# Required Reading: The Most Impactful Articles in Endoscopic Endonasal Skull Base Surgery

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■ OBJECTIVE: **Endoscopic endonasal skull base surgery has become widely accepted in neurosurgery and otolaryngology over the last 15 years. However, there has yet to be a formal curation of the most impactful articles for an introductory curriculum to its technical evolution.**

■ METHODS: **The Science Citation Index Expanded was used to generate a citation rank list (October 2015) on articles relevant to endoscopic skull base surgery. The top 35 cited articles overall, as well as the top 15 since 2009, were identified. Journal, year, author, study population, article format, and level of evidence were compiled. Additional surgeon experts were polled and made recommendations for significant contributions to the literature.**

■ RESULTS: **The top 35 publications ranged from 98 to 467 citations and were published in 10 different journals. Four articles had more than 250 citations. A period of frequent contribution occurred between 2005 and 2009, when 21/35 reports were published. 18/35 articles were case series, and 13/35 were technical reports. There were 11/35 articles focused primarily on pituitary surgery and 10/35 on extrasellar lesions. The top 15 articles since 2009 had 8/15 articles focused on extrasellar lesions. Polled surgeons consistently identified the most prominently cited articles, and their recommendations drew attention to cerebrospinal fluid leak as well as extrasellar management.**

■ CONCLUSIONS: **Identification of the most cited works within endoscopic endonasal skull base surgery shows greater anatomic access and safety over the last 2 decades. These articles can serve as an educational tool for novices or midlevel practitioners wishing to obtain a greater understanding of the field.**

## INTRODUCTION

The origins of endoscopic skull base surgery date back to the 1960s, when Guiot et al.[1] first used endoscopy for a transphenoidal approach, and to the 1970s, when Halves and Bushe[2] first used endoscopy as an adjunct in microscopic pituitary resection. However, the subspecialty has only recently achieved a momentum from the availability of new instruments, clinical indications, rigorous explorations of surgical boundaries, and the development of methods to close the skull base from below.[3] Contributing to this growth in endoscopic skull base surgery has been the publication of influential journal articles reporting on innovative experiences.

In a variety of disciplines, citation rank lists are frequently used to identify such significant contributions, whereby a journal or article from a given database receives 1 citation for each time it is referenced by another indexed publication. Although several methodologies exist for determining how impactful journals and articles are based on these citation counts, citation rank lists continue to be successfully used to signify and recognize influential work in areas including neurosurgery, otolaryngology, ophthalmology, orthopedic surgery, and spine surgery.[4-14] The limitation of this technique is that articles of more historical impact, such as early case reports, may garner more citations but

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- Citation rank list
- CSF leak
- Endoscopic
- Extended
- Pituitary
- Skull base surgery

**Abbreviations and Acronyms**
CSF: Cerebrospinal fluid

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reflect technical methods that have since been replaced by more novel innovations.

Both otorhinolaryngology and neurosurgery have played a central role in the development of endoscopic skull base surgery, beginning with the first publications in *Archives of Laryngology* in 1903.[15,16] However, the greatest contributions are likely more recent. We sought to identify and characterize the most frequently cited references within the Science Citation Index Expanded database. Our key objective was to curate a curriculum of fundamental articles from which new residents and fellows can appreciate the evolution and technique of endoscopic skull base surgery. Some important studies may not have had time to acquire citations. Thus, we also separately examined more recent articles and queried experts in the field regarding articles that they recommend as most important to the development of endoscopic skull base surgery.

## METHODS

In October 2015, we searched the Science Citation Index Expanded from 1965 to 2015 for articles citations in the following subject categories: "surgery", "otorhinolaryngology", "clinical neurology", "neuroimaging", and "endocrinology metabolism" for their relationship to the management of endoscopic skull base surgery (**Supplementary Table 1**). Three independent reviewers evaluated references for pertinence to the natural history, diagnosis, and management of endoscopic skull base disorders. As conducted previously, the cited reference search command (a component of the Science Citation Index Expanded) was used to identify the most frequently cited articles, which were subsequently reviewed for relevance to endoscopic skull base surgery.[4,10] Inclusion of an article necessitated agreement among all 3 reviewers.

The Top 35 Cited References—Overall (henceforth to be referred to as top 35) related to endoscopic skull base surgery were identified, along with the Top 15 Cited References—Since 2009 (henceforth to be referred to as top 15) to give consideration to publications that may not have had sufficient time to accumulate citations (**Table 1**). 2009 was chosen because it demarcated the last year of multiple publications from the top 35. Articles related to radiation therapy of skull base tumors, posterior skull base approaches, or rhinology-related diseases were excluded because of their separate timelines of development. To characterize the history of endoscopic skull base surgery, the reference journal, year of publication, and authors' names were documented. In addition, articles were categorized by their chief population of study (pituitary, extrasellar, mixed [defined as pituitary and extrasellar], or cerebrospinal fluid [CSF] leak management), format (technical report, case series, or review), and level of evidence based on the *Journal of Bone and Joint Surgery (American Edition)*. To determine if journal impact or year of publication significantly contributed to article ranking, additional information on journal impact factor was obtained from InCites Journal Citation Reports.

To help affirm and expand the scope of our findings, 20 national and international experts in endoscopic skull base surgery were then identified by representation on the generated citation rank list. Fourteen responses (70%) were obtained after a 2-month follow-up period. All contributors were provided with an unranked compilation of the 2 generated citation rank lists and requested to submit their subselection of the top 5 articles. In addition, contributors were asked to recommend 1 article that merited inclusion in the list of most influential articles, as well as 1 article published after 2011, the year after which no articles reached our citation rank lists.

## RESULTS

### Citation Rank Lists: Top 35 and Top 15

Thirty-five of the most cited articles describing endoscopic endonasal resection of anterior skull base disease were identified, with citations ranging from 98 to 467, derived from 10 different journals (**Table 1**). Four articles had more than 250 citations. The periods between 2005 and 2007 and 2008 and 2010 were among the most productive, with 10 and 11 articles, respectively, each beginning with a spike in productivity (**Figure 1**). No articles from 1993–1994, 1998–2000, 2010, or 2012 onwards were represented in the final compilation.

Among the top 35 articles, *Neurosurgery* was responsible for the largest number of articles (10 articles), followed closely by the *Journal of Neurosurgery* (9 articles; **Table 2**). The remaining journals, including *Neurosurgical Focus*, *Laryngoscope*, *Minimally Invasive Neurosurgery*, *Journal of Laryngology and Otology*, *Surgical Neurology*, *Journal of Neuro-oncology*, *American Journal of Rhinology and Allergy*, and *American Journal of Rhinology* each published 5 or fewer times within the final list. The most prolific surgeons included R.L. Carrau, A.B. Kassam, and C.H. Snyderman, with 16, 13, and 13 publications, respectively, reflecting the field's significant history at the University of Pittsburgh, as well as its multidisciplinary and collaborative nature. Eight surgeons contributed more than 5 publications.

The most discussed disease of emphasis in 11 publications was pituitary lesions. This was followed by 10 publications emphasizing extrasellar diseases and 8 publications reporting on a combination of sellar and parasellar lesions. Six articles discussed the endoscopic management of skull base closure to prevent CSF leak. All articles among the top 35 were clinical research in nature, with 18 publications primarily reporting on a case series, followed by 14 publications describing operative techniques. Three articles were a review of the literature. Overall, the level of evidence among the top 35 was generally low, with most providing level IV evidence (85%). Four articles of higher-quality level III evidence appeared after 2008, of which 2 were prospective studies.

Fifteen of the most cited articles in the field, restricted to the period after 2009, were identified with citations ranging from 57 to 118 (**Table 1**). Four articles had more than 100 citations. All but 2 articles were published in 2009, with the remaining from 2011. Four studies were published in *Neurosurgery* and *The Laryngoscope*, and 3 in the *Journal of Neurosurgery*. The most commonly described topic, with 8 articles, was extrasellar in emphasis (**Table 2**). The same 3 surgeons as before were among the most frequent contributors, with 8 publications each, and 5 authors produced 5 or more publications. Eleven articles were in the form of a case series. There were 5 articles with level III