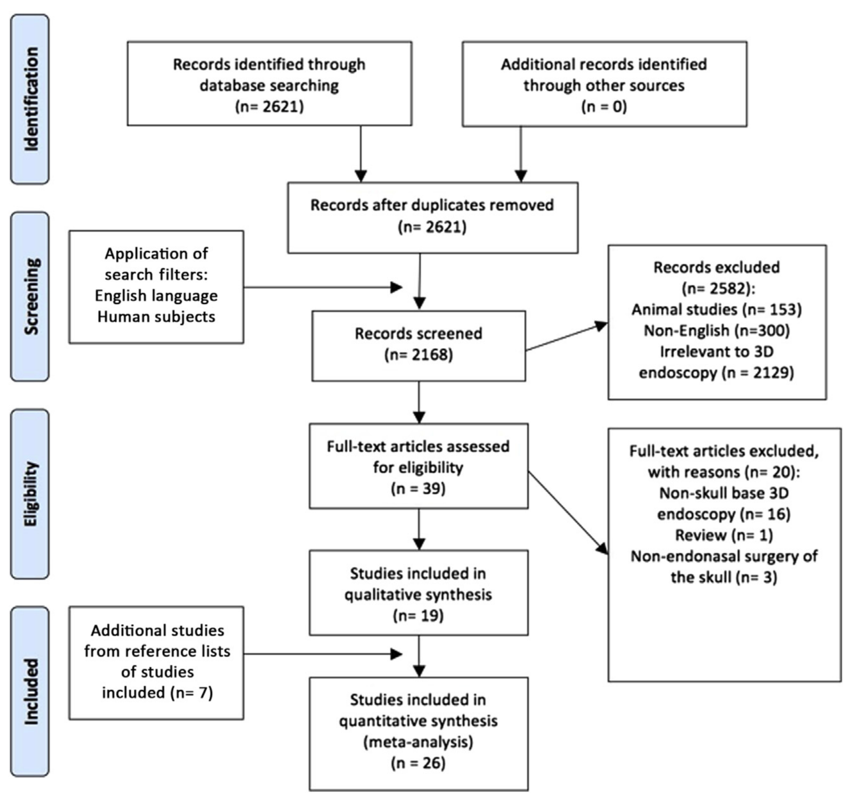

Figure 1. Flow diagram for study selection.