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Research Article

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Predictive factors of acoustic neuroma growth

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ABSTRACT

Background: Since the use of magnetic resonance imaging (MRI) as the gold standard for acoustic neuroma diagnosis, the size of the majority of newly diagnosed acoustic neuromas has decreased. Management strategy is challenging, especially in young patients with small tumors. Therefore, prognostic factors for tumor growth may facilitate physicians to optimize treatment choice.
Methods: Patients diagnosed with acoustic neuromas were recruited in this study. Gender, age, side, presence of hearing loss, tinnitus, vertigo, unsteadiness, other symptoms, hearing level in the affected ear and tumor growth at the first follow up MRI were recorded. Two primary endpoints were set: overall acoustic neuroma (AN) growth and growth correlated to treatment plan change (clinically significant growth). Multivariate and survival analysis were conducted to this end.
Results: 85 patients were finally included in the study. The most prevalent presenting symptoms were hearing loss (76%), tinnitus (56%) and unsteadiness (46%). The tumour grew in size in less than 50% of the cases during the observation period. Clinically significant growth was observed in 27% of the cases. Mean initial diameter was 10.41mm and mean final follow-up diameter (diameter at the end of the observation period) 12.73 mm. Following binary logistic regression analysis, tumour growth during the initial follow up visit was found to be correlated in a statistically significant level to overall tumour growth (p-value 0.023). Regarding clinically significant growth, three factors were found to be statistically significant: growth at the initial visit (p-value 0.02), initial diameter (p-value 0.045) and existence of unsteadiness at diagnosis (p-value 0.02).
Conclusions: Acoustic neuroma overall growth is not identical to clinically significant growth. Growth at first visit is a significant prognostic factor and intervention potential should be considered under this perspective.

Keywords: Acoustic neuroma, Growth, Prognostic factors

INTRODUCTION

Vestibular schwannomas or acoustic neuromas (ANs) are benign neoplasms originating from the 8th cranial nerve. They are the most common tumors of the cerebellopontine angle, accounting for 80% of tumors in this area and 6% of all intracranial tumors.[1] Lifetime risk of development is 1/1000, whereas 2,000 to 3,000 new cases are diagnosed in USA in a yearly basis.[2]

Since mid-1980s, MRI has been established as the gold standard for diagnosis of these tumours. This has made early stage diagnosis feasible, and as a consequence, more intracanalicular and small size tumors are diagnosed at presentation.

Accepted treatments for vestibular schwannomas (VS) include stereotactic radiotherapy and surgical removal. Stereotactic radiosurgery does not eliminate the tumor, but aims to stop its growth. Success rate is over 90%, but has considerable complication rate, whereas some

infrequent malignant transformations have been referred.[3-6] Surgical removal, reserved for larger vestibular schwannomas over 2.5 cm, is associated with significant functional morbidity (hearing loss, cranial nerves paresis, unsteadiness and headaches), lower quality of life and even mortality.[7] Many studies have shown that a big proportion of acoustic neuromas remain stable in time in terms of size as well as in terms of symptom severity. Consequently, conservative approach, including wait and scan policy and stereotactic radiotherapy is essential in acoustic neuroma management nowadays. Wait and scan policy consists of consecutive MRIs for a period of up to 5 years.[8-11] So far, growth in MRI and clinical symptoms are considered decisive in patient management planning.

Consequently, determination of growth risk factors at presentation is vital both for prognostic reasons, as well as for management planning. Since detecting acoustic neuromas at the time that they are still small has become the rule, prognostic factors have increased value, since they can possibly support timely and optimal treatment choice or help clinicians avoid both unnecessary or delayed interventions. Hence, consensus regarding prognostic factors of AN growth is still pending. The aim of this study is to identify possible factors affecting the natural history of acoustic neuromas. These factors could be used to determine prognosis at the time of diagnosis, as well as to help treatment decision making.

METHODS

This was a longitudinal observational study. After obtaining approval by our institution review board, a prospective study of AN growth, in correlation with presentation symptoms, growth at first visit and demographic factors was conducted. There were no additional interventions in the study participants and all diagnostic and therapeutic procedures were not affected by their participation in the study. The study protocol was consistent to ethical principles for medical research based Helsinki Human Rights Declaration and to current EU clinical trials regulation (2001/20/EC).

Between 2008 and 2015, patients with acoustic neuromas were recruited. Presenting symptoms, demographic information and growth at first follow up visit were collected. Patients were advised to be followed up to 5 years, with a new MRI every 6-12 months. Inclusion criteria were sporadic unilateral AN, diagnosed with MRI, initially managed conservatively with serial MRIs and followed up for at least 9 months, with known history and presenting symptoms. Patients with maximum tumor size less than 15 mm and those who did not wish intervention were considered eligible for conservative management. Patients with NF2, patients with indication of surgical removal or stereotactic radiosurgery and patients without follow up MRI in at least one year interval were excluded from the study.

Gender, age, side, presence of hearing loss, tinnitus, vertigo, unsteadiness, other symptoms including headache, earache, facial nerve numbness at the time of diagnosis, history of sudden sensorineural hearing loss, hearing level in the affected ear and tumor growth at the first follow up MRI were recorded. Hearing loss was considered present if mean PTA values at 0.5, 1, 2 and 4 KHz exceeded 25 dB. Unsteadines/Vertigo spells were considered present if they occurred during the last year before diagnosis and in absence of other attributable vestibular disorder (Meniere's disease, vestibular migraine, vestibular neuritis, BPPV). American Society of Otolaryngology definition was used for sudden sensorineural hearing loss (SSHL), according to which SSHL is defined as greater than 30 dB hearing reduction, over at least three contiguous frequencies, occurring over a period of 72 hours or less.[13]

Maximum axial AN diameter was considered the main measure outcome. The axial magnetic resonance image showing the largest tumor size was identified and measured. Growth was calculated based on T1-weighted gadolinium enhanced MRI.[14] Diameter was calculated both by radiologist and otolaryngologist. If tumors were extended to the cerebellopontine angle, the greatest dimension parallel to the petrous ridge was considered as the main diameter.

There were two primary endpoints. The first one was overall growth measured in millimeters. Second primary endpoint was the decision to change treatment policy. This means that, in regards to the second endpoint, growth not considered large enough to alternate treatment was not censored as event. Based on these endpoints, patients were divided for the purposes of the analysis in two different subgroup couples:

- AN growth (existence of overall growth).
- Change in treatment plan (clinically significant growth).

Main criteria for treatment change consideration were size greater than 20 mms growth more than 2 mms in a yearly MRI scan and/or significant symptoms deterioration. AN course after treatment was not taken into consideration for the purposes of this study.

Statistical analysis

SPSS v 16.0 was used for statistical analysis. Chi square was used in order to compare factors incidence between groups of patients for both primary endpoints (overall growth and clinically significant growth). Bivariate analysis was performed in order to check correlation between all possible prognostic factors and two primary endpoints. Logistic regression was performed for endpoints (overall growth and clinically significant growth), using both R square and Hosmer and Lenshow test as goodness of fit determinants.

P value <0.05 was considered statistically significant.

RESULTS

Descriptive statistics

In total, 85 patients were included in the study. The mean age at the time of diagnosis was 56.6 years (SD±12.85, range 26-83), whereas mean follow up time was 28.58 months (SD±10.63) and mean time of MRIs performed was 2.84 (SD±1.56) (Table 1).

Regarding presenting symptoms, 65 out of 85 patients (76.47%) presented with some degree of hearing loss, 38 (44.71%) with unsteadiness, 35 (41.17%) suffered at least one vertigo attack, whereas in 16 (18.82%) of the cases, sudden sensorineural hearing loss was the presenting symptom. Tinnitus was present in 48 patients (56.5%) and 5 patients (6%) referred the existence of symptoms classified as others during presentation. Mean hearing level in the affected ear was 46.56 dB (SD±21.17) (Table 2).

Regarding growth, only in 41 out of 85 cases (48.24%) presented some growth during the observation period. In 32 cases growth was apparent during the first follow up visit. Consequently, in 37.65% of the overall cases and in 78% of the cases with growth, growth was apparent during the first follow up visit.

The mean initial diameter was 10.41 mms (SD±4.94), the mean final diameter was 12.73 mm (SD±6.38) and the mean overall growth (difference between initial and final diameter) was 2.43 mm. The difference between initial and final diameter was found to be statistically significant (p-value <0.001). Mean growth at first follow up was 1.14 mm (Table 3).

An interesting finding was that, although in 48.24% of the cases some growth occurred, only in 23 out of 85 of the overall cases (27% of the overall cases, 56.1% of cases who grew) growth was judged to be clinically significant to require change of management strategy either to stereotactic radiosurgery or surgical removal (clinically significant growth). Out of these 23 patients, 20 underwent stereotactic radiosurgery and 3 surgical excision. In the remaining 18 (43.9%) cases, observed growth was not considered clinically significant.

Correlations

Bivariate correlations were made between two main endpoints (overall growth yes.no and change of treatment) and presenting symptoms as well as growth during first visit (Table 4).

Presence of growth at first follow up visit, growth in first visit in milimeters was found to be correlated in statistically significant level with both endpoints. Initial diameter was found to be correlated in a statistically significant level with the treatment change endpoint.

Table 1: Summary of findings.

Number of patients	85
Mean age	56.6 years
Mean follow up time	28.58 months
Mean initial diameter	10.41 mm
Mean final diameter	12.73 mm
Growth during first visit	32/85 (37.64%)
Overall growth	41/85 (48.24%)
Clinically significant growth	23/85 (27%)

Table 2: Presenting symptoms.

Presenting symptoms	Percentage
Hearing loss	76.47%
Tinnitus	56.5%
Unsteadiness	44.71%
Vertigo spells	41.17%
Sudden sensorineural hearing loss	18.82%
Other	6%

Table 3: Correlation between overall presence of growth, presenting symptoms and growth at first visit.

Presenting symptoms	P-value	Statistically significant correlation
Initial diameter	0.84	No
Tinnitus	0.47	No
Unsteadiness	0.35	No
Hearing level	0.42	No
Vertigo	0.23	No
Sudden hearing loss	0.31	No
Other	0.25	No
Presence of growth during first visit	<0.001	Yes
Growth at first visit (mms)	<0.001	Yes

Table 4: Correlation between treatment change decision, presenting symptoms and growth at first visit.

Presenting symptoms	P-value	Statistically significant correlation
Initial diameter	0.04	Yes
Tinnitus	0.12	No
Unsteadiness	0.41	No
Hearing level	0.4	No
Vertigo	0.76	No
Other	0.75	No
Sudden hearing loss	0.65	No
Presence of growth during first visit	<0.001	Yes
Growth at first visit (mms)	<0.001	Yes

Regression analysis

Binary logistic regression was performed for both endpoints (overall growth and clinically significant growth). Regression is a method that can test the influence of various factors to a dependent variable. Advantage is that it can weigh which of the examined factors are crucial and correlated in a statistically significant level. Co-existence and co-influence are also taken into consideration.

Goodness of fit tests was satisfactory for both tests. Cox and Snell R square values were 0.493 and 0.444 for overall growth and statistically significant growth models respectively, whereas Nagelkerke R squarewere 0.663 and 0,68.Hosmer and Lemeshow Test returned a p-value of 0.82 and 0.92 respectively, which was not statistically significant in either case, confirming goodness of fit.

According to binary logistic regression results, existence of growth during the first follow up visit was found to correlate in a statistically significant level to the overall growth of the tumour (p-value 0.023, 95% C.I 0.01-0.574). Regarding clinically significant growth, three factors were found to correlate in a statistically significant level: growth at first visit (p-value 0.028, 95% C.I 0.000-0.433), initial diameter (p-value 0.045, 95% C.I 1.007-1.856) and existence of unsteadiness at diagnosis (p-value 0.02, 95% C.I 2.51-5.74).

DISCUSSION

In spite of growing literature evidence during the past years, there is no consensus regarding AN natural history and optimal management.[15,16] AN treatment options consist of conservative management ("wait and scan"), surgical removal (total or subtotal) and stereotactic radiotherapy. Sometimes, choosing a treatment option can be challenging either in newly diagnosed patients or in patients with atypical growth patterns. Confounding factors also include age, coexisting morbidity and consideration of malignancy development following stereotactic radiosurgery. Regarding prognostic factors for AN growth, no consensus has been achieved yet. Literature flaws have been highlighted including small cohorts and short follow up times, retrospective data collection and measurements variability.[17]

Natural course of ANs allows an adaptive wait and scan period, at least for small ANs with mild symptoms. The "wait and scan" approach was initially introduced during the 1980's by Silverstein and consists of a serial MRI and audiometric assessment from diagnosis until either choice of another treatment policy or discharge.[18] Numerous studies, have confirmed the fact that a proportion of tumours ranging from 30% to 90% does not change size during observation.[19,20] Growth rate varies from 0.7 to 2 mm annually, there are plenty of long term follow up studies proposing that over 65% of ANs do not grow or even decrease in size, limiting the need for intervention between 20-35% of the cases.[21-24] In a meta-analysis by Smouha et al 57% of ANs did not seem to grow after a mean follow up period of more than 3 years, whereas failure rate of conservative management was 20%.[18,21] Overall mean AN growth was 1.9 mm per year. These results are similar to the findings our study.

Another key finding of our study was that clinically significant growth was observed in only 27% of the patients. This is also consistent to a relevant study by Jethanamest et al.[25] In this series, 22.3% of 94 patients observed for AN occurred clinically significant growth and underwent a change in management strategy to microsurgical excision or stereotactic radiotherapy. In the same study, disequilibrium and unsteadiness was identified as bad prognostic factor for tumor growth. This finding was also replicated in our study, in regards to the endpoint correlated to clinically significant growth.

Moreover, findings of our study suggest that both for overall and clinically significant growth, growth at first follow up visit are a significant prognostic factor. This was also suggested by Moffat et al in one of the few studies with identical research hypothesis to the present one.[26] In a series including more than 300 patients, they found that 52.3% of cases in which the tumour grew in size, growth was apparent during the first visit, which is also very close to 56.1% compared to our study. Less than 8% of cases presented growth after 5 years of observation. Similar findings were also presented in a smaller study, including 36 patients, by van de Langeberg et al, in which growth at first visit was identified as a prognostic factor too.[27]

Stereotactic radiotherapy appears to be effective up to 95% of the cases, even after 15 years of follow up.[28,29] Source of radiation in SR and fractionated SR is either gamma ray photons or a linear accelerator which uses X-ray photons derived from high-energy electrons. According to a recent systematic review incidents of malignant transformation or occurrence of a new malignant tumor have been referred after stereotactic radiosurgery.[7,30] Even though it is not clear whether malignancy occurrence is more likely in the population who underwent radiotherapy, this factor should probably be also taken into consideration before management planning. Moreover several studies, about surgical excision after radiotherapy report technical difficulties, adhesion of the facial nerve to the tumor remnant, scarring and fibrosis, were increasing complications potential.[31,32]

Hearing preservation potential could be an important treatment choice factor. Elliot et al did not find statistically significant differences in hearing assessment between conservatively managed patients and patients who underwent stereotactic radiosurgery, in a 132 case series.[33] Initial hearing level was identified as main prognostic factor, based on Kaplan Meier analysis. These results confirm the study from Baschangel et al who also

found serviceable hearing in vast majority of patients who underwent stereotactic radiosurgery in a three year follow up.[4] Hence, Carlson et al reported that hearing outcome in long term follow up was as poor as 23%.[34] 10 years after stereotactic radiosurgery. They also confirmed initial hearing levels and tumor size as prognostic factors.

Another methodological issue is that vast majority of studies only focuses on size and does not take into consideration growth clinical significance, as in our study.

The main study limitation is tumor size estimation, since numerous studies suggest volumetric instead of maximum diameter approach. Size remains the main determinant for management selection and also the most reliable prognostic factor for hearing preservation and facial nerve function.[35] Hence, in a recent systematic review of large AN series it was shown that in vast majority of articles included (17 out of 19) various linear and not volume measurements techniques were used, including qualitative ANCSRR and Koos tumor size classification systems.[36,37] These systems, despite the fact that have been introduced for many years have not been commonly used since less than 20% of the papers identified had used them.[37] Moreover, even though volumetric measurements have been suggested since 1990s, still are not used in vast majority of relevant studies.[37,38]

CONCLUSION

Findings of this study suggest that growth during first follow up is highly effecting both overall growth and clinically significant growth. This fact could facilitate physicians to consider gamma knife or surgery sooner rather than later in case growth is detected during first follow up visit.

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