ORIGINAL ARTICLE

Surgical outcome of Acoustic Neuroma Surgery in a Malaysian Tertiary Hospital

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ABSTRACT

INTRODUCTION: Acoustic neuroma (AN) or vestibular schwannoma, is a benign, slow-growing tumour that arises from the Schwann cell of the vestibular branch of the vestibulocochlear nerve. Treatment options are mainly conservative or surgical excision. The aim of this study is to describe the clinical characteristics of AN and the surgical outcomes in a Malaysian tertiary hospital. **MATERIALS AND METHOD**: Records of 73 patients who were diagnosed with AN from January 2008 until December 2019 were retrieved. All patients were analyzed for demographic data and clinical characteristics. In all 52 patients underwent AN surgery and had normal preoperative facial nerve function. A descriptive analysis was used for the surgical outcomes of each patient. **RESULTS**: The median age of patients was 51.5 (15.8 SD). Hearing levels pre-operatively were severe to profound in 74.0% of the patients, followed by moderate to severe in 15.1%, mild to moderate in 6.8%, and mild hearing loss in 2.7%. Retrosigmoid (48.1%) was the most common surgical approach used, followed by translabyrinthine (44.2%) and middle cranial fossa (MCF) (7.7%). The translabyrinthine approach is associated with the least incidence of facial nerve paresis postoperatively (21.2%) when compared to the retrosigmoid and middle cranial fossa approaches (40.4%). However, there was no significant association between surgical approaches and facial nerve outcome (p=0.07). **CONCLUSION**: AN surgery is a safe procedure, regardless of the surgical approach used. There was a significant relationship between tumour size and facial nerve outcome.

Keywords
acoustic neuroma outcome, translabyrinthine approach, retrosigmoid approach, middle cranial fossa approach, tinnitus

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INTRODUCTION

Acoustic neuromas (AN), or vestibular schwannomas, are benign, slow-growing tumours. It arises from the Schwann cells of the vestibular branch of the vestibulocochlear nerve in the internal auditory meatus and cerebellopontine angle.[1] It represents approximately 80% of tumours of the cerebellopontine angle and 6% of all intracranial tumours.[2,3] The average growth rate is approximately 2 mm per year.[4] In cases of bilateral AN, it is always defined as neurofibromatosis type 2 (NF2).[5] Changes in the pattern of patient presentation have been observed. Hearing loss, as the only presenting feature, is decreasing. Since early 2000, there has been increasing variability in the presenting symptoms. Tinnitus, ataxia, vertigo, and incidental findings account for more patient presentations.[6] Gadolinium enhanced magnetic resonance imaging (MRI) of the internal acoustic meatus and cerebellopontine angle helped in the diagnosis.[7] Histopathological examination of AN revealed two different appearances, namely Antoni A and Antoni B types.[8] Treatment options were mainly done conservatively or by surgical excision.[9] There were many factors that influences the choice of treatment. There are a few common complications that arise following surgery, namely facial nerve paresis, cerebrospinal fluid leakage and meningitis.[10] To date, there are three Malaysian studies on AN surgery.[11,12,13] The aim of this study is to describe the clinical characteristics of AN and the outcomes of AN surgery in a tertiary hospital in Malaysia.

MATERIAL AND METHODS

This was a retrospective study conducted over a two-year period at Hospital Canselor Tuanku Muhriz (HCTM), Kuala Lumpur, Malaysia. The study obtained approval from the Universiti Kebangsaan Malaysia (UKM) research and ethics committee (FF-2019-045). Universal sampling was used, and all AN patients were seen during the period were included in this study. The data was identified from the Case Mix Unit (ICD 10 coding D33.3), operation theatre census, otorhinolaryngology (ORL), and neurology clinics. Inclusion criteria were patients diagnosed with AN between January 1 and December 31, 2008, and the availability of their medical records. The exclusion criteria were unavailability or incomplete patient case notes, patients with neurofibromatosis type II, and those with impaired facial nerve function (grade III and above) preoperatively.

The facial nerve outcome was defined as normal in House Brackman (HB) grades I and II and impaired in HB grades III and above. A tumour was defined small when the size was less than 2.5 cm, and a large tumour was when the size was 2.5cm or larger in the longest diameter. Facial nerve paresis is defined as impaired facial nerve function from post-extubation to 6 months post-operation. Palsy is defined when impaired facial nerve function lasted longer than 6 months. Based on the prevalence of complications from previous studies, a minimal sample size of 45 patients was calculated.[3,14] Data was collected using a pre-designed study proforma and analyzed using SPSS version 23.0.

RESULTS

Of the total of 73 patients diagnosed with AN, 60 patients underwent surgical excision of the tumour, while eight of them were excluded since their facial nerves were impaired pre-operatively (n=52). Out of 52 subjects, 64.4% were females and 35.6% were males. The youngest patient was eighteen, and the oldest was eighty-eight years old, with a mean age of 51.5 (15.8 SD). Majority of the patients were Malays (58.9%), followed by Chinese (28.8%), Indians (9.6%), and 2.7% from other races, who were Somalian and Burmese nationals.

All patients presented with progressive hearing loss, followed by tinnitus in 38(52.1%) patients, ataxia 33 (45.2%) patients, headache 26(35.6%) patients, vertigo (27.4%) patients, facial numbness or pain 18(24.7%) patients and others such as facial asymmetry or trigeminal, glossopharyngeal cranial nerve palsies. Only 93.2% (n= 73) had preoperative hearing assessments performed using standard pure tone audiometry (PTA). The hearing loss was mainly on the right side (50.7%), while 49.3% had left-sided hearing loss. In all 74% of patients had severe to profound hearing loss. A total of 9.6% were identified as having moderate to severe hearing loss, 6.8% with mild to moderate hearing loss, and 2.7% with mild hearing loss.

The two imaging modalities used in this study were computed tomography (CT) and magnetic resonance imaging (MRI) with gadolinium. 17.8% had undergone CT scans, of which 7 had plain CT brain, 5 had contrast-enhanced CT scans, and 1 had high-resolution CT (HRCT) temporal bone. 98.6% of patients underwent MRI gadolinium with 0.6-mm cuts.

Based on MRI images, the tumour size was dichotomized into more than or equal to 2.5 cm in the largest diameter, which comprised 58.9%, and less than 2.5 cm in 41.1%.

In all 82.2% of patients in this study underwent surgical treatment, while 17.8% were treated conservatively, including one patient who opted for Gamma Knife therapy. Surgical approaches were divided into translabyrinthine, retrosigmoid, and MCF. Twenty-five (48.1%) patients had surgical resection of the tumour via the retrosigmoid approach, 23 (44.2%) patients via the translabyrinthine approach, and four (7.7%) patients underwent the MCF approach.

The most common complication that developed postoperatively was facial nerve paresis, which could be seen in 61.5% of patients. Other complications were headache in 38.5%, vertigo in 34.6%, exposure keratitis in 15.4%, imbalance in 13.5%, cerebrospinal fluid (CSF) leaks including otorrhea in 7.7%, oto-rhinorrhea in 5.8%, other sites in 5.8%, rhinorrhea in 3.8%, meningitis in 3.8%, and cerebellar oedema in 1.9%. In this study, the

Table 1: CSF otorrhea (complication) with surgical approaches (n = 52).

Complication	Surgical approach (n = 52)		
	Translabyrithine n (%)	Retrosigmoid + MCF n (%)	P value[a]
CSF leak (otorrhea)			
Yes	4 (100.0)	0 (0.0)	0.033
No	19 (39.6)	29 (60.4)	

[a]Fisher's exact test

Table 2: Facial nerve paresis (immediate post-operative) with surgical approaches (n = 52).

Surgical approach	Post-operation (immediately) n (%)		
	Normal	Impaired	*p* value*
Trans labyrinthine	12 (52.2)	11 (47.8)	0.070

*Chi-Square test

results showed that the surgical approach, translabyrintine, had more post-operative CSF otorrhea than retrosigmoid (Table 1), with p=0.033. Facial nerve paresis was less severe in the translabyrinthine approach; however, it was not significant statistically (Table 2).

The facial nerve was normal in 52 (86.7%) patients and impaired in 8 (13.3%) patients preoperatively. Those patients who had impaired facial nerves preoperatively were excluded from this study. Out of the 52 patients, 20 (38.5%) patients had immediate post-operative facial nerve paresis and 30 (61.5%) patients had normal facial nerve function. 48% of those patients with FNP showed recovery after subsequent 6-month follow-up.

Outcomes of facial nerve were categorized into either expected and poor outcome. Patients with normal facial nerve function at baseline (HB Grade 1) then became impaired after surgery (HB Grade III–VI) were classified as having a poor outcome. Those who had normal facial nerve function six months after the operation were classified as having the expected outcome. The chi-square test was used to assess the association between facial nerve outcome and gender, tumour size. Fisher's exact test was applied for assessing the association between facial nerve outcome and age, ethnicity, and surgical approach. There was a significant relationship between tumour size and facial nerve outcome (p=0.044) (Table 3).

The histopathological results of our patients were divided into Antoni A, Antoni B or mixed features. Majority of

Table 3: Facial nerve outcome among acoustic neuroma patients after 6 months postoperative (n = 52).

Facial nerve outcome	Expected outcome		Poor outcome		P value
	n	%	*n*	%	
Total	20	38.5	32	61.5	-
Gender					
Male	*7*	*38.8*	*11*	*44.1*	*0.244[a]*
Female	*19*	*55.9*	*15*	*61.1*	
Age groups					
<30 years	*5*	*71.4*	*2*	*28.6*	*0.108[b]*
30-39 years	*2*	*28.6*	*5*	*71.4*	
40-49 years	*8*	*80.0*	*2*	*20.0*	
50-59 years	*7*	*43.8*	*9*	*56.2*	
60 years and above	*4*	*33.3*	*8*	*66.7*	
Ethnicity					
Malay	*19*	*52.8*	*17*	*47.2*	*0.166[b]*
Chinese	*7*	*58.3*	*5*	*41.7*	
Indian	*0*	*0.0*	*4*	*100.0*	
Tumour size					
Less than 2.5cm	*13*	*68.4*	*6*	*31.6*	*0.044[a]*
More than 2.5cm	*13*	*39.4*	*20*	*60.6*	
Surgical approach					
Trans labyrinthine	*14*	*60.9*	*9*	*39.1*	*0.275[b]*
Retro Sigmoid	*11*	*44.0*	*14*	*56.0*	
Middle Cranial Fossa	*1*	*25.0*	*3*	*75.0*	

[a] Chi-Square test, [b] Fisher's exact test

tumours i.e 48 (92.3%) exhibited mixed histopathological features, and 4 (7.7%) showed Antoni A. There were no Antoni B-type cases observed.

There is no significant difference (p = 0.324) in length of hospital stay (LOS) among the three types of surgery (Table 4)

Table 4: Comparison of length of stay among surgical approaches (n=52)

Types of surgery	Mean	95%CI	F statistic (df)	P value
Translabyrinthine	10.2	8.75, 11.59	1.15 (2)	0.324
Retrosigmoid	14.9	8.69, 21.15		
Middle cranial fossa	12.3	6.24, 18.26		

A one-way ANOVA test was applied.

DISCUSSION

Acoustic neuromas arise from the Schwann cells of the vestibular branch of the vestibulocochlear nerve in the internal auditory meatus and cerebellopontine angle.[1] The mean age of patients in this study was 51.5 years, similar to 2 previous studies reported in United States, which were 53.1 years and 56 years, respectively.[1,2] The predominance of female patients in the literature may be due to hormonal processes involved in the development of vestibular schwannomas.[10,15,16] Similarly we found female predominance (64.4%) of AN?. Other authors did not report regarding the gender distribution. [4,17]

All our patients presented with progressive hearing loss. The right-side accounted for 50.7%, and the left side was at 49.3%. Asymmetrical hearing loss was the main complaint in 75%–80% of patients with AN.[4,6] Nearly two -thirds (74%) of our patients presented late with severe to profound hearing loss due to the slow progression of tumour size. Several long-term follow-up studies have found that, during the follow-up of small tumours, the possibility of hearing loss after 5 years was about 70%.[18,19] The hearing preservation in small tumours after surgery is about 60% in surgeries done experienced institutes if the fundus of the IAC is free of tumour involvement.[20] Whereas for small tumours involving the IAC fundus, the hearing preservation rate is lower than 50% even in experienced institutes. [20]

Tinnitus was the second-most common presentation we noted. The main symptoms of an AN are hearing loss and tinnitus.[4,6] They are caused by the tumour compression over the vestibulocochlear nerve. Although the tumour grows on the vestibular branch, imbalance is usually mild or absent due to compensation from the opposite side. The other common symptoms seen were ataxia, headache, and vertigo.

MRI with gadolinium is the best diagnostic tool for AN when compared to CT scans.[1,3,4] High-resolution computed tomography (HRCT) temporal bone is not required but may delineate anatomical abnormalities, including high jugular bulb, sclerotic mastoid, or anteriorly placed sigmoid sinus in certain cases.[21] AN patients achieve comparable results in terms of surgical treatment. The experience of the surgical teams and their preferences might be a major factor. Post-operative hearing preservation for small tumours is common at various centres. The relationship between hearing preservation and absent internal auditory canal (IAC) fundal involvement is also noted in other centres.

Treatment options are conservative, radiotherapy, surgery, or stereotactic surgery. The choice of treatment is based on both on the nature of the tumour and patient characteristics, such as tumour size, growth pattern, heterogeneity of the tumour, and amount of hearing loss. Moreover, decisions regarding treatment should also be guided by patient preference.[9]

Previous studies showed treatment was based on tumour size.[1] A greater percentage of smaller tumours (less than 2 cm) were treated with radiation and conservative therapy, while larger tumours (more than 4 cm) were treated almost exclusively with surgery or with surgery combined with radiotherapy. Increasing age of patients is associated with conservative treatment.

In our study, one patient underwent Gamma Knife surgery and 17.8% were treated conservatively. Majority of the cases (82.1%) underwent surgical removal of their tumours. Surgery remains the preferred method of management for large lesions and those with considerable symptoms related to mass effects. There are three common surgical approaches for acoustic neuromas used in this study: the middle cranial fossa (MCF), translabyrinthine, and retrosigmoid. The retrosigmoid and MCF approaches are recommended when hearing preservation is considered. Endoscopic technique and advanced surgical experience, as well as the extent of or IAC fundus involvement, are not deterrents for this approach because some centres have reported excellent hearing outcomes in patients with small tumours with fundus involvement. The selection of approach should depend on the size of tumor, hearing level and the surgeon's preference and experience.[22]

Studies in United States from 2008 to 2016 demonstrate increased usage of retrosigmoid over translabyrinthine and middle cranial fossa approaches.[23] This result was also demonstrated in our study. Retrosigmoid approach was used in 48.1% as compared to translabyrinthine 44.2% and middle cranial fossa 7.7%. While it remains uncertain as to what is driving this, we suspect the acceptance of less invasive modalities and the dominance of retrosigmoid approaches have begun to supplant the need for these approaches in many clinical scenarios as compared to translabyrinthine and middle cranial fossa approaches.

This study showed the translabyrinthine approach had significantly less post-operative cerebrospinal fluid (CSF) otorrhea (7.7%) as compared to the retrosigmoid and

middle cranial fossa (p=0.033). The incidence of CSF leak following translabyrinthine approach surgery ranged from 8.1 to 20.1%. [16,25] A CSF leak following AN surgery results from persistent communication between the subarachnoid space and the temporal bone, resulting either from tumour erosion or surgical dissection. The leak can be from an incisional wound, otorrhoea, or oto-rhinorrhoea. There were no deaths reported in our study. Previous studies reported mortality rate of less than 0.5%.[26] Therefore, it shows that AN surgery is safe and has a low mortality rate.

In facial nerve preservation surgery, the main approach will be translabyrinthine, followed by retrosigmoid and middle cranial fossa.[10] We found that the incidence of post-operative facial nerve paresis using the retrosigmoid and middle cranial fossa approaches 72.4% when compared to translabyrinthine 47.8%. However, the surgical approach was not significant in terms of predicting the outcome of facial nerve post-surgery (p=0.070). Facial nerve function preservation is a primary goal during solitary vestibular schwannoma resection. Facial nerve paresis occurring immediately postoperatively was 61.5% in this study. This impairment had improved with time, as the 6-month facial nerve impairment reduced to 50.0%. A previous study stated the post-operative facial nerve impairment was 26%.[10] Our study gave a higher rate since we measured immediate post-operative facial nerve function (24-hour post-extubation) instead of after one week like in the previous study. Factors such as strong tumour adhesion to the nerve and tumour size were independently associated with a poor facial nerve outcome.[10]

The AN size was significantly associated with facial nerve outcome (p = 0.044). Rinaldi et al. 2012 also found similar findings.[25] An increased incidence of impaired facial nerve function was found in patients with larger tumours compared with those with smaller tumours. Mainly because in larger tumours, the pre-existing nerve suffering (due to the tumour compression) and increased number of harmful surgical manoeuvres on the nerve during tumour removal.[25] Other factors, including gender, age, ethnicity, and surgical approaches, were found not to be significant with facial nerve outcome.[27] Nowadays, facial nerve monitoring is mandatory during acoustic neuroma surgery because it has been shown to significantly reduce the risk of iatrogenic facial nerve injury.[28] The main goals of intraoperative facial nerve monitoring are early nerve identification and mapping within soft tissue, tumour, and bone, allowing also to evaluate the neural integrity and prognosis at the end of the surgery. [28]

The translabyrinthine approach allows direct access to the tumour, the lateral aspect of the internal auditory meatus, and the cerebellopontine angle, and it is associated with excellent postoperative facial function.[28] Cystic tumours, previous surgical or radio-surgical treatment, and preoperative deficits represent important negative prognostic factors for postoperative facial nerve outcome.[27] The collaboration between neurosurgeon and otolaryngologist, the use of neuro-navigation systems, and endoscopy can promote the reduction of the complication rates associated with acoustic neuroma surgery. A recent study by Chiang K-W et al. 2021 reported that more extensive acoustic meatus tumour removal was associated with poor post-operative facial nerve function.[29] The retrosigmoid approach is known to have a higher prevalence of post-operative headache, ranging from 20-35%.[30] In this study, it was the second-most common complication. Postoperative headache can be prevented by replacement of the bone flap, dualistic use, avoidance of fibrin glue, or extensive drilling of the posterior aspect of the internal auditory canal.[30] Acoustic neuroma surgery results in complete loss of vestibular function on the operated side in certain cases. Patients frequently experience vertigo and imbalance post-surgery.[31,32] Vestibular rehabilitation may speed recovery from this deficit.

AN influence vestibular functioning by means of three mechanisms: compromising labyrinthine blood supply, changing the composition of inner ear fluids, and stretching or destroying afferent axons.[33] Studies postulate that Antoni B tumours are more likely to result in blockage of vestibular pathways than type A tumours causing vestibular paresis. [34] All our patients presenting with vestibular symptoms were those who had mixed histopathological features (Antoni A and B). The type of surgical approach did not determine the major

complications that arise postoperatively, resulting in prolonged hospital stay. Long-term follow-up is mandatory after tumour radiotherapy, which just controls tumour growth. So far, there is a lack of large-scale data on long-term follow-up. It has been documented that in longer-term follow-up after fractionated stereotactic radiotherapy, 30% of tumours continued to grow (defined as at least a 15% increase in tumour volume).[22] For young people with AN, radiotherapy is not recommended. Radiotherapy is applied to recurrent cases after surgery or elderly patients.[22]

Evaluation of tumour resection

Tumour resection can be in the form of total resection, near total resection, subtotal resection, or partial resection. Total resection means no tumour residual. Near-total resection (NTR) was assigned when a small piece of tumour remnant (size no greater than 25 mm^2 and 2 mm thick) could not be detected by routine MRI. The tumour was intentionally left *in situ* in an effort to preserve neural integrity.[22] Subtotal resection (STR) was used to describe any situation where less than NTR was performed.[35] Partial resection (PR) was defined when the percentage of tumour residue is greater than >5%.[36] The size of the residual tumour is indicated by the vertical diameter. In the post-operative MRI, the location of the residual tumour should be carefully documented.

RECOMMENDATION

We advocate that all patients with tinnitus have a thorough clinical history taken. Any patient with tinnitus and unilateral hearing loss should have MRI imaging. Patients from small hospitals without otorhinolaryngologists should be referred early to a secondary or tertiary hospital.

LIMITATION

In this study, the residual hearing outcome was not measured because of missing data.

CONCLUSION

Two-thirds of our patients (74%) with AN presented late to the hospital. Surgery is a safe procedure, regardless of the surgical approach used. There was a significant association between tumour size and facial nerve outcome.

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