Incidence of Prolonged Systemic Steroid Treatment after Surgery for Acoustic Neuroma and Its Implications

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Abstract

Objectives To determine the incidence of prolonged postoperative systemic corticosteroid therapy after surgery for acoustic neuroma as well as the indications and associated risk factors that could lead to prolonged steroid administration, and the incidence of steroid-related adverse effects.

Study Designs Retrospective chart review.

Methods Retrospective chart review of patients undergoing resection of acoustic neuroma between 2010 and 2017 at two tertiary care medical centers. Patient and tumor characteristics, operative approach, hospital length of stay, initial postoperative taper length, number of discrete postoperative steroid courses, and postoperative complications were analyzed.

Results There were 220 patients (99 male, 121 female) with an average age of 49.4 (range 16–78). There were 124 left-sided tumors and 96 right-sided tumors. Within the group, 191 tumors were operated through a retrosigmoid approach, 25 tumors through a translabyrinthine approach, and 4 tumors with a combined retrosigmoid–translabyrinthine approach under the same anesthetic. In total, 35 (15.9%) patients received an extended initial course of postoperative systemic steroids, defined as a taper longer than 18 days. Twenty six (11.8%) patients received additional courses of systemic steroids after the initial postoperative taper. There were 5 (2.3%) patients who required an extended initial taper as well as additional courses of steroids. Aseptic meningitis, often manifested as headache, was the most common indication for additional steroids (14 cases of prolonged taper and 17 cases of additional courses). None of the patient or tumor factors including age, gender, side, size, and approach were statistically significantly associated with either a prolonged initial steroid taper or additional courses of steroids. An extended hospital length of stay was associated with a prolonged initial steroid taper ($p = 0.03$), though the initial taper length was not predictive of additional courses of steroids. The cumulative number of days on steroids was associated with need for additional procedures ($p < 0.01$) as well as steroid-related

Keywords

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- vestibular schwannoma
- postoperative complications

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side effects ($p = 0.05$). The administration of steroids was not found to significantly improve outcomes in postoperative facial paresis. Steroid-related complications were uncommon, seen in 9.26% of patients receiving steroids, with the most common being psychiatric side effects such as agitation, anxiety, and mood lability.

Conclusions Systemic corticosteroids are routinely administered postoperatively for patients undergoing craniotomy for the resection of acoustic neuromas. In a review of 220 patients operated by a single neurotologist, no patient or tumor factors were predictive of requiring prolonged initial steroid taper or additional courses of steroids. The cumulative number of days on systemic steroids was associated with undergoing additional procedures and steroid-related side effects. The most common indications for prolonged or additional steroids were aseptic meningitis, cerebrospinal fluid leak, and facial paresis. Additional steroids for postoperative facial paresis did not significantly improve outcomes. Patient-reported steroid-related complications were infrequent and were most commonly psychiatric including agitation, anxiety, and mood lability.

Introduction

Acoustic neuromas are uncommon tumors that arise from the vestibular nerve and often involve the internal auditory canal (IAC) and cerebellopontine angle (CPA). These tumors, depending on size and location, may be resected via craniotomy through one of several approaches, and often by a multidisciplinary team including a neurotologist and a neurosurgeon. In the mid-1900s, intraoperative systemic corticosteroids were found to decrease morbidity and mortality after neurosurgery and are now routinely used to reduce cerebral and intra-axial edema.¹ Steroid use, however, has not been shown to definitively improve clinical outcomes after acoustic neuroma surgery such as facial nerve function or hearing loss.^{2,3} Nevertheless, dexamethasone is routinely administered intraoperatively and tapered off in the postoperative period following acoustic neuroma surgery. Steroids are also used to manage some of the common complications that arise after acoustic neuroma surgery including aseptic meningitis, cerebrospinal fluid (CSF) leak, pseudomeningocele, and delayed facial paralysis.

The first goal of this study was to describe to dosing pattern of systemic steroids at our institutions in the postoperative period following acoustic neuroma surgery and the incidence and indications for prolonged steroid tapers or additional courses of steroids. Second, this study aimed to identify any patient or tumor factors associated with requiring additional systemic steroids. Given the known risks of prolonged steroid use, a third goal was to assess the frequency of steroid-related side effects. In short courses, the most common side effects are mood swings, insomnia, gastritis, hyperphagia, hyperglycemia, fluid retention, and increased blood pressure.⁴ With chronic administration, additional side effects are seen including an increased risk of elevated intraocular pressure, infection, adrenal suppression, skin changes, weight gain, and avascular necrosis of the hip.⁴ Lastly, this study presents a review of the literature

including the rationale and evidence for treating postoperative complications with additional systemic steroids.

Materials and Methods

Study Design

A retrospective chart review of patients who underwent craniotomy for resection of acoustic neuroma was performed. All surgeries were performed at one of two tertiary care centers by a single neurotologist (SS) typically with one of three experienced neurosurgeons (PS, CB, PG). All patients who were included had complete electronic medical records for analysis. This study qualified for expedited review and was approved by the institutional review boards of Weill Cornell Medical College and Memorial Sloan Kettering Cancer Center (IRB #1702017964).

A total of 220 consecutive procedures performed by the senior author between 2010 and 2017 fulfilled the inclusion criteria. The criteria were the following: (1) craniotomy for resection of a CPA mass via retrosigmoid, translabyrinthine, or middle cranial fossa approach; (2) confirmed diagnosis of acoustic neuroma on pathology; (3) complete record of inpatient medications, discharge prescriptions, taper schedules, and outpatient medications; and (4) postoperative follow-up of at least 6 months. All patients were included without age restriction. No patients were excluded due to incomplete records or inadequate follow-up.

At the institutions from which the data in the present study were obtained, patients were admitted to the neurosurgical service after craniotomy for acoustic neuroma resection and the dosing and duration of steroids were determined by the neurosurgical service.

For each case, patient factors recorded included age and gender. Tumor factors including tumor side, size, and extent of involvement of the IAC were reviewed. The tumor size reported was the greatest diameter of the tumor at the CPA. Tumors entirely within the IAC were recorded as an

intracanalicular tumor. Intraoperative and postoperative analysis included the surgical approach to the tumor, postoperative length of stay, and duration and dosing of postoperative steroids both in the hospital and on discharge. Tapers greater than 18 days were classified as a prolonged taper. The incidence of patients requiring additional courses of steroids was also analyzed. The indications for prolonged taper or additional courses of steroids were identified from the chart. Any postoperative complications including readmissions, additional procedures, and steroid-related side effects were recorded and analyzed.

In the analysis of facial nerve outcomes after surgery, any patients with acute postoperative facial weakness defined as deterioration of at least two House-Brackmann grades were identified. Patients with pre-existing facial weakness were not analyzed in this group. Return to normal function was defined as a final House-Brackmann grade of I/VI or II/VI, and persistent facial weakness was defined as House-Brackmann III/VI or worse.

Data Analysis

The incidence of prolonged initial taper as well as additional courses of steroids was analyzed against the patient and tumor factors as well as the postoperative course to assess for any associations. Patients were grouped based on the response variables, first if the patient had a normal (1) or prolonged (2) initial taper, and second, if the patient received a single (1) or multiple (2) courses of post-op steroids. Demographic (age, gender) and intraoperative variables (approach, side, and tumor size) were compared between the two groups of each response variable. Tumor size had four categories: intracanalicular, small (less than 1 cm), medium (between 1 and 3 cm), and large (> 3 cm). QQ plots were made for the continuous variables as a test of normality. Unpaired two-sided *t*-test was conducted for normally distributed age variable across the different groups. Differences in categorical variables such as gender, side, tumor size, and approach across the response groups (number of steroid courses, length of initial postoperative taper) were analyzed using chi-squared tests. Mann-Whitney U tests were performed for non-normally distributed variables to determine whether the cumulative number of days on steroids was correlated with steroid-related side effects as well as additional procedures. Chi-square tests were conducted to determine whether a prolonged initial taper length was associated with additional steroids. Multivariate logistic regressions were conducted with the above variables for the initial taper length and number of steroid courses. All analyses were conducted in R version 3.2.3.

Results

A total of 220 cases were identified for analysis. ►**Table 1** summarizes the patient and tumor factors. The average patient age was 49.4 years (range 16–78, standard deviation [SD] 13.4) with a tumor size of 2.04 cm (range 0.1–5.3, SD 1.10). The average hospital length of stay was 4.67 days

Table 1 Patient and tumor characteristics

	Average
Age	49.4 years (range 16–78, SD 13.4)
Tumor size	2.04 cm (range 0.1–5.3, SD 1.10)
Hospital LOS	4.67 days (range 2–26, SD 3.23)
Length of initial taper	15.07 days (range 0–64, SD 6.74)

Abbreviation: LOS, length of stay.

(range 2–26, SD 3.23) and the average initial taper length was 15.07 days (range 0–64, SD 6.74).

While there were many differing taper schedules, the typical taper started at 6 mg of dexamethasone every 6 hours with a 30% reduction in dosage every 2 days. ►**Table 2** shows the four most common taper schedules, all between 12 and 14 days, and ►**Fig. 1** illustrates the distribution of taper lengths with most falling between 12 and 18 days. An prolonged initial taper was defined as greater than 18 days.

A more granular breakdown of the initial taper length as well as total number of steroid courses is shown in ►**Table 3**. There were 4 patients (1.8%) who received no postoperative steroids, 14 patients (6.3%) with a fast taper less than 10 days, 167 patients (75.9%) with a standard taper between 10 and 18 days, and 35 patients (15.9%) with a prolonged taper greater than 18 days. All four patients who received no postoperative steroids underwent a translabyrinthine approach. The number of courses of systemic steroids is also summarized in ►**Table 3**. One-hundred ninety patients (86.4%) received one course, 22 patients (10%) took two courses, and 4 patients (1.8%) took three courses. There were five patients (2.3%) who required both an prolonged initial taper and multiple courses of steroids.

The results of the multivariate analysis of the patient and tumor characteristics with respect to a prolonged initial taper or additional course of steroids are summarized in ►**Table 4**. None of the variables examined, including age ($p = 0.10$), gender ($p = 0.87$), tumor side ($p = 0.06$), tumor size ($p = 0.92$), and surgical approach ($p = 0.61$), were statistically significantly associated with prolonged initial taper. Similarly, age ($p = 0.35$), gender ($p = 0.22$), tumor side ($p = 0.89$), tumor size ($p = 0.35$), and surgical approach ($p = 0.21$) were not found on multivariate analysis to be correlated with additional courses of steroids. The length of the initial steroid taper was also not found to be predictive of requiring additional courses ($p = 0.84$).

The average length of hospital stay was 4.67 days. ►**Fig. 2** shows the relationship between hospital stay and taper length. Multivariable logistic regression analysis showed that increasing hospital length of stay was statistically significantly associated with a longer initial postoperative taper ($p = 0.03$). The odds ratio of 1.13 (95% confidence interval; 1.01, 1.28) indicates that each additional hospital day is correlated with an increased likelihood of an extended initial taper by a factor of 1.13. A summary of the primary indications for additional steroids is shown in ►**Table 5**. The indications are divided between patients receiving

Table 2 Most common initial postoperative taper regimens

Post-Op day	Taper 1 (14d)	Taper 2 (14d)	Taper 4 (12d)	Taper 3 (13d)
	22.3% (49/220)	13.2% (29/220)	7.7% (17/220)	7.3% (16/220)
0	6 mg every 6 hours	6 mg every 6 hours	6 mg every 6 hours	6 mg every 6 hours
1				
2	4 mg every 6 hours	4 mg every 6 hours	4 mg every 6 hours	4 mg every 6 hours
3				
4	4 mg every 8 hours	4 mg every 8 hours	4 mg every 8 hours	4 mg every 8 hours
5				
6	4 mg every 12 hours	4 mg every 12 hours	4 mg every 12 hours	4 mg every 12 hours
7				
8	2 mg every 8 hours	4 mg AM, 2 mg PM	2 mg every 12 hours	2 mg every 12 hours
9				
10	2 mg every 12 hours	2 mg every 12 hours	2 mg every 24 hours	2 mg every 24 hours
11				
12	2 mg every 24 hours	2 mg every 24 hours	Off	Off
13				
14	Off	Off		

prolonged tapers and additional courses. Taken together, the most common indication was suspected aseptic meningitis (29 patients), followed by CSF leak (14 patients), facial paresis (11 patients), hydrocephalus (3 patients), and pseudomeningocele (2 patients). One patient each was treated for fatigue and shortness of breath, new-onset seizures, and acute bacterial meningitis.

The cumulative number of days a patient was on steroids ranged from 0 to 130 days, with an average of 18.0 days. Forty-seven patients required a total of 57 subsequent procedures, either urgently intraoperative or in the postoperative period (►Table 6). The most common procedures were a lumbar drain (28 patients) or lumbar puncture (9

patients). Other procedures included removal of hardware (5 patients), wound revision (4 patients), ventriculostomy (3 patients) or ventriculoperitoneal shunt (3 patients), wound revision (3 patients), Eustachian tube obliteration (3 patients), evacuation of a hematoma (1 patient), and percutaneous endoscopic gastrostomy tube (1 patient). Ten patients required multiple procedures. All 10 patients had either a lumbar puncture or lumbar drain in addition to another procedure such as a ventriculoperitoneal shunt or wound revision. Of the patients requiring additional procedures, 16 (34.0%) had extended postoperative steroid tapers and 13 (27.7%) received more than one course of steroids. Statistical analysis showed that the cumulative number of

Fig. 1 Distribution of initial postoperative taper lengths.

Table 3 Summary of postoperative steroid dosing

Initial taper	No steroids	4 (1.8%)
	Fast taper (< 10d)	14 (6.3%)
	Standard taper ($\leq$ 18d)	167 (75.9%)
	Prolonged taper (>18d)	35 (15.9%)
Number of steroid courses	No steroids	4 (1.8%)
	1 course	190 (86.4%)
	2 courses	22 (10.0%)
	3 courses	4 (1.8%)

days on steroids was higher with patients who had additional procedures ($p < 0.01$), with an average of 23.79 days versus 16.43 days. Similar analysis showed that the cumulative number of days on steroids was associated with steroid-related side effects ($p = 0.05$).

► **Table 7** summarizes the reported adverse events of systemic steroid use identified from chart review. A total of 39 steroid-related side effects were reported in 20 patients (9.26% of patients who received postoperative steroids), with the most common being anxiety, agitation, or mood lability (6.02%), insomnia (3.70%), facial swelling (1.85%), and rash (1.85%). When combining the initial steroid taper and

Table 4 Summary of multivariate analysis of patient and tumor factor associations with prolonged taper or additional courses of steroids

		N (out of 220)	Prolonged taper	p Value	Additional courses	p Value
Age				$p = 0.10$		$p = 0.35$
Gender	Male	99 (45.0%)	15 (15.2%)	$p = 0.87$	14 (14.1%)	$p = 0.22$
	Female	121 (55.0%)	20 (16.5%)		12 (9.9%)	
Side	Left	124 (56.4%)	25 (20.2%)	$p = 0.06$	16 (12.9%)	$p = 0.89$
	Right	96 (43.6%)	10 (10.4%)		11 (11.5%)	
Size (average 2.02)	Intracanalicular	17 (8.18%)	2 (11.8%)	$p = 0.92$	3 (17.6)	$p = 0.35$
	<1 cm	24 (10.9%)	3 (12.5%)		1 (4.2%)	
	1–3cm	130 (59.1%)	22 (16.9%)		17 (13.1%)	
	>3 cm	49 (22.3%)	8 (16.3%)		5 (10.2%)	
Approach	Retrosigmoid	191 (86.8%)	29 (15.2%)	$p = 0.61$	23 (12.0%)	$p = 0.21$
	Translabyrinthine	25 (11.4%)	5 (20.0%)		2 (8.0%)	
	Combined	4 (1.8%)	2 (50.0%)		1 (25.0%)

Fig. 2 Association between length of hospital stay and postoperative taper length.

Table 5 Primary indication for additional steroids

Indication for additional steroids	Combined (tapers and courses)	Prolonged taper	Additional courses
Aseptic meningitis (including headache, n/v)	29 ^a	14	17
CSF leak	14 ^a	11	3
Facial paralysis/weakness	11 ^a	7	6
Hydrocephalus	2 ^a	1	2
Pseudomeningocele	2 ^a	0	2
Fatigue and shortness of breath	1 ^a	0	1
Seizures	1 ^a	0	1
Acute bacterial meningitis	1 ^a	0	1

^aThe numbers in the combined column do not add up correctly for aseptic meningitis, facial paralysis, and hydrocephalus because there are patients who received both prolonged initial taper and additional courses.

Abbreviation: CSF, cerebrospinal fluid.

additional courses, 55 patients were steroid dependent for more than 18 days, and of these patients, 9 (16.36%) patients had one or more steroid-related side effects. In comparison, of the 17 patients who were on steroids less than 10 days total, only 1 (5.9%) reported a side effect. The cumulative number of days on steroids was greater for patients with a side effect attributed to steroids ($p = 0.05$). All steroid-related adverse effects were self-reported by patients at follow-up rather than identified from a systematic survey of possible complications.

In this study, 19 patients experienced either immediate facial paresis despite intraoperative stimulation of the facial nerve at 0.1 or 0.2 mA ($n = 9$), or delayed facial paresis, defined as deterioration of facial function of at least two House-Brackmann grades to HB III/VI or worse between postoperative days 5 and 30 ($n = 10$). This analysis does

not include patients with pre-existing facial weakness or who required intraoperative nerve sacrifice. Out of the 19 patients with immediate or delayed postoperative facial paresis, 11 patients (57.9%) received additional steroids in the form of prolonged tapers (6), additional courses (5), or both (1). Ten out of the 11 patients (90.9%) returned to normal function, with an average of 65.1 days (range 3–279) between onset and resolution. Of the 8 patients (42.1%) who did not receive steroids during their facial paresis, 6 (75%) returned to normal function, with an average duration of 53.2 days (range 2–128). Overall, 84.2% (16 of 19) patients returned to normal function, which was defined as a House-Brackmann grade I/VI or II/VI. There was no difference in the time to or completeness of recovery when comparing those patients who received and those who did not receive steroids. There was also no difference in the recovery of function between patients with immediate or delayed facial paresis. Comparing all patients who returned to normal facial function, their tumors tended to be smaller than those who did

Table 6 Adverse effects attributed to steroids

Adverse effect (number of patients with adverse effects 20/216, 9.26%)	Incidence
Psychiatric side effects (e.g., agitation, anxiety, distractibility, mood lability, mania, depression, and aggressiveness)	13 (6.02%)
Insomnia	8 (3.70%)
Facial swelling	4 (1.85%)
Rash	4 (1.85%)
Weight gain	2 (0.93%)
Acne	2 (0.93%)
Blurry vision	2 (0.93%)
Mild moon facies	1 (0.46%)
Steroid-induced hyperglycemia	1 (0.46%)
Increased hunger	1 (0.46%)
Infection (oral candida)	1 (0.46%)

Table 7 Additional postoperative procedures

Additional procedure (emergent intra-op or immediate post-op, 57 total procedures in 47 patients)	Incidence
Lumbar drain	28 (10.9%)
Lumbar puncture	9 (4.1%)
Hardware removal	5 (2.3%)
Ventriculostomy	3 (1.4%)
Ventriculoperitoneal shunt	3 (1.4%)
Wound revision	3 (1.4%)
Eustachian tube obliteration	3 (1.4%)
Evacuation of hematoma	1 (0.5%)
Wound dehiscence	1 (0.4%)
PEG	1 (0.4%)

Abbreviation: Percutaneous endoscopic gastrostomy.

not (average size of 1.8 cm vs 3.0 cm). This finding did not reach statistical significance ($p = 0.11$).

Discussion

Beginning in the early 1960s, corticosteroids have been administered to patients undergoing craniotomy.¹ Since then, it has become commonplace to administer intraoperative and postoperative steroids for the resection of acoustic neuromas with the primary goals of reducing cerebral and intra-axial volume to improve surgical exposure and reducing edema from surgical manipulation and trauma. However, studies looking at facial nerve function and hearing loss have not shown steroids to improve outcomes.^{2,3} The experience and practice of prescribing postoperative systemic steroids from the present study are described and critically analyzed to develop an optimized strategy of postoperative systemic steroid use.

To the best of our knowledge, this is the first publication to specifically address the question of extended postoperative steroid duration or the reinstitution of an additional course of steroids. In our series, 35 patients (15.9%) received an initial postoperative steroid tapers longer than 18 days and 26 patients (11.8%) received additional courses of steroids after completing an initial taper. There were five patients (2.3%) requiring both a prolonged initial taper and additional courses of steroids. The time at which the additional courses were administered ranged from the day after completing the initial taper to 3 months postoperatively. The length of the initial steroid taper was not found to be associated with requiring additional courses of steroids ($p = 0.84$). In the present study, 2 out of 14 patients (14.3%) with initial tapers shorter than 10 days required an additional course, compared with 19 out of 165 (11.5%) with normal tapers and 5 out of 35 (14.3%) with long tapers. Of the four patients who received no steroids postoperatively, none required steroids during their postoperative course.

Limitations of this study include the number of different neurosurgeons who operated with the single neurotologist, resulting in a variety of different steroid taper regimens. Without a rigorous "standard" taper regimen, there may be confounders such as the speed at which the steroid is tapered, or the physiologic response from receiving 12 days of steroids versus 18 days of steroids. In addition, it is possible that the number of additional courses is underreported, as additional courses of steroids may have been prescribed by other providers such as their primary care physician in the postoperative period.

A multivariate analysis did not find age, gender, tumor side, surgical approach, or tumor size to be statistically significantly associated with either a prolonged initial taper of systemic steroids or additional courses of steroids. Because only a small percentage of patients required additional steroids, this study may not have been sufficiently powered to reach statistical significance. A prolonged postoperative hospital stay was associated with a prolonged initial steroid taper ($p = 0.03$). This is not surprising since a patient with a more turbulent postoperative course might

be expected to have a prolonged hospital stay and an increased need for additional steroids. We observed that the length of initial steroid taper was not associated with requiring additional courses of steroids ($p = 0.84$) but that the cumulative days on steroids was associated with an additional procedure ($p < 0.01$) or steroid-related side effects ($p = 0.05$).

The most common indications for prolonged taper were aseptic meningitis (15 patients), CSF leak (9 patients), and facial paresis (7 patients), whereas the most common indications for additional courses were aseptic meningitis (11 patients), facial paresis (4 patients), CSF leak (4 patients), hydrocephalus (4 patients), and pseudomeningocele (4 patients). Most patients receiving steroids for aseptic meningitis complained of persistent headaches.

Some studies have shown that complication rates following acoustic neuroma surgery vary by tumor size and surgical approach.⁵⁻⁷ The most common complications overall include hearing loss, facial nerve dysfunction, cerebrospinal leak, and postoperative headache.⁵ Despite the frequent use of steroids for these complications, there is a paucity of evidence in the literature to indicate that steroids improve outcomes. Reported benefits of systemic steroids include treatment of headaches, reduced postoperative pain and nausea, and shortened length of hospitalization.⁸ In a study of 59 patients who underwent elective craniotomies, patients administered steroids preoperatively reported reduced postoperative pain relative to patients who were not given steroids.⁹ Dexamethasone may help relieve headache pain caused by meningeal inflammation in the early postoperative period. Alternatively, corticosteroids may relieve headaches by decreasing the incidence of aseptic meningitis commonly encountered after this procedure. Corticosteroid therapy has also been noted to improve pain management after craniotomy via its anti-nausea effect, thereby allowing patients to tolerate higher amounts of opioids.¹⁰

The incidence of aseptic meningitis has been reported to be less than 4% of acoustic neuroma cases.⁵ Aseptic meningitis may be an inflammatory response to products that enter the CSF intra- and postoperatively, including blood, bone dust, and foreign bodies such as lint from gauze. Symptoms consistent with aseptic meningitis are headaches, nausea, and vomiting, commonly beginning soon after the discontinuation of steroid.¹¹ When suspected, steroid and often empiric antibiotic treatment until a lumbar puncture and CSF culture results are obtained is recommended.^{11,12} A CSF profile showing mildly elevated white blood cell with normal CSF and serum glucose is indicative of aseptic meningitis rather than bacterial meningitis, although confirmation with a negative CSF gram stain and culture is often recommended. In cases of chronic headache after the initial steroid taper, patients were offered presumptive trial of steroids without a CSF analysis first. In the present study, 27 patients received additional steroids for aseptic meningitis, with 15 receiving a prolonged taper, 11 requiring an additional course, and 1 requiring both an initially extended taper and additional course. In most cases, patients were treated based on

consistent clinical diagnosis of aseptic meningitis with symptoms such as headaches (23 patients), nausea and vomiting (1 patient), or both (3 patients). Of these, only three patients subsequently had CSF analysis from a lumbar puncture when symptoms did not initially improve. There were no cases of bacterial meningitis.

In the facial nerve literature, it has been reported that systemic steroids may improve outcomes after acute facial palsy or Bell's palsy, although this data has been equivocal.¹³ One might hypothesize that systemic steroids function to reduce neural edema resulting from surgical manipulation and trauma, thereby improving postoperative facial nerve function after removal of acoustic neuroma.² However, the literature is inconclusive as to whether intraoperative or postoperative steroid treatment results in improved facial nerve outcomes. Buchman et al reported no improvement in facial nerve function when comparing 75 patients who received a single dose of intraoperative steroids with 94 patients who did not receive steroids. In addition, there was no effect on the observed frequencies of any postoperative complications.² Similarly, a double-blind randomized study of 310 patients reported no benefit for facial nerve function of postoperative methylprednisolone (1 mg/kg/day intravenous [IV] for 5 days) versus placebo, including when stratified for tumor size.¹⁴ Another retrospective study of 489 patients by Carlstrom et al found no difference in recovery time between patients with delayed facial paralysis who received treatment with steroids, steroids with antivirals, or no treatment at all.¹⁵ Darrouzet et al described 12 patients with delayed facial paralysis 6 to 10 days after surgery for acoustic neuroma who were treated with 2 mg/kg of IV methylprednisolone and acyclovir for 7 days.¹⁶ All patients in this study showed complete recovery but this study was limited by the lack of a control group for comparison.

Postoperative facial paresis was observed in 19 patients with intact intraoperative facial nerve stimulation at 0.1 or 0.2 mA. Of this group, 9 patients had immediate postoperative facial paresis, and 10 patients had delayed facial paresis, which presented between postoperative days 5 and 30. Most patients returned to normal function (16 of 19, 84.2%), though only about half of these patients received steroids and there was no significant difference in the rate or completeness of recovery. There was also no difference in the recovery of function between patients with immediate or delayed facial paresis. Comparing all patients who returned to normal facial function, their tumors tended to be smaller than those who did not (average size of 1.8 cm vs 3.0 cm, $p = 0.11$). Steroids did not improve the percent of patients who recovered. While it appears as though the patients who received steroids actually had a longer time until improvement was noted, this finding may be biased by tumor factors that led to additional steroids as well as the interval between follow-up appointments.

In a review of complications following acoustic neuroma surgery, CSF leak may occur in 7% to 30% of patients following resection.⁵ In the present study, there were 13 cases of CSF leaks out of 220 cases (5.9%) with 12 out of 13 receiving additional steroids. All 13 patients were managed with a

lumbar drain, with 5 patients requiring a second procedure including 2 Eustachian tube obliterations, 2 ventriculoperitoneal shunts, and 1 wound revision. One patient was readmitted a second time after an initial CSF leak was managed with a lumbar drain and Eustachian tube obliteration and required a second lumbar drain.

Five patients in the present study received additional steroids for pseudomeningocele with the goal of decreasing intracranial pressure that may contribute to the development of the meningocele. In the literature, most patients are sufficiently managed nonoperatively with a pressure dressing, percutaneous drainage, or lumbar drain and bed rest.¹⁷

It is established that surgical complications, including facial weakness, CSF leak, and infection, following acoustic neuroma resection are associated with larger tumor size.^{6,7} The present findings support this with a trend toward less postoperative steroids in small, nonintracanalicular tumors, though this trend was not statistically significant. Patients with tumors smaller than 1 cm had the lowest incidence of prolonged initial steroid tapers and additional courses. Patients with intracanalicular tumors, however, had the highest rate of requiring additional courses of steroids, which may be expected given the limited space within the IAC. One pitfall of tumor size stratification, however, is that the reported size is a two-dimensional measurement of the component of the tumor within the CPA and does not fully describe the volume of the tumor, the displacement of the cerebellum, or the extent of the tumor within the IAC.

The majority of the acoustic neuromas were removed through the retrosigmoid approach. The translabyrinthine approach had the lowest rates of prolonged taper and additional courses. The translabyrinthine approach may be selected for a variety of reasons including patient's hearing loss, age, tumor size, tumor location, and prior surgical approach. The combined retrosigmoid and translabyrinthine approach under the same anesthetic was only utilized for very large tumors for which the translabyrinthine approach alone did not afford adequate access for complete resection, but was used to radically debulk the tumor before removing the remaining tumor via the retrosigmoid approach. In the combined approach, less retraction is necessary since additional room in the CPA has been afforded by the prior translabyrinthine debulking portion of the surgery. These patients underwent more extensive and longer surgeries and would have been expected to have had more difficult recoveries postoperatively.

When prescribing steroids, the surgeon should be mindful of the potential side effects, especially for high dose or extended use. Known steroid complications include redistribution of adipose tissue, hyperglycemia, increased risk of infection, increased intraocular pressure, and skin changes.⁴ Fifteen percent of patients exhibited redistribution of fat within 3 months at a dose of 10 to 30 mg per day. The effect on hyperglycemia was variable, though the rate of infection was observed to increase from 8% to 12.7% in one meta-analysis.¹⁸ Intraocular pressures increased within the first few weeks of therapy with 18% to 36% of patients developing a 5 mm Hg or greater increase. Skin changes including rash

and acne were as prevalent as 46% of patients on an average dose of 30 mg of prednisone over 3 months.⁴ Psychiatric side effects of steroids may be mild (27.6%, range 13–62%) such as agitation, anxiety, distractibility, insomnia, lethargy and mood lability, or more severe reactions, such as mania, depression, and aggressiveness (5.7%, range 1.6–50%).⁴ While more than 90% of patients recover from these psychiatric effects, they can be quite worrisome when they persist. It has been reported that even short-term use of oral corticosteroids of less than 30 days was associated with increased rates of sepsis, venous thromboembolism, and fractures.¹⁹ It is known that chronic steroid use may result in adrenal insufficiency with high dose and longer use being significant risk factors.²⁰ However, the exact duration and dosage of steroid causing adrenal suppression are unclear.

Similarly, the precise cumulative dose of dexamethasone at which steroid-related side effects may be observed is not defined. The standard steroid taper employed in the present study begins with 24 mg/day tapering down to 16 mg/day by postoperative day 2 with a total taper of ~2 weeks. The statistical analysis found that the cumulative number of days on steroids was correlated with steroid-related side effects. Unsurprisingly, the two patients with the highest cumulative number of days on steroids (97 and 130 days for headaches and arachnoiditis, respectively) experienced the most adverse effects attributed to steroids.

In the present study, the reported adverse effects of steroid use were recorded based on the patient's subjective complaints. A more accurate and systematic approach to identifying side adverse effects would be to with a structured questionnaire. It is possible that steroid-related side effects may be underreported. Of note, there have been studies on steroid substitutes that may avoid the side effects of systemic steroids. One such agent that has shown some promise and deserves further study is corticotrophin-release factor.¹

Analysis of postoperative steroid use in the present study indicates that, while steroids are relatively well tolerated, systemic steroids should be used judiciously and with evidence-based guidelines in mind. Review of the literature has found clear evidence supporting the use of steroids only for meningitis. The use of steroids in the treatment for postoperative facial paralysis, CSF leak, hydrocephalus, and pseudomeningocele is deserving of further comparative trials. With evidence supporting conservative management, patients treated with steroids may be unnecessarily exposed to adverse effects from steroids. Given the low rate of steroid-related complications observed in the present study, the authors did not identify any patterns of postoperative steroid that resulted in patient harm and should be avoided. Although no changes in our steroid-prescribing practice directly resulted from this study, further research should be done on the ideal dosing and duration of the initial taper such as a randomized control trial of different initial taper lengths. The experience from the present study suggested that a shorter initial taper did not increase the incidence of postoperative complications and minimized the risk of steroid-related side effects. With all doses and durations, clinicians must be mindful of the adverse effects of prolonged

systemic steroids when examining patients in the postoperative setting.

Conclusion

Systemic steroids are routinely administered postoperatively for patients undergoing craniotomy for the resection of acoustic neuromas. In a review of 220 patients operated by a single neurotologist, there were no patient or tumor factors found to be predictive of requiring prolonged initial steroid taper or additional courses of steroids. The cumulative number of days on systemic steroids was associated with requiring additional procedures and steroid-related side effects. The most common indications for prolonged or additional steroids were aseptic meningitis, CSF leak, and facial paresis. Additional steroids for delayed postoperative facial paresis were not found to significantly improve outcomes. Patient-reported steroid-related complications were infrequent and were most commonly psychiatric but may be underreported.

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None.

Conflicts of Interest

None.

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