Systematic Underestimation of Residual Vestibular Schwannoma Volume by the ABC/2 Ellipsoid Method After Subtotal Resection

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INTRODUCTION

- Subtotal resection (STR) for large vestibular schwannomas (VS) requires accurate residual tumor measurement to guide surveillance and adjuvant radiosurgery decisions.[1,2]
- The ABC/2 ellipsoid method is widely used for its simplicity[3], but assumes regular geometry, which is likely violated by irregular post-surgical remnants.[4,5]
- **Study Objective:** To evaluate ABC/2 accuracy against volumetric segmentation for residual VS after STR and quantify the impact on extent of resection (EOR) classification.

METHODS

Study Design and Participants

- Retrospective cohort study at a single tertiary academic center
- 261 adults who underwent STR for VS (2004–2024)
- Pre- and postoperative contrast-enhanced T1-weighted MRI

Tumor Measurement Methods

Method	Type	How Measured
Volumetric Segmentation[6]	3D Volume (cm^3)	Slice-by-slice contouring in BrainLab (reference standard)
ABC/2 Ellipsoid	Estimated Volume (cm^3)	(AP × ML × CC) / 2 from orthogonal MRI dimensions
Maximum Linear Dimension	Linear (mm)	Largest of AP, ML, or CC dimensions
AAO-HNS Extrameatal Diameter[7]	Linear (mm)	√(extrameatal AP × ML)
Koos Grade[8]	Categorical (I–IV)	Tumor extent relative to IAC and brainstem

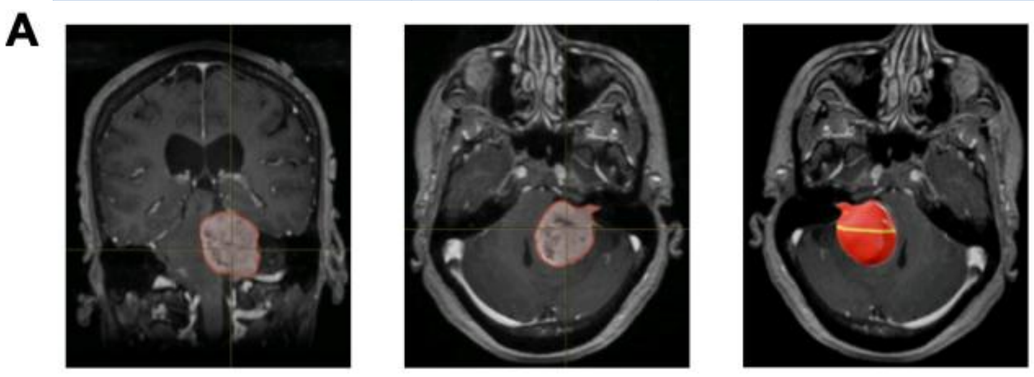

Figure 1. Measurement methods compared on a representative preoperative contrast-enhanced T1-weighted MRI. **(A)** Volumetric segmentation (reference standard): slice-by-slice contouring in BrainLab, yielding volume in cm^3. **(B)** Anteroposterior (AP), mediolateral (ML), and craniocaudal (CC) dimensions used to calculate ABC/2 ellipsoid volume (AP × ML × CC / 2, cm^3) and maximum linear dimension (MLD, largest of the three, mm). **(C)** AAO-HNS extrameatal diameter: √(extrameatal AP × ML), mm. Koos grade (I–IV, not shown) classifies tumor extent relative to the internal auditory canal and brainstem.

Outcome Measures

- ***Primary:*** Agreement between ABC/2 and volumetric segmentation (Pearson/Spearman correlation, Bland-Altman analysis)
- ***Secondary:*** EOR classification concordance (Cohen's kappa); size-stratified bias analysis (small <2, medium 2–8, large 8–20, giant >20 cm^3); predictive discrimination for facial nerve dysfunction (HB ≥ III) and perioperative complications (AUC)

RESULTS

ABC/2 overestimated preoperative volume by 21.9% (r=0.905) but reversed to underestimate postoperative residual volume by 21.3% (r=0.631)

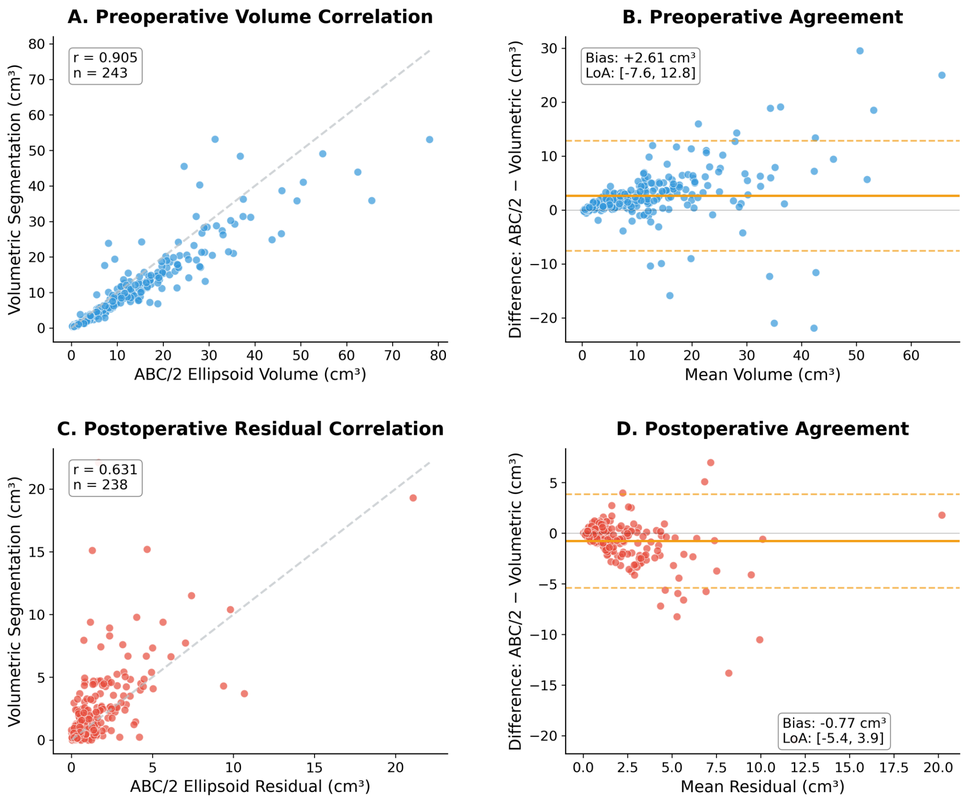

Figure 2. Agreement between ABC/2 and volumetric segmentation. **(A)** Preoperative scatter plot (r=0.905, n=243). **(B)** Preoperative Bland-Altman plot; mean bias = +21.9%. **(C)** Postoperative scatter plot showing degraded correlation (r=0.631, n=238). **(D)** Postoperative Bland-Altman plot; mean bias = −21.3%. Dashed lines = mean difference; dotted lines = 95% limits of agreement.

RESULTS

EOR classification agreed in only 45.1% of cases (κ=0.206), with ABC/2 upgrading resection category in 45.6%

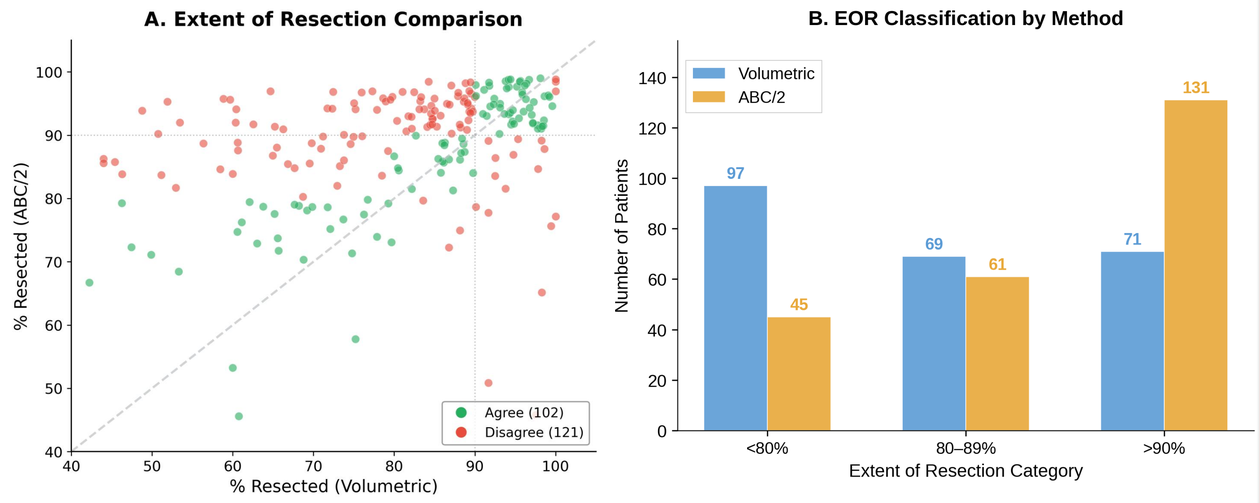

Figure 3. EOR classification discordance. **(A)** Percent resected by each method; green = concordant, red = discordant classification. Dashed lines = EOR boundaries at 80% and 90%. **(B)** Patients per EOR category by volumetric (blue) and ABC/2 (yellow). ABC/2 classified 55.3% as >90% resection vs. 30.0% by volumetric. Overall agreement = 45.1% (κ=0.206).

No measurement method demonstrated clinically meaningful discrimination for adverse outcomes (AUC 0.506-0.646)

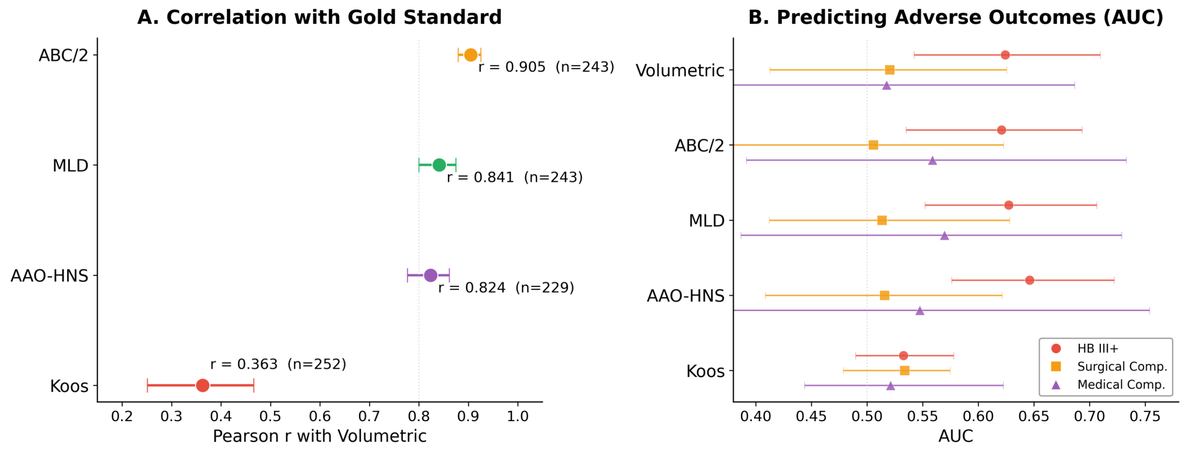

Figure 4. **(A)** Forest plot of Pearson correlations between each measurement method and volumetric segmentation; error bars = 95% CI. **(B)** ROC curves for prediction of House-Brackmann grade ≥III. AUC ranged from 0.533 (Koos) to 0.646 (AAO-HNS); no method demonstrated clinically meaningful discrimination.

ABC/2 overestimated preoperative volume by 21.9% (r=0.905) but reversed to underestimate postoperative residual volume by 21.3% (r=0.631)

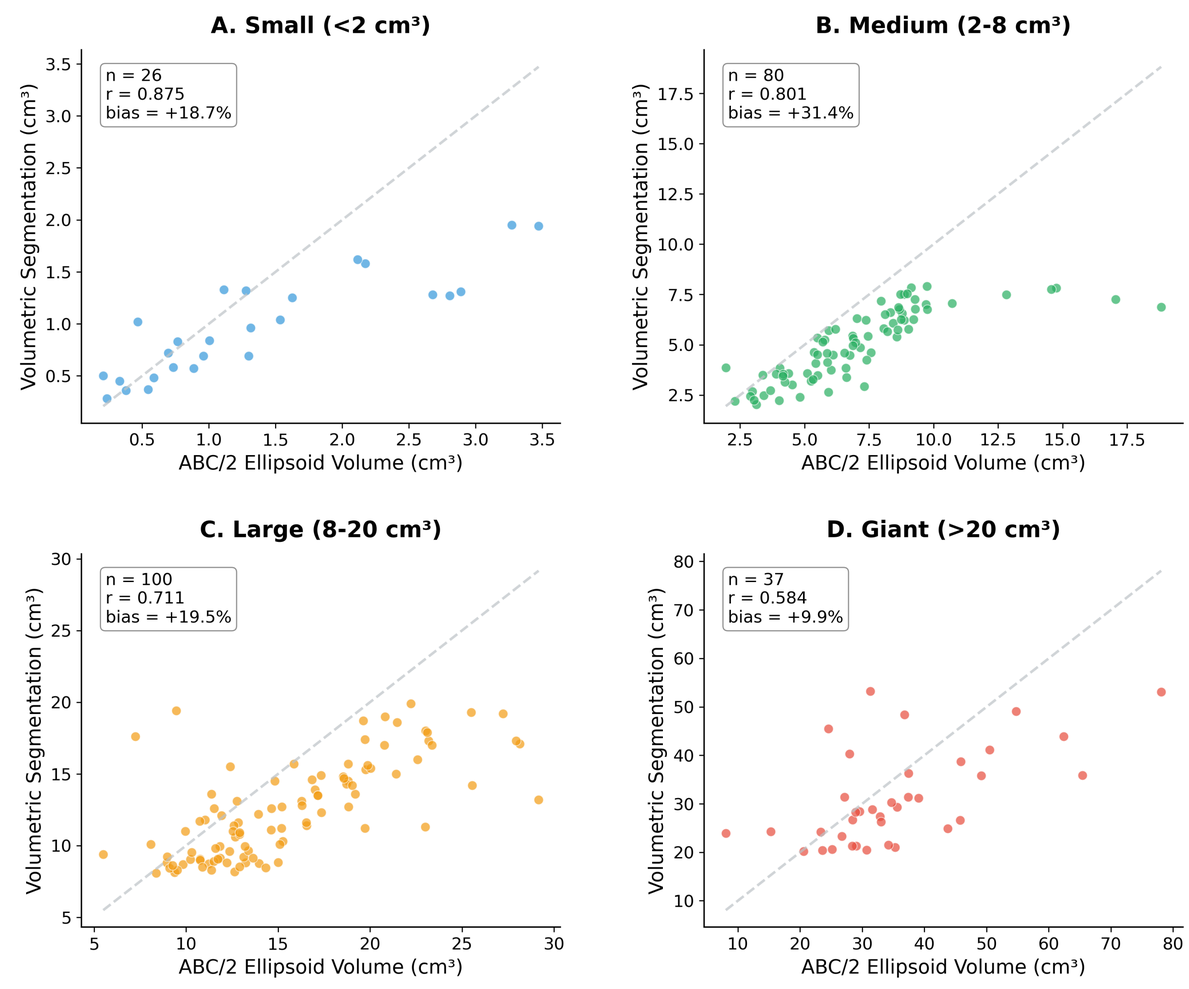

Figure 5. Size-stratified preoperative ABC/2 accuracy. Correlation declined from small tumors (<2 cm^3; r=0.875, n=26) to giant (>20 cm^3; r=0.584, n=37). Percent overestimation was greatest for medium tumors (+31.4%) and lowest for giant (+9.9%), though absolute bias increased with tumor size.

CONCLUSIONS

- The ABC/2 method systematically underestimates residual VS volume after STR, reversing its preoperative overestimation bias, due to the irregular geometry of postoperative tumor remnants.
- This bias reversal classified 55.3% of patients as >90% resection by ABC/2 vs. only 30.0% by volumetric; an inaccurate baseline that may delay detection of interval growth on surveillance imaging.
- No measurement method demonstrated meaningful predictive discrimination for facial nerve dysfunction or perioperative complications (all AUCs <0.65).
- Volumetric segmentation should be considered the standard for postoperative VS surveillance when clinical decisions depend on accurate residual quantification.

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