Retinal Nerve Fiber Layer (RNFL) Thickness: A Surrogate for Optic Nerve Axonal Integrity and Composite Vision Outcomes in Median and Paramedian Skull Base Meningiomas

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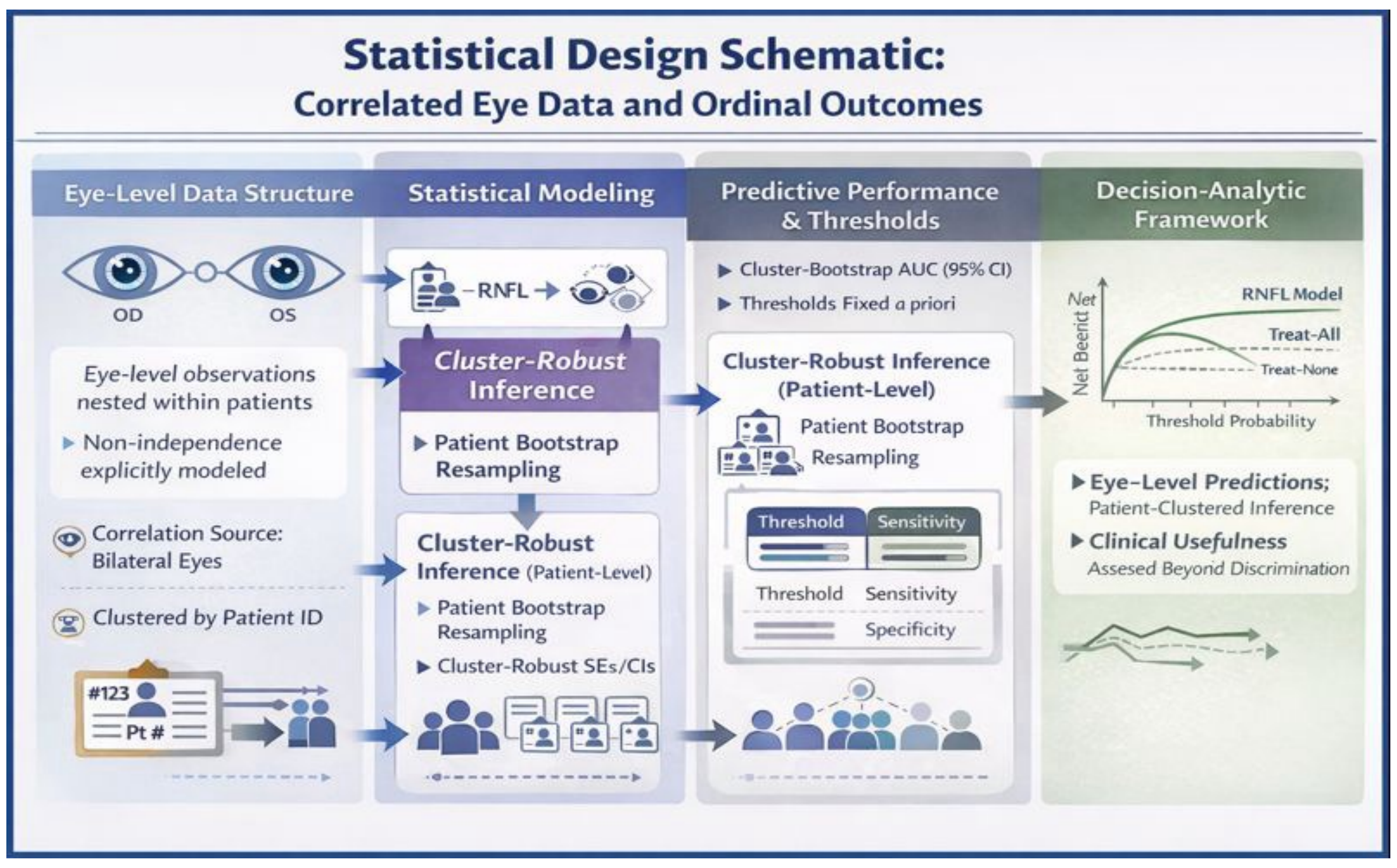
Introduction

Parasellar compartment meningiomas may originate medial to the optic nerve and within the median parasellar compartment, such as olfactory groove (OG), planum sphenoidale (PS), and tuberculum sellae (TS) meningiomas. Alternatively, meningiomas arising from the paramedian and lateral corridors of the parasellar region tend to eccentrically involve the unilateral optic nerve from the lateral aspect.[1] These include anterior clinoidal (AC), cavernous sinus (CS), optic nerve sheath (ONS), spheno-orbital (SpO), sphenocavernous (SpC), and sphenocavernopetroclival (SpCPC) meningiomas[2]. These anatomic differences may cause distinct mechanisms of optic nerve injury with a subsequent phenotypic vision loss pattern which may explain the varying results reported in the literature.[3,4,5] In addition to the biological variables affecting postoperative vision prognostication, much of the published data has not accounted for inter-eye correlation (IEC) or has relied on analytical approaches that treat eyes as independent observations.[6,7,8]

We examined postoperative vision outcomes in parasellar meningiomas stratified by median compartment and paramedian/lateral parasellar compartment tumor topology. By integrating paired ophthalmologic data that accounts for inter-eye correlation and structural measures of optic nerve integrity, we describe how tumor topology and preoperative optic nerve integrity may influence postoperative vision recovery.

Methods and Materials

We retrospectively analyzed 66 patients with median or paramedian parasellar skull base meningiomas undergoing standardized pre- and postoperative neuro-ophthalmologic evaluation. OCT cohorts included institutional standardized scans (n=48) with serial measurements on the same device. Central vision was measured by Snellen VA (LogMAR), peripheral vision by Humphrey VF mean deviation (MD), and peripapillary RNFL thickness (µm) by OCT. Clinically meaningful change was defined as ±0.2 LogMAR for VA (improvement ≥0.2 decrease; worsening ≥0.2 increase) and ±2.5 dB for VF MD (improvement ≥2.5 dB increase; worsening ≥2.5 dB decrease). Eye-level analyses used GEE with patient-level clustering and robust variance to account for inter-eye correlation. Multivariable models adjusted for prespecified covariates, including age and baseline visual function.. All tests were two-sided (α = 0.05; p < 0.001 reported as such).



Results

Table 1: Patient Demographics and Radiographic Findings (n=66)

	All (n = 66)	Median (n = 29)	Paramedian (n = 37)	p-value
Sex, n (%)				0.587
Female	48	20	28	–
Male	18	9	9	–
Age, mean (SD)	52.3 (14.25)	53.6 (13.5)	51.3 (14.9)	0.596
Previous Treatment, n (%)	7	3	4	1.0
Time to Surgery (d), mean (SD)	38 (50.3)	23 (18.8)	49 (63.2)	0.215
Presenting Symptoms, n (%)				
Vision Deficits	48	23	20	0.405
EOM Palsy	9	3	5	0.720
Proptosis	4	0	3	0.125
Radiographic Characteristics				
Tumor volume (cm³), mean (SD)	20.24 (28.21)	26.40 (38.95)	15.2 (4.3)	0.698
Peritumoral edema, n (%)	23	10	13	1.0
Optic canal invasion, n (%)	42	16	26	0.303
Vascular involvement, n (%)	47	19	28	0.419
Operative Variables				
Approach				**< 0.001**
SO	32	24	8	–
FT	17	4	13	–
FTO	11	2	9	–
EEA	6	3	3	–
Clinoidectomy	33	7	26	**< 0.05**
Optic Canal Decompression	40	13	27	**< 0.001**
GTR	29	20	9	**< 0.05**
STR/NTR	37	9	28	–
Complications	9	5	4	0.706
Post-Operative XRT	22	4	18	**< 0.001**

SO = supraorbital; FT = frontotemporal; FTO = frontotemporalorbital; EEA = expanded endonasal approach; GTR = gross total resection; STR = subtotal resection; NTR = near total resection

Table 2. Multivariable Predictors of Postoperative Vision (n=48[1])

Central Vision	B (95% CI)	OR (95% CI)	p-value
Tumor location (Paramedian vs Median)	-1.556 (-3.214 - 0.101)	0.21 (0.04–1.11)	0.066
Preoperative BCVA	-0.136 (-1.135 - 0.864)	0.87 (0.32–2.37)	0.79
Preoperative RNFL (per µm thicker)	-0.031 (-0.072 - 0.009)	0.97 (0.93–1.01)	0.13
Age (per year)	-0.052 (-0.132 - 0.029)	0.95 (0.88–1.03)	0.21
RNFL (per 10 µm thinner)*	0.280 (-0.181 - 0.738)	1.32 (0.83–2.09)	0.24
Peripheral Vision	**B (95% CI)**	**OR (95% CI)**	**p-value**
Tumor location (Paramedian vs Median)	-0.803 (-2.044 - 0.438)	0.45 (0.13-1.55)	0.21
Preoperative HVF MD (per dB)	0.137 (0.066 - 0.207)	1.15 (1.07-1.23)	<0.001
Preoperative RNFL (per µm thicker)	-0.072 (-0.117 to -0.027)	0.93 (0.89-0.97)	0.002
Age (per year)	-0.031 (-0.082 - 0.020)	0.97 (0.92-1.02)	0.23
RNFL (per 10 µm thinner)*	0.693 (0.263 - 1.123)	2.00 (1.30-3.08)	0.0016

All models were patient-clustered logistic GEE. Median tumors were specified as the reference group.
OR <1 indicates lower odds of postoperative vision deterioration, adjusted for age and baseline vision function (VA or VF)
*Separate model: RNFL_per10_thinner + baseline function + Age (plus intercept); RNFL −10 µm estimates represent the reciprocal transformation for interpretability.
[1]Standardized OCT sub cohort

Figure 1. Functional Measures of Vision Across Parasellar Compartments

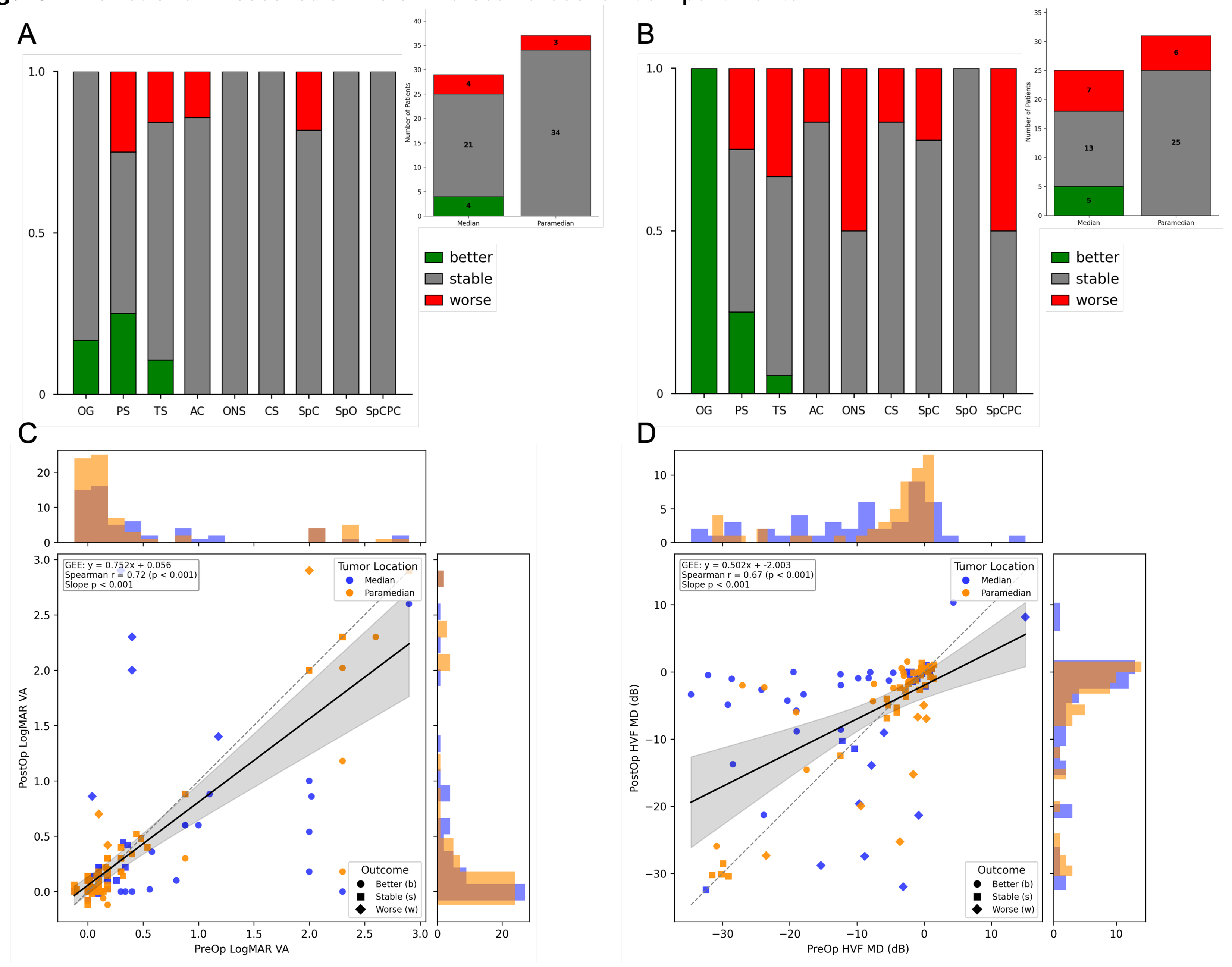
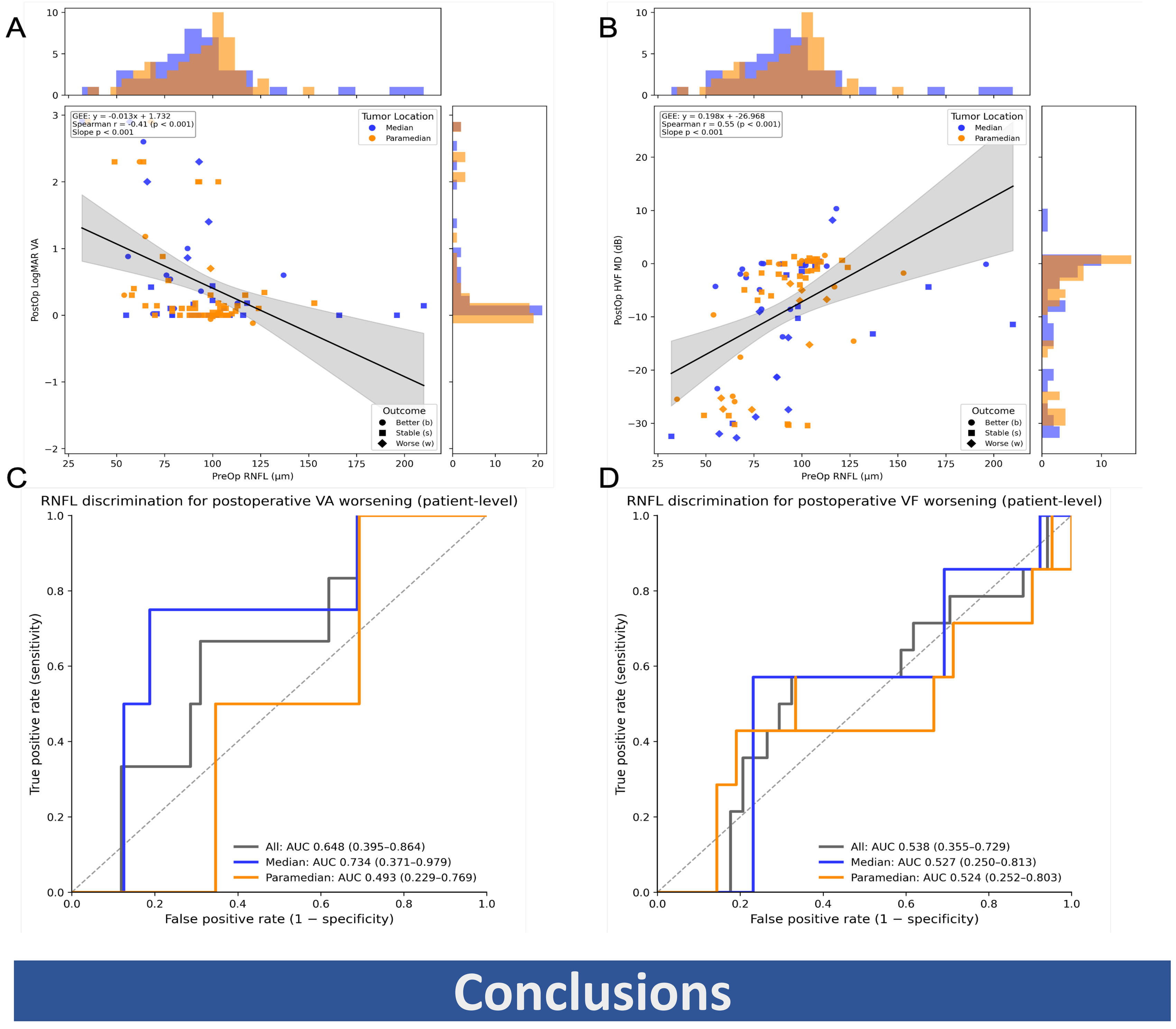


Figure 2. Structural Integrity as a Predictor of Vision Outcomes



Conclusions

1. There were significant differences in the surgical approaches, need for an anterior clinoidectomy, extent-of-resection, and need for postoperative XRT.
2. Surgery predominately preserves baseline central vision (acuity) with population-level improvement in peripheral vision (visual field).
3. Baseline VA and VF functional measures correlate with postoperative functional measure and patients tend to remain within the same functional strata.
4. Median parasellar compartment tumors showed greater VF recovery, while paramedian tumors remained stable or worsened.
5. Thicker RNFL protected against postoperative VF deterioration.
6. Lower RNFL thickness and worse baseline VF correlate with postoperative VF deterioration.

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