

Hearing Durability and Trajectory after Radiosurgery for Vestibular Schwannoma

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Introduction

Vestibular schwannomas (VS) are benign skull base tumors arising from the eighth cranial nerve (Figure 1). Stereotactic radiosurgery (SRS) is emerging as treatment for smaller sized tumors with the intent being to prevent further tumor growth, thus avoiding mass-effect symptoms. While historically much of the literature reporting hearing outcomes involved immediate post-intervention results, analysis of long-term hearing outcomes are now possible given that more than a decade has passed since the widespread introduction of SRS for VS [1–8]. Hearing outcomes are commonly presented as preservation of class A/B hearing (defined as Pure Tone Average (PTA) ≤50 dB with Word Recognition Score (WRS) ≥50 dB). Long-term follow-up data on hearing outcomes and hearing trajectory trends are limited. [2,3,5,9].

Aims and Objectives: Analyze the long-term durability of hearing and the trajectory of hearing function after treatment of VS with gamma knife radiosurgery.

Table 1. Summary of baseline patient characteristics, n = 93

Feature	N (%)
Sex (F (%); M (%))	49 (53); 44 (47)
Laterality (R (%); L (%))	47 (51); 46 (49)
Hearing loss	64 (69)
Tinnitus	65 (70)
Primary tumor	93 (100)
	Median (IQR; Range)
Age at surgery in years	60 (53–66; 26–80)
Pre-treatment PTA (dB)	26 (19–37; 6–50)
Pre-treatment WRS (%)	96 (88–100; 52–100)
Months of audiometric follow-up	41 (19–84; 12–145)
Last post-treatment PTA (dB)	47 (30–61; 6–110)
Last post-treatment WRS (%)	68 (40–92; 0–100)

Methods

This retrospective case series assessed patients treated with SRS for VS between March 2007 to March 2017. Exclusion criteria included pre-treatment AAO-HNS class C/D hearing level, NF type II, history of previous surgical resection, and follow-up less than 1 year.

The main outcome measure was hearing function assessed both by maintenance of serviceable hearing (AAO-HNS Class A/B) and by maintenance of baseline hearing (≤20 dB change in pure-tone average [PTA]) after GKRS. Kaplan-Meier actuarial curves were employed for time-to-event analysis.

Results

A total of 93 patients were included in this study. The median duration of audiometric follow-up was 41 months (IQR, 19–81) (Table 1). Patients with pre-treatment class A hearing status maintained serviceable hearing for a longer duration in the post-treatment period (p=0.005) yet did not maintain hearing to within 20 dB of baseline for a longer duration than patients with class B hearing (p=0.294), according to Kaplan-Meier analysis (Figure 2). At 5 years (70 months) post-treatment, rates of serviceable hearing **durability** were 48% for Class A and 23% for Class B.

Analysis of changes in PTA after radiosurgery revealed a common hearing **trajectory** comprised of an acute, rapid decline in function, followed by stabilization, and then a delayed phase of slow decline after 36 months (Figure 3). The initial decline in hearing may be more severe for patients with better hearing (class A), as suggested by the drop from 20 dB to 45 dB at 24 months, which is greater than the drop from 40 dB to 55 dB at 24 months among patients with class B hearing (p = 0.045) (Figure 3A).

Conclusion

Interestingly, patients with baseline AAO-HNS class A hearing maintained serviceable hearing (Class A/B) for a longer duration than patients who were initially in class B. The **opposite relationship** was found when the quantitative PTA-based outcome measure was assessed. Patients with pre-treatment class B hearing tended to maintain hearing function to within 20 dB from baseline PTA for a longer duration than patients with class A hearing. Although not statistically significant, this finding highlights the utility of assessing changes in hearing function with the quantitative PTA-based outcome measure. This approach takes into consideration that baseline hearing function is different for each patient.

Normalization to baseline hearing using the **quantitative** PTA-based outcome measure (Figure 2B) afforded a more precise description of hearing trends compared to **categorical** preservation of serviceable hearing (class A/B) assessment (Figure 2A). An understanding of year-by-year hearing trajectories and the concept that patients with better hearing may experience a larger initial decline in hearing function (rise in PTA) could prove useful for counseling patients on hearing expectations after treatment.

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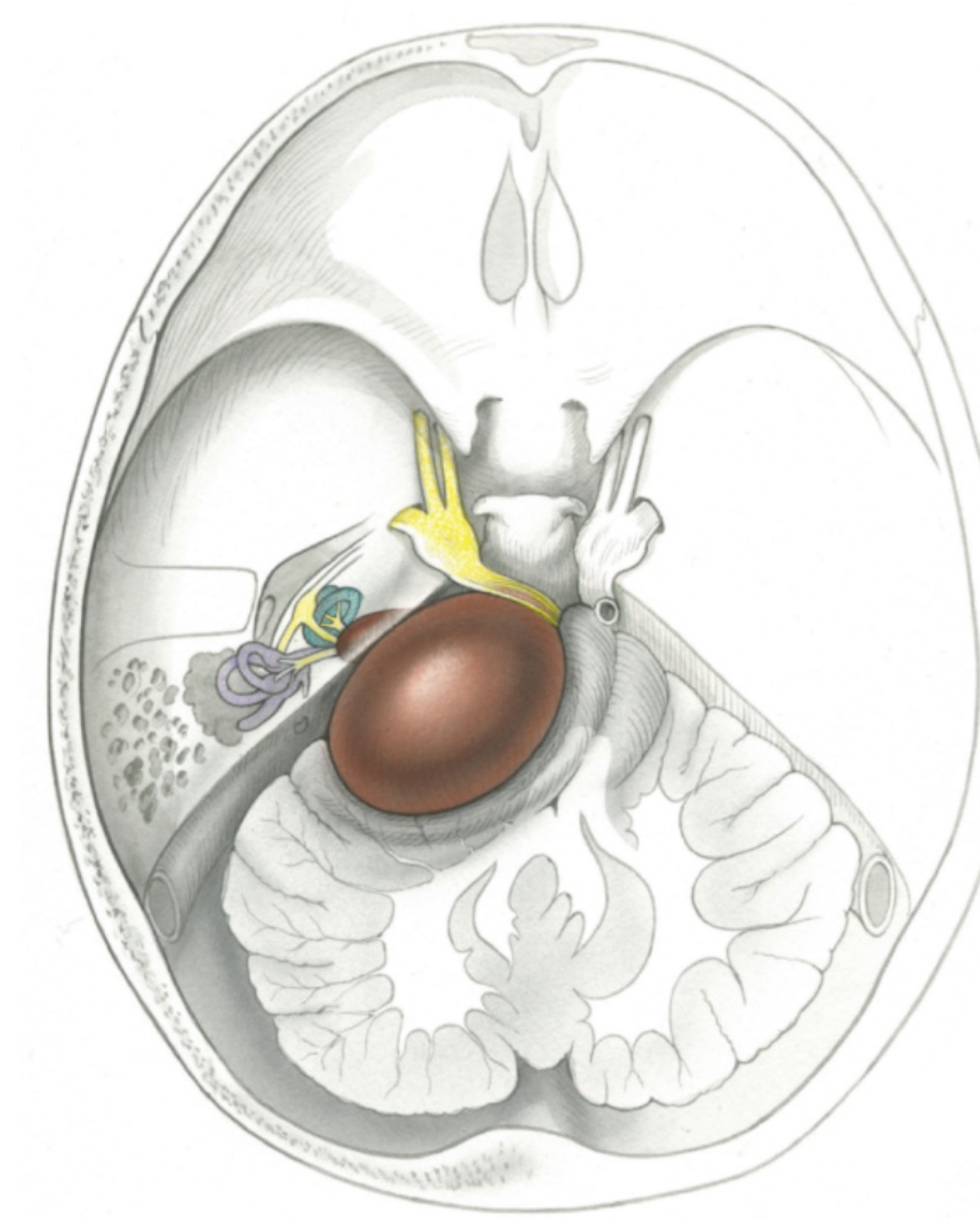


Figure 1. Classic tumor appearance and location in skull base. Adapted from [10].

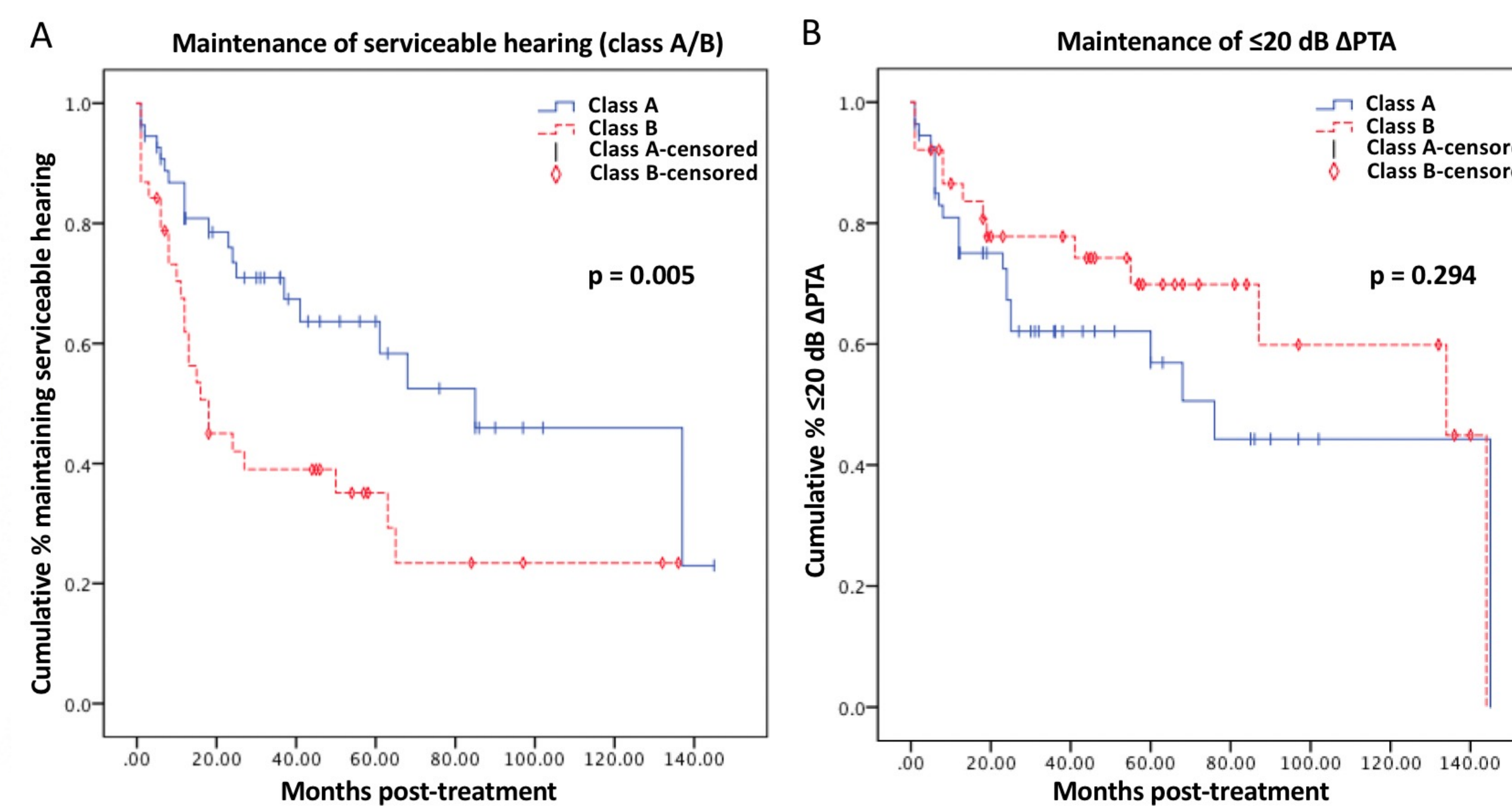


Figure 2. Kaplan-Meier actuarial curves showing estimated maintenance of serviceable class A/B hearing (A), and estimated maintenance of baseline hearing with ≤20 dB change in Pure Tone Average (PTA) (B).

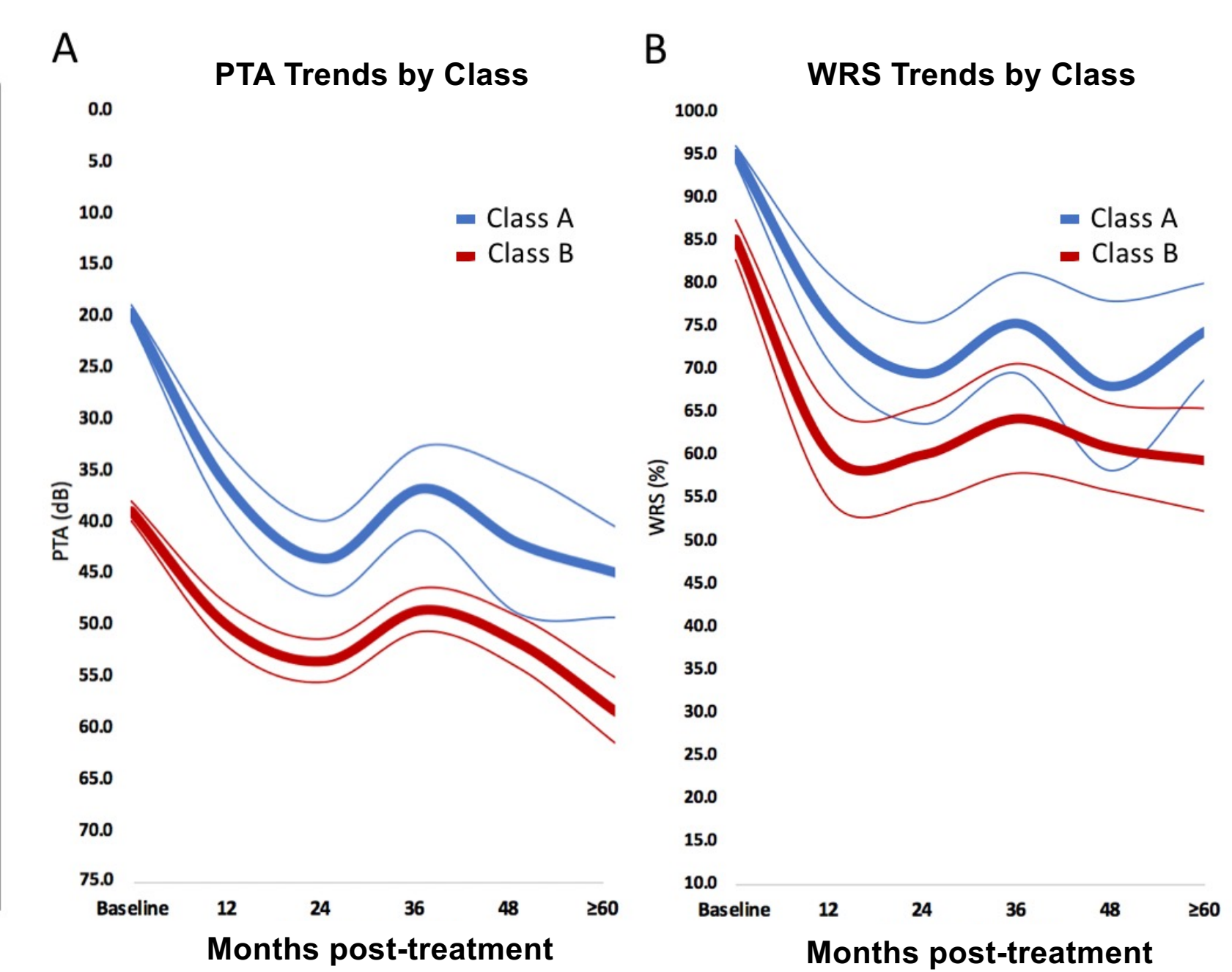


Figure 3. Hearing outcomes by mean PTA (A) and WRS (B). Thick lines are mean value. Thin lines are standard error of the mean (SEM).

References

- Friedman RA, Kesser B, Brackmann DE, Fisher LM, Slattery WH, Hittselberger WE. Long-term hearing preservation after middle fossa removal of vestibular schwannoma. *Otolaryngol - Head Neck Surg.* 2003;129(6):660–5.
- Carlson ML, Jacob JT, Pollock BE, Neff BA, Tombers NM, Driscoll CLW, et al. Long-term hearing outcomes following stereotactic radiosurgery for vestibular schwannoma: Patterns of hearing loss and variables influencing audiometric decline. *J Neurosurg.* 2013;118(3):579–87.
- Santa Maria PL, Shi Y, Gurgel RK, Corrales CE, Soltys SG, Santa Maria C, et al. Long-Term Hearing Outcomes Following Stereotactic Radiosurgery in Vestibular Schwannoma Patients-A Retrospective Cohort Study. *Clin Neurosurg.* 2019;85(4):550–9.
- Dowling EM, Patel NS, Lohse CM, Driscoll CLW, Neff BA, Van Gompel JJ, et al. Durability of Hearing Preservation Following Microsurgical Resection of Vestibular Schwannoma. *Otol Neurotol.* 2019;40(10):1363–72.
- Watanabe S, Yamamoto M, Kawabe T, Koiso T, Yamamoto T, Matsumura A, et al. Stereotactic radiosurgery for vestibular schwannomas: average 10-year follow-up results focusing on long-term hearing preservation. *J Neurosurg.* 2016;125(December):64–72.
- Quist TS, Givens DJ, Gurgel RK, Chamoun R, Shelton C. Hearing preservation after middle fossa vestibular schwannoma removal: Are the results durable? *Otolaryngol - Head Neck Surg (United States).* 2015;152(4):706–11.
- Wang AC, Chinn SB, Than KD, Arts HA, Telian SA, El-Kashlan HK, et al. Durability of hearing preservation after microsurgical treatment of vestibular schwannoma using the middle cranial fossa approach: Clinical article. *J Neurosurg.* 2013;119(1):131–8.
- Hasegawa T, Kida Y, Kato T, Iizuka H, Yamamoto T. Factors associated with hearing preservation after Gamma Knife surgery for vestibular schwannomas in patients who retain serviceable hearing: Clinical article. *J Neurosurg.* 2011;115(6):1078–86.
- Coughlin AR, Willman TJ, Gubbels SP. Systematic Review of Hearing Preservation after Radiotherapy for Vestibular Schwannoma. *Otol Neurotol.* 2018;39(3):273–83.
- Acoustic neuroma (vestibular Schwannoma). Stanford Health Care (SHC) - Stanford Medical Center. (n.d.). Retrieved September 14, 2021, from <https://stanfordhealthcare.org/medical-conditions/ear-nose-and-throat/acoustic-neuroma.html>.