The Top 50 Most-Cited Articles on Acoustic Neuroma

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BACKGROUND: **Acoustic neuroma is the most common extra-axial primary cerebellopontine angle tumor in adults. A plethora of studies have been published on acoustic neuroma, but none of the previous works have highlighted the most influential articles. Our objective was to perform a bibliometric analysis of the 50 most-cited articles on acoustic neuroma.**

METHODS: **We performed a title-specific search on the Scopus database using the following search terms: "acoustic neuroma," "vestibular schwannoma," and "cerebellopontine angle." We recorded the 50 most-cited articles and reviewed them.**

RESULTS: **The 50 most-cited articles had an average of 175 citations per article. All articles were published between 1980 and 2006, with 1997 the most prolific year, when 7 articles were published. The journals *Neurosurgery* and *Laryngoscope* published 10 and 8 of these articles, respectively. The most common study categories were nonsurgical management (17/50) and surgical management (13/50). Studies were predominantly published by otolaryngologists (22/50) and neurosurgeons (14/50). Douglas Kondziolka was the author with the highest number of contributions, with 7 publications. The majority of the articles were produced in the United States (64%).**

CONCLUSIONS: **Identifying articles on acoustic neuroma with the most impact provides an important overview of the historical development of treatment methods and publication trends related to this condition. A finalized, comprehensive list of the most important works represents an excellent tool that can serve as a guide for evidence-based clinical practice.**

INTRODUCTION

Acoustic neuroma is a benign, slow-growing neoplasm arising from the nerve sheath of the vestibular branch of the vestibulocochlear nerve. It is the most common tumor of the cerebellopontine angle and the internal auditory canal,[1,2] with an incidence of 0.6–0.8 per 100,000 persons per year.[3-5] The first case of acoustic neuroma was reported in 1777 by Sandifort.[5] In 1894, Ballance performed the first successful resection of acoustic neuroma.[6] In 1925, the surgical mortality rate was 67%–84% according to Walter Dandy, whereas Harvey Cushing reported that the mortality rate was only 11%.[7] In 1951, radiosurgery was introduced as a treatment option by Lars Leksell[8] and, over the following 20 years, the outcome of radiosurgery improved significantly.

Today, the available management options for acoustic neuroma are microsurgical resection, stereotactic radiosurgery, and observation of patients using imaging surveillance.[9,10] The continuous expansion of the scientific literature to achieve a multidisciplinary overview compelled us to highlight the most important work to help guide future practice.[11] Although bibliometric analyses have been conducted in many fields, such as neurosurgery,[12-15] orthopedic surgery,[16] otolaryngology–head and neck surgery,[17] radiology,[18] and anesthesiology,[19] no such analyses have been performed solely on acoustic neuroma. We aimed to conduct a bibliometric analysis of the 50 most-cited works on acoustic neuroma and to provide this as a guide for health care providers in that field.

Key words
- Acoustic neuroma
- Bibliometric
- Citation analysis
- Vestibular schwannoma

Abbreviations and Acronyms
CC: Citation count
CY: Citation per year
SJR: SCImago Journal Rank
SNIP: Source-Normalized Impact per Paper
WOS: Web of Science

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MATERIALS AND METHODS

Search Strategy

In April 2017, we conducted a title-specific search of the Scopus database to identify highly cited works on acoustic neuromas. In our search, we used the following keywords: "acoustic neuroma," "vestibular schwannoma," and "cerebellopontine angle." The search results were arranged in descending order, with the article with the highest citation count (CC) positioned at the top. We then collected and analyzed the 50 most-cited articles.

Data

The following significant data were collected: article title; author position (primary author, coauthor, most senior author; we defined the most senior author as the last author in the order as submitted by the authors); first author's specialty; country of origin; year of publication; publishing journal; CC; and study category. The studies were divided into 5 categories: review studies, natural history studies, surgical management studies, nonsurgical management studies, and classification studies.

Bibliometric Parameters

To quantify our search result, the following statistical parameters were considered: article's citations per year (CY) (the number of citations divided by the number of years [year of publication until 2017]), CC (the total number of received citations for an article by another article since the year of its publication), author's h index (an author has published h number of articles, each of which has received at least h number of citations), the journal's SCImago Journal Rank (SJR) (a parameter reflecting the journal's influence by considering the number of received citations for the journal and the type of journal from which it has received the citations), and the journal's source-normalized impact per paper (SNIP) (a parameter reflecting how discipline-specific the journal is according to the journal from which it received the citation). The abovementioned parameters were collected from the Scopus database; the top 5 authors in terms of h indexes and the top 5 journals in terms of SNIP and SJR were also recorded.

RESULTS

Article Analysis

Our search query returned 5171 articles. Of these, the 50 most-cited articles were identified with the following data recorded: CC, CY (rank), first author, title, year of publication, and publishing journal (Table S1). Overall, the 50 most-cited articles had an average of 175 citations per article. All articles were published between 1980 and 2006, with 19 articles published between 1995 and 1999, which represents the peak period of acoustic neuroma publication (Figure 1). The most prolific year was found to be 1997, with the publication of 7 articles: 6 in *Neurosurgery* and 1 in the *American Journal of Otology*. In our list, 17 articles were categorized as addressing nonsurgical management, and 13 articles were categorized as addressing surgical management. Articles addressing nonsurgical management focused primarily on radiosurgery, whereas articles addressing surgical management featured multiple approaches to microsurgery (i.e., suboccipital approach and middle fossa approach). The remaining 20 articles were categorized as follows: review studies (11 articles), natural history (6 articles), and classification studies (3e articles). In our top-50 list, 19 articles discussed the surgical management of acoustic neuroma and focused on hearing and facial nerve preservation; 15 articles discussed radiosurgical management and talked mainly about its outcome. The remaining articles discussed natural history, pathogenesis and/or etiology, clinical presentation, clinical guidelines, incidence, risk factors, and neurofibromatosis (Figure 2).

Figure 1. Topics discussed in the top 50 most-cited articles on acoustic neuroma.

In regard to authors' backgrounds, otolaryngologists contributed to 22 of the 50 articles, and neurosurgeons contributed to 14 of the 50 articles. The remaining articles were written by authors from the following specialties: radiation oncology (4 articles), rehabilitation medicine (2 articles), research (2 articles), biochemistry (2 articles), and other specialties (4 articles). Next, analysis of the top 5 institutions in terms of contribution showed that Nordstadt Krankenhaus contributed to 5 articles, and Massachusetts General Hospital contributed to 4 articles (Table 1).

The United States was the most prolific country, producing 32 articles. Germany was ranked as the second top country with 8 articles. Japan contributed to 4 articles, and the United Kingdom contributed to 3 articles. The most frequently cited article (439 citations) was authored by Douglas Kondziolka in 1998, was titled, "Long-Term Outcomes After Radiosurgery for Acoustic Neuromas," and was published in the *New England Journal of Medicine*. Analysis of the top 10 articles in relation to CC showed a CC of between 439 and 223; these articles were published between 1986 and 2000 (Table 2). Furthermore, the top 10 articles in terms of CY were published between 1988 and 2006, with CY between 261 and 131 (Table 3).

Author Analysis

A total of 193 authors contributed to the 50 most-cited articles. Analysis of the authors who had contributed to the greatest number of articles in the list showed that Douglas Kondziolka and John C. Flickinger were the 2 most prolific in this regard, publishing 7 and 6 articles, respectively. Furthermore, Kondziolka returned an h index of 91, which was the highest of all authors

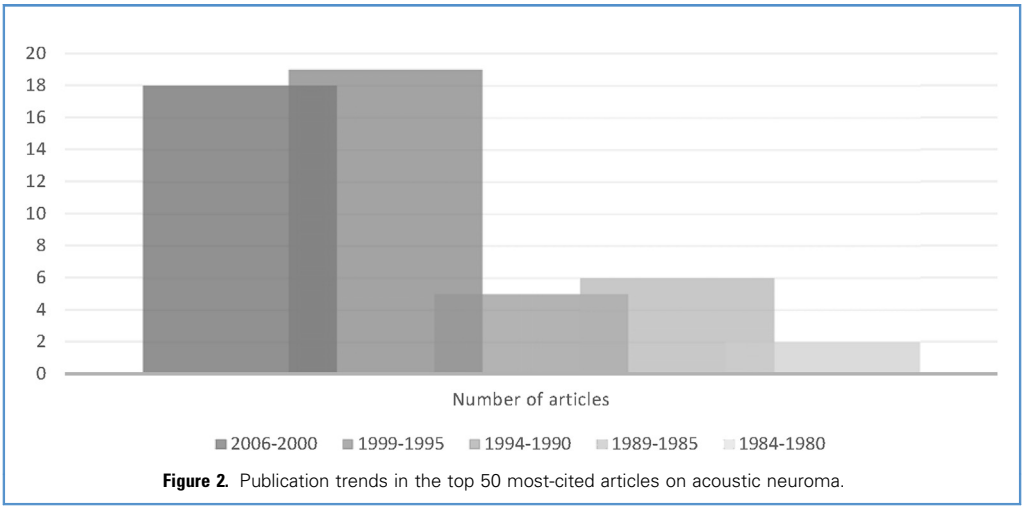

Figure 2. Publication trends in the top 50 most-cited articles on acoustic neuroma.

examined, whereas Flickinger had an h index of 86, ranking third behind L. Dade Lunsford, whose h index was 87 (Table 4).

Journal Analysis

The list of the 50 most-cited articles on acoustic neuroma included 17 journals. Further evaluation of the top 5 journals in terms of contribution, with this group accounting for 34 articles, showed that *Neurosurgery* and *Laryngoscope* published 10 and 8 articles, respectively, on the topic of acoustic neuroma; *Neurosurgery* had superior SNIP (1.44) and SJR (1.41) scores to those of *Laryngoscope* (SNIP of 1.349 and SJR of 1.342) (Table 5).

DISCUSSION

Bibliometric studies do not necessarily prove the quality of the articles examined; however, the research value and importance an article has in the medical literature can be roughly determined by the number of citations it has received. In addition, analysis of the myriad number of published articles in the field of acoustic neuroma highlights the accumulation of knowledge that has occurred over time. Therefore, we undertook analysis of the top 50 most-cited articles on acoustic neuroma.

The Scopus database is commonly[18,20] used for its wide coverage of English-language and non–English-language articles dating back to 1823, and all articles published after 1996 have a full bibliometric representation. Scopus has indexed 20,500 journals, whereas PubMed has indexed 25,000 articles. Web of Science (WOS) has indexed only 11,000 journals. The Scopus and WOS databases have a feature for tracking citations, whereas the PubMed database lacks that feature.[21] Conceptually, WOS is considered an optimal choice for English-language studies published in the early 20th century for its bibliometric coverage compared with the Scopus database, but a recent study by Vieira found that the Scopus database provided 20% more citation coverage for articles than WOS.[22] Furthermore, self-citation accounted only for 8.7%, which was provided by Scopus without the need for manual calculation as a very advantageous feature of this database.

Major specialties of contribution to the field of acoustic neuroma were otolaryngology (22 articles) and neurosurgery (14 articles); minor specialties were radiation oncology (4 articles), rehabilitation medicine (2 articles), research (2 articles), biochemistry (2 articles), and others (4 articles). The dominance of ear, nose, and throat and neurosurgery specialties in this overview reflects the lack of other disciplines producing important studies in the field of acoustic neuroma. Notably, most of the top 50 most-cited articles were found in 5 journals (Table 5). The leading journal among the top 5 journals was *Neurosurgery*, with a

Table 1. Top 5 Institutions That Contributed to the 50 Most-Cited Articles on Acoustic Neuroma

Rank	Institution	Number of Articles	Country
1st	Nordstadt Krankenhaus	5	Germany
2nd	Massachusetts General Hospital	4	USA
3rd	Amtssygehuset i Gentofte	3	Denmark
4th	Otology Group	2	USA
5th	Joint Radiation Oncology Center	2	USA

Table 2. Top-10 Articles on Acoustic Neuromas in Terms of Citation Count

Rank	CC	First Author	Last Author	Title	Year	Journal	Country
1st	439	Kondziolka	Flickinger	Long-Term Outcomes After Radiosurgery for Acoustic Neuromas	1998	*New England Journal of Medicine*	USA
2nd	384	Gardner	Robertson	Hearing Preservation in Unilateral Acoustic Neuroma Surgery	1988	*Annals of Otology, Rhinology & Laryngology*	USA
3rd	381	Samii	Matthies	Management of 1000 Vestibular Schwannomas (Acoustic Neuromas): Surgical Management and Results with an Emphasis on Complications and How to Avoid Them	1997	*Neurosurgery*	Germany
4th	363	Committee on Hearing Loss and Equilibrium		Committee on Hearing and Equilibrium Guidelines for the Evaluation of Hearing Preservation in Acoustic Neuroma (Vestibular Schwannoma)	1995	*Otolaryngology—Head and Neck Surgery*	Unavailable
5th	344	Seizinger	Gusella	Loss of Genes on Chromosome 22 in Tumorigenesis of Human Acoustic Neuroma	1986	*Nature*	USA
6th	299	Samii	Matthies	Management of 1000 Vestibular Schwannomas (Acoustic Neuromas): Hearing Function in 1000 Tumor Resections	1997	*Neurosurgery*	Germany
7th	254	Pollock	Jannetta	Outcome Analysis of Acoustic Neuroma Management: A Comparison of Microsurgery and Stereotactic Radiosurgery	1995	*Neurosurgery*	USA
8th	251	Samii	Matthies	Management of 1000 Vestibular Schwannomas (Acoustic Neuromas): The Facial Nerve—Preservation and Restitution of Function	1997	*Neurosurgery*	Germany
9th	247	Flickinger	Lunsford	Results of Acoustic Neuroma Radiosurgery: An Analysis of 5 Years' Experience Using Current Methods	2001	*Journal of Neurosurgery*	USA
10th	233	Prasad	Steiner	Gamma Surgery for Vestibular Schwannoma	2000	*Journal of Neurosurgery*	USA

CC, citation count.

contribution of 10 articles (SNIP 1.44, SJR 1.41). Following is *Laryngoscope* with 8 articles (SNIP 1.349, SJR 1.342), which reflect the contribution of the fields of neurosurgery and otorhinolaryngology to acoustic neuroma.

The institution with the greatest contribution to the research field of acoustic neuroma was Nordstadt Krankenhaus, in Hannover, Germany, with 5 published articles. In second place, Massachusetts General Hospital, in Boston, Massachusetts, contributed 4 articles. Of the top 5 institutions, 3 are based in the United States (**Table 1**).

When examining the articles by research topics, we found that most of the studies in the past 15 years have focused on the management of acoustic neuroma, including nonsurgical intervention in 17 articles and surgical intervention in 13 studies. No significant pattern highlighted the most commonly used method of management according to the published articles; both surgical and nonsurgical interventions were mentioned as a type of treatment for acoustic neuroma.

The most-cited article overall, with 439 citations, was "Long-Term Outcomes After Radiosurgery for Acoustic Neuromas" by Kondziolka, which was published in 1998 in *New England Journal of Medicine*.[23] Furthermore, it was also ranked as the number 1 article in CY, with a score of 261. This article's highest rank in both CC and CY reflects the article's influence on the popularity of managing acoustic neuromas by radiosurgery, which has become the most commonly used management method since publication of the article; furthermore, no contemporary or later studies have challenged its findings. Kondziolka reported that patients who underwent radiosurgery required no further surgery. Tumor control was confirmed by imaging techniques and, after 3 years, no patient had enlargement of the tumor, and further regression was noted in the tumor volume. Kondziolka stated that microsurgery and radiosurgery provided similar rates in preventing problems that were due to tumor growth. This was why he believed that patients with smaller tumors, patients with residual or recurrent tumors <3 cm, elderly patients, and patients in poor medical health were good candidates for stereotactic radiotherapy.

Microsurgery and stereotactic radiosurgery were also the focus of another article in the top 50, in this case, Pollock's article entitled "Outcome Analysis of Acoustic Neuroma Management: A Comparison of Microsurgery and Stereotactic Radiosurgery."[24] This article was published in 1995 in *Neurosurgery* and ranked 7th on our list in CC (254) and 15th in CY (15.4). Pollock compared both techniques in terms of cranial nerve preservation, tumor growth control, postoperative complications, patient symptoms, length of hospital stay, cost-effectiveness, and patient satisfaction. The results of the study confirmed that stereotactic radiosurgery is more effective than microsurgical resection in all examined aspects. Therefore, stereotactic radiosurgery should be offered as an alternative management. In a similar vein, an article by Flickinger entitled "Results of Acoustic Neuroma Radiosurgery:

Table 3. Top-10 Articles on Acoustic Neuroma in Terms of Citations per Year

Rank	CY	First Author	Last Author	Title	Year	Journal	Country
1st	261	Kondziolka	Flickinger	Long-Term Outcomes After Radiosurgery for Acoustic Neuromas	1998	*New England Journal of Medicine*	USA
2nd	19.05	Samii	Matthies	Management of 1000 Vestibular Schwannomas (Acoustic Neuromas): Surgical Management and Results with an Emphasis on Complications and How to Avoid Them	1997	*Neurosurgery*	Germany
3rd	16.5	Committee on Hearing Loss and Equilibrium		Committee on Hearing and Equilibrium Guidelines for the Evaluation of Hearing Preservation in Acoustic Neuroma (Vestibular Schwannoma)	1995	*Otolaryngology—Head and Neck Surgery*	Unavailable
4th	16.18	Samii	Samii	Improved Preservation of Hearing and Facial Nerve Function in Vestibular Schwannoma Surgery via the Retrosigmoid Approach in a Series of 200 Patients	2006	*Journal of Neurosurgery*	Germany
5th	15.43	Flickinger	Lunsford	Results of Acoustic Neuroma Radiosurgery: An Analysis of 5 Years' Experience Using Current Methods	2001	*Journal of Neurosurgery*	USA
6th	14.95	Samii	Matthies	Management of 1000 Vestibular Schwannomas (Acoustic Neuromas): Hearing Function in 1000 Tumor Resections	1997	*Neurosurgery*	Germany
7th	13.6	Stangerup	Thomsen	The Natural History of Vestibular Schwannoma	2006	*Otology and Neurotology*	Denmark
8th	13.46	Lönn	Feychting	Mobile Phone Use and the Risk of Acoustic Neuroma	2004	*Epidemiology*	Sweden
9th	13.24	Gardner	Robertson	Hearing Preservation in Unilateral Acoustic Neuroma Surgery	1988	*Annals of Otology, Rhinology & Laryngology*	USA
10th	13.11	Prasad	Steiner	Gamma Surgery for Vestibular Schwannoma	2000	Journal of Neurosurgery	USA

CY, citations per year.

An Analysis of 5 Years' Experience Using Current Methods," which was published in 2001 in *Journal of Neurosurgery*, discusses the efficacy of radiosurgery as an initial management in treating acoustic neuroma without surgical intervention. The study proved that stereotactic radiosurgery for management of acoustic neuroma produced a higher rate of control of tumor growth and resulted in a lower rate of morbidities compared with previously published morbidity rates in older studies. On our list, Flickinger's article was ranked ninth according to CC (247) and fifth according to CY (15.43).

The second most highly cited article overall, "Hearing Preservation in Unilateral Acoustic Neuroma Surgery," was authored by Gardner and published in 1988 in *Annals of Otology, Rhinology & Laryngology*.[25] The article received 384 citations and was ranked the ninth most-cited article in CY (13.4). In this article, Gardner highlighted the possibility of achieving hearing preservation as a primary goal from schwannoma resection surgery. He considered that unilateral schwannomas with a size <3 cm were more likely to have such an outcome with the use of advanced surgical techniques.

Samii wrote 3 articles under the title, "Management of 1000 Vestibular Schwannomas (Acoustic Neuromas)," all of which were published in *Neurosurgery* in 1997.[26-28] All 3 studies received a high number of citations and were ranked in the top 10 on our list of most-cited articles on acoustic neuroma. Each article related to a different objective. The first article, which was published in January 1997, was ranked third in CC (381) and second in CY (19.05). In this article, Samii highlighted that adopting the suboccipital approach when resecting acoustic neuromas facilitated the complete resection of the tumor while also bringing a notable

Table 4. Top-5 Contributing Authors to 50 Most-Cited Articles on Acoustic Neuroma

Rank	Author	Number of Articles	Author's *h* Index
1st	Kondziolka	7	91
2nd	Flickinger	6	86
3rd	Samii	6	56
4th	Matthies	5	29
5th	Lunsford	4	87

Table 5. Top-5 Contributing Journals to 50 Most-Cited Articles on Acoustic Neuroma

Rank	Journal	Number of Articles	SNIP	SJR
1st	*Neurosurgery*	10	1.44	1.41
2nd	*Laryngoscope*	8	1.349	1.342
3rd	*Journal of Neurosurgery*	7	1.764	1.637
4th	*International Journal of Radiation Oncology Biology Physics*	5	1.63	2.274
5th	*Otolaryngology Head and Neck Surgery*	4	1.213	1.176

SNIP, Source-Normalized Impact per Paper; SJR, SCImago Journal Rank.

reduction in morbidity, mortality, and tumor recurrence. It also highlighted that cystic schwannomas require special attention because they are more difficult to remove and associated with high risk of hemorrhage postoperatively.

In February 1997, Samii's second article, "Management of 1000 Vestibular Schwannomas (Acoustic Neuromas): Hearing Function in 1000 Tumor Resections," was published, and this is ranked sixth in both CC (299) and CY (14.95). This article focused on the preservation of cochlear nerve function, which is one of the more recent standard treatment goals in acoustic neuroma resection. Samii found that hearing preservation could be achieved at a rate of 47%–88% if the following factors exist: being male, having small to medium tumor size, having hypoacusis duration of <1.5 years, having vestibular disturbance for <0.7 years, and having preoperative good to moderate hearing (up to 40 dB loss). In his final article, "Management of 1000 Vestibular Schwannomas (Acoustic Neuromas): The Facial Nerve—Preservation and Restitution of Function," which was published in April 1997, Samii changed his focus to facial nerve preservation. Samii set management criteria in patients with facial nerve dysfunction and highlighted 3 major fundamental actions to achieve a better outcome in facial nerve preservation: intraoperative monitoring of facial nerve function, immediate reconstruction if discontinuation occurred, and follow-up with all patients without regard of whether or not the nerve was intact. This article ranked 8th in CC (251) and 11th in CY (12.5).

A notable paper entitled "Committee on Hearing and Equilibrium Guidelines for the Evaluation of Hearing Preservation in Acoustic Neuroma (Vestibular Schwannoma)" was published in *Otolaryngology—Head and Neck Surgery* in 1995 and ranked fourth in CC (363) and third in CY (16.5 CY).[29] The committee offered a guideline to improve hearing preservation during the treatment of acoustic neuroma. The guideline stated that investigators should report pretreatment and posttreatment hearing thresholds; best word recognition (speech discrimination); and hearing class reported as unchanged, improved, or worse. They should also include the tumor size, its size after radiation treatment, facial nerve status using the House-Brackmann scale, surgical technique, and complete tumor resection.

The oldest study in our 50 most-cited list was published in *Neurology* in 1980 by Kanter and was titled "Central Neurofibromatosis with Bilateral Acoustic Neuroma: Genetic, Clinical and Biochemical Distinctions from Peripheral Neurofibromatosis."[30] It discussed the distinction between 2 forms of neurofibromatosis. This study was ranked 36th in CC (126) and 50th in CY (3.4). The most recent article in the list was published in 2006 in *Journal of Neurosurgery* by Samii, in which he reported achieving complete resection for the first time with hearing preservation using a retrosigmoid approach for 200 cases. This article was ranked 15th in CC (178) and 4th in CY (16.18).

In the past decade, multiple significant studies were published in the field of vestibular neuroma, but our bibliometric search strategy did not identify them because of the lack of CC owing to their recent date of publication. In 2017, Fu et al.[31] pointed out that Gamma Knife radiosurgery is the primary treatment option for small to medium acoustic neuromas with functional neurologic preservation and improvement of life quality. Furthermore, the authors concluded that radiosurgery yielded effective tumor control when repeated after a failed first trial, and it should be considered an option after previous microsurgical resection or after subtotal resection.

In 2016, Klijn et al.[32] emphasized that the rate of tumor control was similar after radiosurgery and microsurgery but that radiosurgery preserved cranial nerve function better. Indications for radiosurgery included a tumor <10 cm^3, decline in hearing, and unfitness for microsurgery because of age and comorbidities.

In 2014, Boari et al.[33] found that, using radiosurgery, tumor control was achieved in 97.1% of cases, which resulted in a low morbidity rate. Facial and trigeminal nerve deficits as well as vertigo and balance disorders resolved or improved significantly. Moreover, the subsequent larger cohort study by Klijn et al.[32] found that the tumor control actuarial rate for 5 years was 91.3% and for 10 years was 84.4%.

In 2014, Savardekar et al.[34] reported that the current target in management focuses on complete tumor resection with hearing and facial nerve preservation if possible. The most important factor in achieving hearing preservation is the integrity of the labyrinthine structures during the drilling of the posterior wall of the internal auditory meatus, which can be achieved by keeping an intact posterior lip of the internal auditory meatus after precise planning preoperatively and using high-resolution computed tomography.

In 2015, a study comparing the outcome difference between the retrosigmoid approach using a semisitting position and a lateral horizontal position showed that surgery time was 183 minutes using the semisitting position but 365 minutes using the lateral horizontal position. Facial nerve function after 6 months was normal in 63% of patients operated on in the semisitting position;

40% of patients operated on in the lateral horizontal position had no facial nerve paralysis. The hearing preservation rate in patients operated on in the semisitting position was 44%, but it was only 14% in patients operated on in the lateral horizontal position. However, the overall complication rate showed no significant difference between using the lateral horizontal position or the semisitting position.[35]

Limitations

This bibliometric analysis has some limitations. Database-related limitations were encountered; in particular, the Scopus database had incomplete statistical analysis of articles published before 1996. Limitations are present in all bibliometric studies, which include a reliance on using the total number of citations to define impact, which can result in a bias toward older articles, as they have had more time to accumulate citations.[36-38] To overcome such underrepresentation of contemporary articles, we calculated the CY for all articles. Second, in-house citations, self-citations, and omission bias may affect the CC of articles.[39-40] Finally, classic articles forming well-known facts about a specific topic are not cited because their information is regarded as an integral part of the basic knowledge about a specific topic.[41]

CONCLUSIONS

Using the Scopus database, we identified the 50 most-cited articles on acoustic neuromas. Most of the 50 articles were written by neurosurgeons and otolaryngologists, and the majority were published in the journals *Neurosurgery* and *Laryngoscope*. Furthermore, most of the articles focused on the use of nonsurgical interventions, such as stereotactic radiosurgery and microsurgical resection, for the treatment of acoustic neuromas. This bibliometric analysis can serve as a guide for future research and as an educational tool for beginners in the field.

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SUPPLEMENTARY DATA

Table S1. List of 50 Most-Cited Articles on Acoustic Neuroma

Rank	Citations	Citations Per Year and Rank	First Author	Title	Year	Journal
1st	439	261 (1st)	Kondziolka	Long-Term Outcomes After Radiosurgery for Acoustic Neuromas	1998	*New England Journal of Medicine*
2nd	384	13.24 (9th)	Gardner	Hearing Preservation in Unilateral Acoustic Neuroma Surgery	1988	*Annals of Otology, Rhinology & Laryngology*
3rd	381	19.05 (2nd)	Samii	Management of 1000 Vestibular Schwannomas (Acoustic Neuromas): Surgical Management and Results with an Emphasis on Complications and How to Avoid Them	1997	*Neurosurgery*
4th	363	16.5 (3rd)	Committee on Hearing and Equilibrium	Committee on Hearing and Equilibrium Guidelines for the Evaluation of Hearing Preservation in Acoustic Neuroma (Vestibular Schwannoma)	1995	*Otolaryngology—Head and Neck Surgery*
5th	344	11 (17th)	Seizinger	Loss of Genes on Chromosome 22 in Tumorigenesis of Human Acoustic Neuroma	1986	*Nature*
6th	299	14.95 (6th)	Samii	Management of 1000 Vestibular Schwannomas (Acoustic Neuromas): Hearing Function in 1000 Tumor Resections	1997	*Neurosurgery*
7th	254	11.54 (15th)	Pollock	Outcome Analysis of Acoustic Neuroma Management: A Comparison of Microsurgery and Stereotactic Radiosurgery	1995	*Neurosurgery*
8th	251	12.5 (11th)	Samii	Management of 1000 Vestibular Schwannomas (Acoustic Neuromas): The Facial Nerve—Preservation and Restitution of Function	1997	*Neurosurgery*
9th	247	15.43 (5th)	Flickinger	Results of Acoustic Neuroma Radiosurgery: An Analysis of 5 Years' Experience Using Current Methods	2001	*Journal of Neurosurgery*
10th	223	13.11 (10th)	Prasad	Gamma Surgery for Vestibular Schwannoma	2000	*Journal of Neurosurgery*
11th	213	10.65 (18th)	Gormley	Acoustic Neuromas: Results of Current Surgical Management	1997	*Neurosurgery*
12th	211	11.1 (16th)	Murofushi	Vestibular Evoked Myogenic Potentials in Patients with Acoustic Neuromas	1998	*Archives of Otolaryngology—Head and Neck Surgery*
13th	197	9.85 (23rd)	Matthies	Management of 1000 Vestibular Schwannomas (Acoustic Neuromas): Clinical Presentation	1997	*Neurosurgery*
14th	182	6.5 (33rd)	Wiegand	Acoustic Neuroma—the Patient's Perspective: Subjective Assessment of Symptoms, Diagnosis, Therapy, and Outcome in 541 Patients	1989	*Laryngoscope*
15th	178	16.18 (4th)	Samii	Improved Preservation of Hearing and Facial Nerve Function in Vestibular Schwannoma Surgery via the Retrosigmoid Approach in a Series of 200 Patients	2006	*Journal of Neurosurgery*
16th	175	13.46 (8th)	Lönn	Mobile Phone Use and the Risk of Acoustic Neuroma	2004	*Epidemiology*
17th	156	9.17 (25th)	Rosenberg	Natural History of Acoustic Neuromas	2000	*Laryngoscope*
19th	150	13.6 (7th)	Stangerup	The Natural History of Vestibular Schwannoma	2006	*Otology and Neurotology*
18th	150	6.5 (34th)	Glasscock	Preservation of Hearing in Surgery for Acoustic Neuromas	1993	*Journal of Neurosurgery*
20th	149	9.93 (22nd)	Shin	Malignant Transformation of a Vestibular Schwannoma After Gamma Knife Radiosurgery	2002	*Lancet*
21st	146	12.16 (12th)	Schoemaker	Mobile Phone Use and Risk of Acoustic Neuroma: Results of the Interphone Case-Control Study in Five North European Countries	2005	*British Journal of Cancer*

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Table S1. Continued

Rank	Citations	Citations Per Year and Rank	First Author	Title	Year	Journal
22nd	146	10.42 (20th)	Kanzaki	New and Modified Reporting Systems from the Consensus Meeting on Systems for Reporting Results in Vestibular Schwannoma	2003	*Otology and Neurotology*
23rd	144	5.76 (40th)	Nadol	Preservation of Hearing and Facial Nerve Function in Resection of Acoustic Neuroma	1992	*Laryngoscope*
24th	143	11.91 (13th)	Smouha	Conservative Management of Acoustic Neuroma: A Meta-Analysis and Proposed Treatment Algorithm	2005	*Laryngoscope*
25th	141	11.75 (14th)	Evans DGR	Incidence of Vestibular Schwannoma and Neurofibromatosis 2 in the North West of England over a 10-Year Period: Higher Incidence than Previously Thought	2005	*Otology and Neurotology*
26th	140	6.67 (32nd)	Flickinger	Evolution in Technique for Vestibular Schwannoma Radiosurgery and Effect on Outcome	1996	*International Journal of Radiation Oncology Biology Physics*
27th	136	10.46 (19th)	Christensen	Cellular Telephone Use and Risk of Acoustic Neuroma	2004	*American Journal of Epidemiology*
28th	135	6.136 (37th)	Herdman	Vestibular Adaptation Exercises and Recovery: Acute Stage After Acoustic Neuroma Resection	1995	*Otolaryngology—Head and Neck Surgery*
29th	135	5.86 (38th)	Strasnick	The Natural History of Untreated Acoustic Neuromas	1994	*Laryngoscope*
30th	131	7.7 (29th)	Brackmann	Prognostic Factors for Hearing Preservation in Vestibular Schwannoma Surgery	2000	*American Journal of Otology*
31st	130	8.65 (26th)	Karpinos	Treatment of Acoustic Neuroma: Stereotactic Radiosurgery versus Microsurgery	2002	*International Journal of Radiation Oncology Biology Physics*
33rd	129	7.16 (31st)	Lanman	Report of 190 Consecutive Cases of Large Acoustic Tumors (Vestibular Schwannoma) Removed via the Translabyrinthine Approach	1999	*Journal of Neurosurgery*
32nd	129	6.45 (35th)	Samii	Management of Vestibular Schwannomas (Acoustic Neuromas): Auditory and Facial Nerve Function After Resection of 120 Vestibular Schwannomas in Patients with Neurofibromatosis 2	1997	*Neurosurgery*
34th	128	9.84 (24th)	Flickinger	Acoustic Neuroma Radiosurgery with Marginal Tumor Doses of 12 to 13 Gy	2004	*International Journal of Radiation Oncology Biology Physics*
35th	127	3.84 (46th)	Ojemann	Use of Intraoperative Auditory Evoked Potentials to Preserve Hearing in Unilateral Acoustic Neuroma Removal	1984	*Journal of Neurosurgery*
36th	126	3.4 (50th)	Kanter	Central Neurofibromatosis with Bilateral Acoustic Neuroma: Genetic, Clinical and Biochemical Distinctions from Peripheral Neurofibromatosis	1980	*Neurology*
37th	125	5.689 (41st)	Foote	Stereotactic Radiosurgery Using the Gamma Knife for Acoustic Neuromas	1995	*International Journal of Radiation Oncology, Biology, Physics*
38th	125	5.68 (42nd)	Charabi	Acoustic Neuroma (Vestibular Schwannoma): Growth and Surgical and Nonsurgical Consequences of the Wait-and-See Policy	1995	*Otolaryngology—Head and Neck Surgery*
39th	124	6.2 (36th)	Slattery	Middle Fossa Approach for Hearing Preservation with Acoustic Neuromas	1997	*American Journal of Otology*
40th	123	7.68 (30th)	Foote	Analysis of Risk Factors Associated with Radiosurgery for Vestibular Schwannoma	2001	*Journal of Neurosurgery*
41st	122	5.8 (39th)	Wiegand	Surgical Treatment of Acoustic Neuroma (Vestibular Schwannoma) in the United States: Report from the Acoustic Neuroma Registry	1996	*Laryngoscope*

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Table S1. Continued

Rank	Citations	Citations Per Year and Rank	First Author	Title	Year	Journal
42nd	121	10.08 (21st)	Combs	Management of Acoustic Neuromas with Fractionated Stereotactic Radiotherapy (FSRT): Long-Term Results in 106 Patients Treated in a Single Institution	2005	*International Journal of Radiation Oncology Biology Physics*
43rd	119	3.838 (47th)	Glasscock	A Systematic Approach to the Surgical Management of Acoustic Neuroma	1986	*Laryngoscope*
44th	117	3.77 (48th)	Prass	Acoustic (Loudspeaker) Facial Electromyographic Monitoring: Part 1. Evoked Electromyographic Activity During Acoustic Neuroma Resection	1986	*Neurosurgery*
45th	116	5.52 (43rd)	Flickinger	Dose and Diameter Relationships for Facial, Trigeminal, and Acoustic Neuropathies Following Acoustic Neuroma Radiosurgery	1996	*Radiotherapy and Oncology*
46th	113	5.38 (44th)	Deen	Conservative Management of Acoustic Neuroma: An Outcome Study	1996	*Neurosurgery*
48th	111	8.53 (27th)	Lalwani	Facial Nerve Outcome After Acoustic Neuroma Surgery: A Study from the Era of Cranial Nerve Monitoring	1994	*Otolaryngology—Head and Neck Surgery*
47th	111	7.92 (28th)	Iwai	Radiosurgery for Acoustic Neuromas: Results of Low-Dose Treatment	2003	*Neurosurgery*
49th	111	4.11 (45th)	Thomsen	Acoustic Neuroma: Clinical Aspects, Audiovestibular Assessment, Diagnostic Delay, and Growth Rate	1990	*American Journal of Otology*
50th	111	3.46 (49th)	Silverstein	Conservative Management of Acoustic Neuroma in the Elderly Patient	1985	*Laryngoscope*