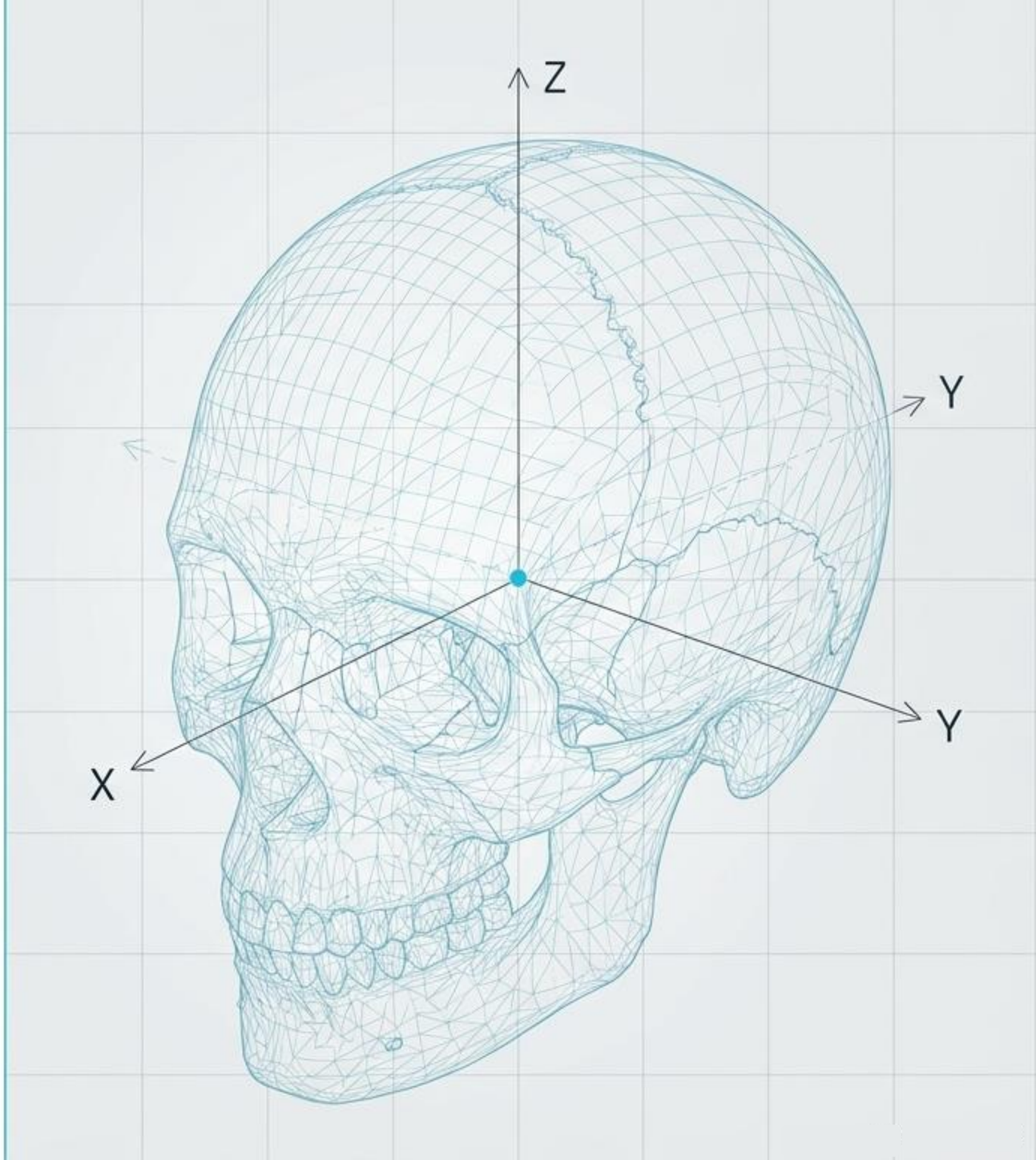
The Precision Paradigm in Neuro-Oncology

Evidence-based applications of **CyberKnife robotic radiosurgery** for aggressive **pituitary tumors** and carcinomas.

Pouria Adeli, Radiation Oncologist

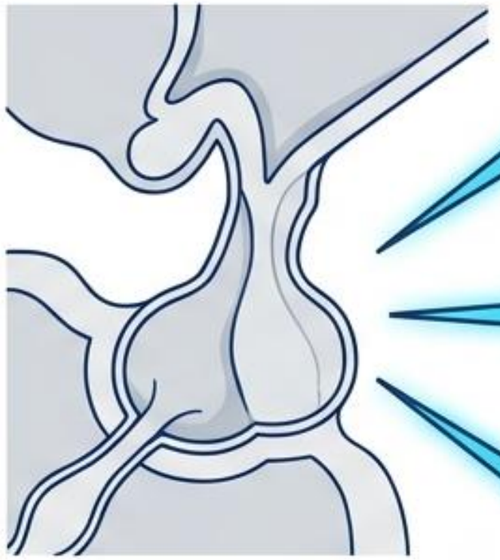


Defining the Clinical Challenge: ESE Guidelines

Clinical Behavior Profile

1. Invasive Macroadenomas
2. Refractory to Resection
3. Resistant to Medical Therapy

Endocrinological Impact



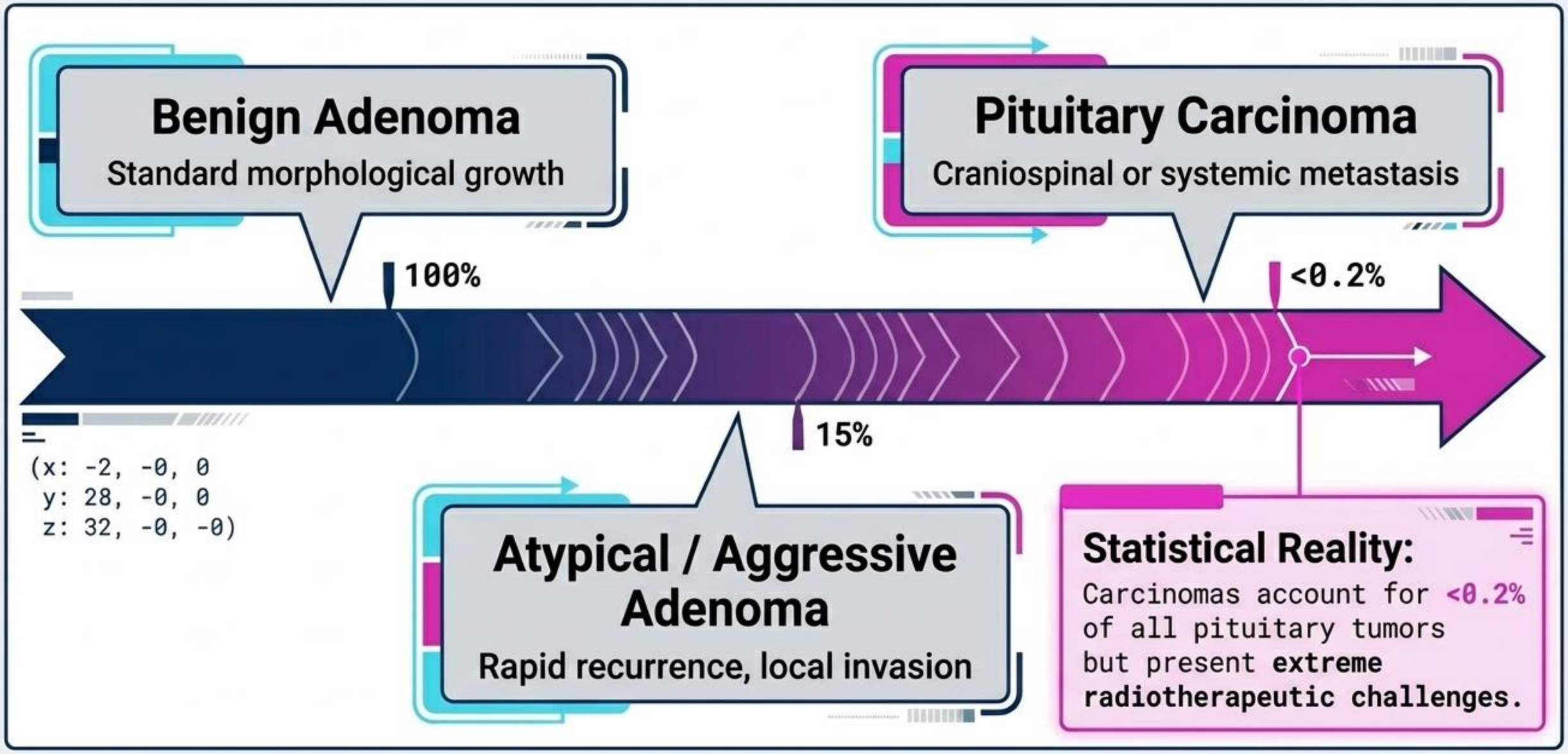
ACTH Hypersecretion

GH Hypersecretion

Prolactin Elevation

Severe mass effect in Non-Functional Adenomas (NFA)

The Extreme Spectrum: Carcinomatous Transformation



Modality Matrix: Cranial Delivery Systems

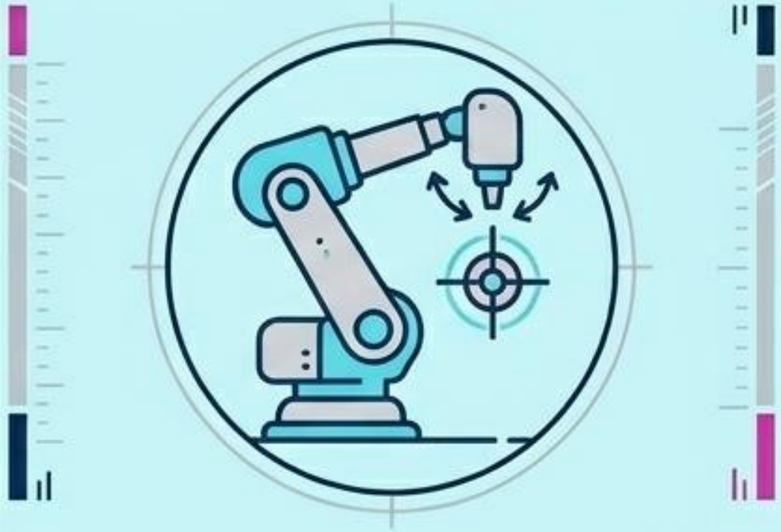
GammaKnife

- Frame-based delivery
- Cobalt-60 source
- Highly precise, single-session limited

Conventional Linac

- Gantry-based isocentric delivery
- CBCT and bite-block reliance
- Less conformal for peri-optic lesions

CyberKnife (CK)

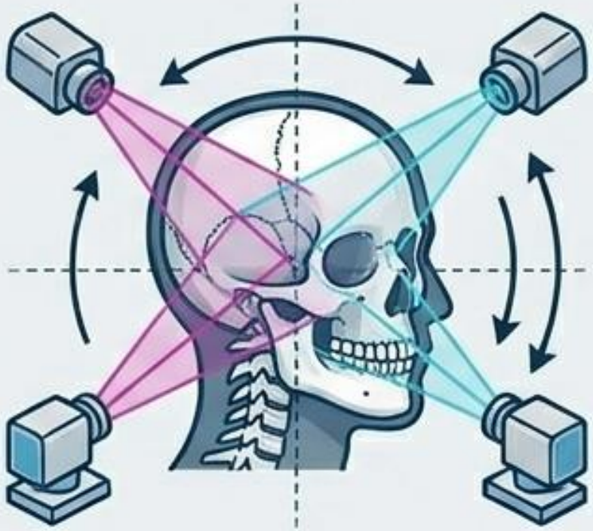


- Frameless robotic Linac
- Real-time 6D skull tracking
- Enables safe hypofractionation

The CyberKnife Advantage: Physics & Framing

Legacy Limitations:

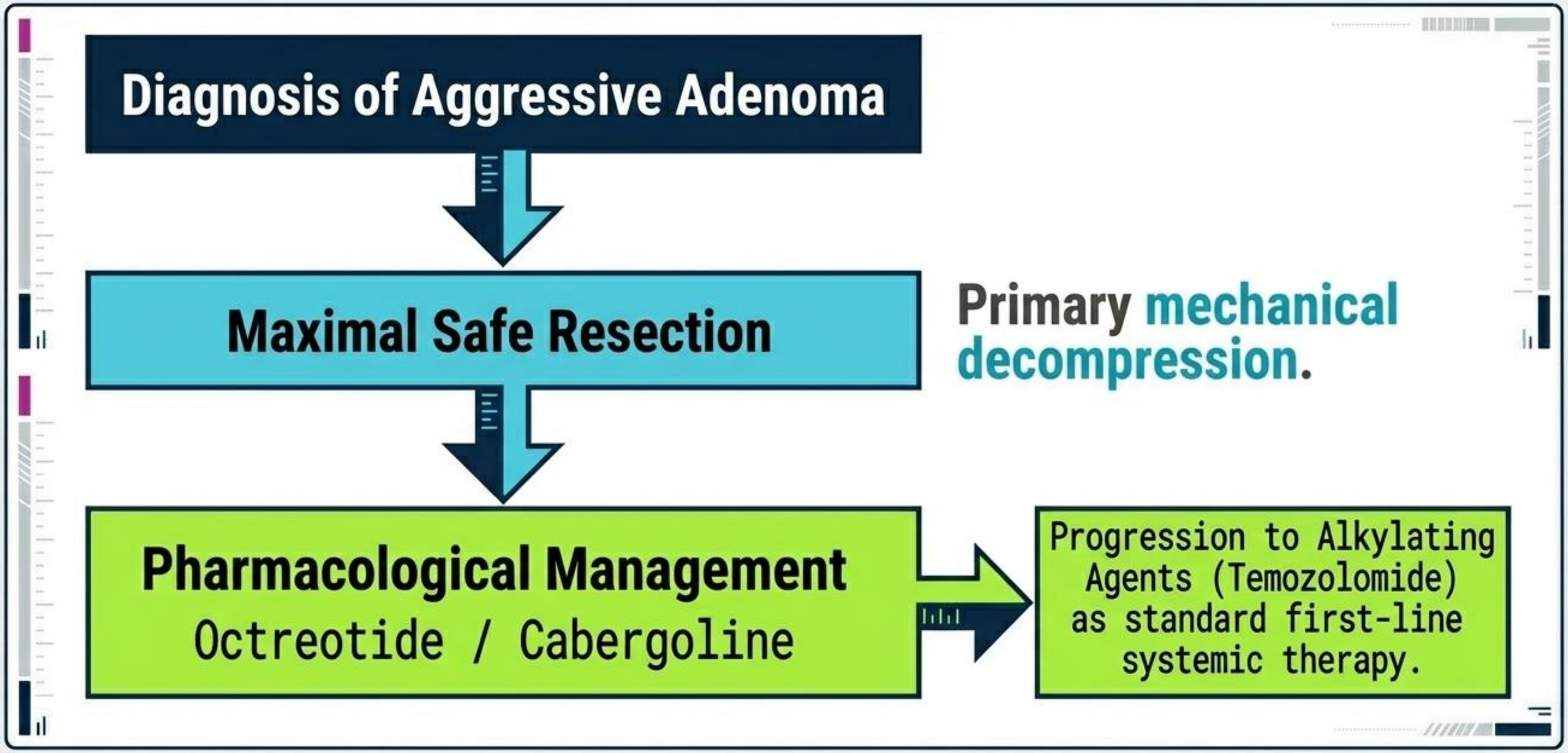
Rigid fixation prohibits multi-day fractionated delivery, forcing **single single high-dose sessions** that risk optic nerve toxicity.



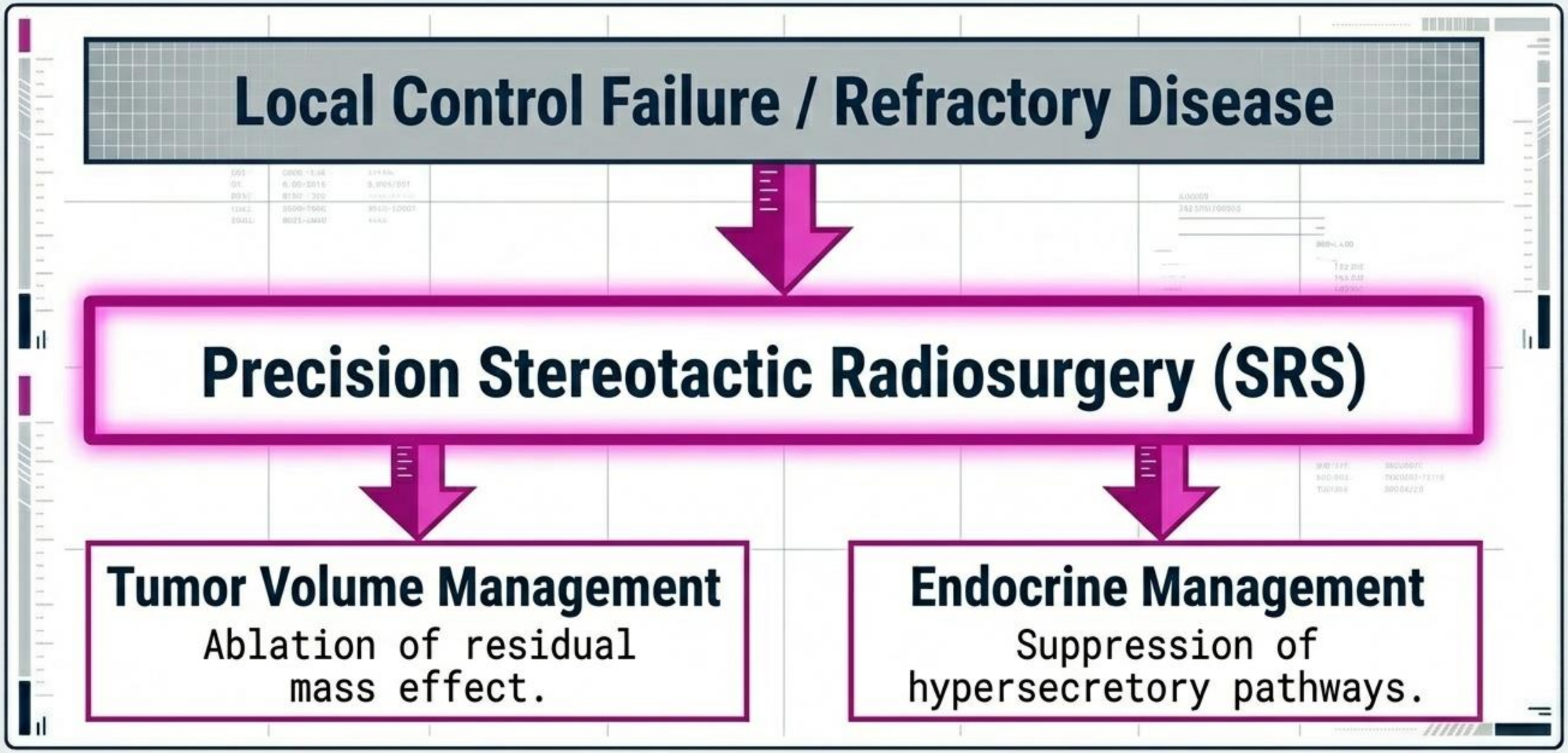
The 6D Tracking Solution:

Continuous **sub-millimeter** image guidance automatically corrects for patient translation and rotation, enabling **frameless, multi-session** delivery (**3-5 fractions**).

ESE Guideline Algorithm: Primary Interventions



ESE Guideline Algorithm: The Radiotherapy Bridge



Clinical Evidence: 278-Patient CyberKnife Cohort

Data adapted from Saeed *et al.*, 2024

Median Age

40.1 Years

Sex Distribution

111 Female / 167 Male

N = 278

Prior Intervention

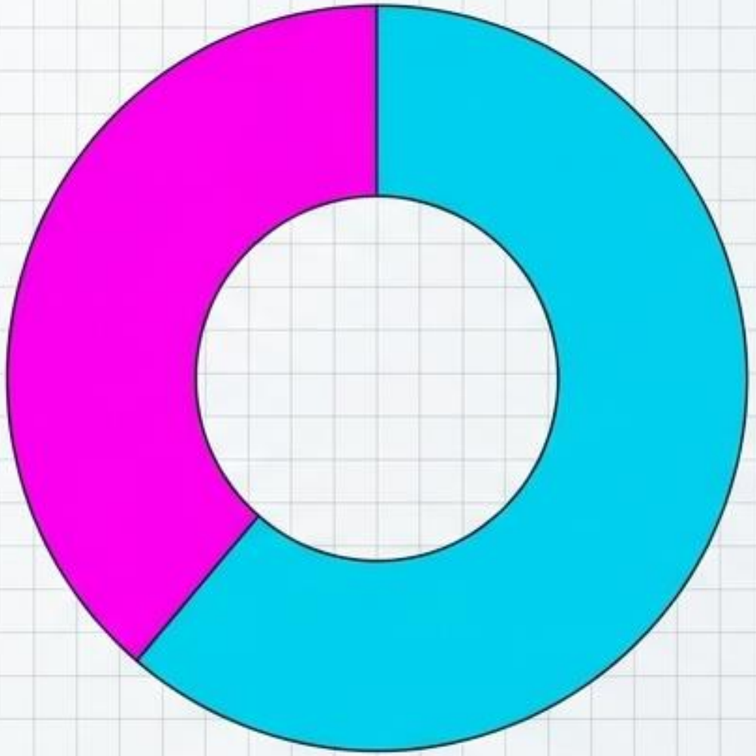
84% previously underwent surgical resection

Follow-up

Median 12 months

Cohort Dynamics: Functional vs. Non-Functional

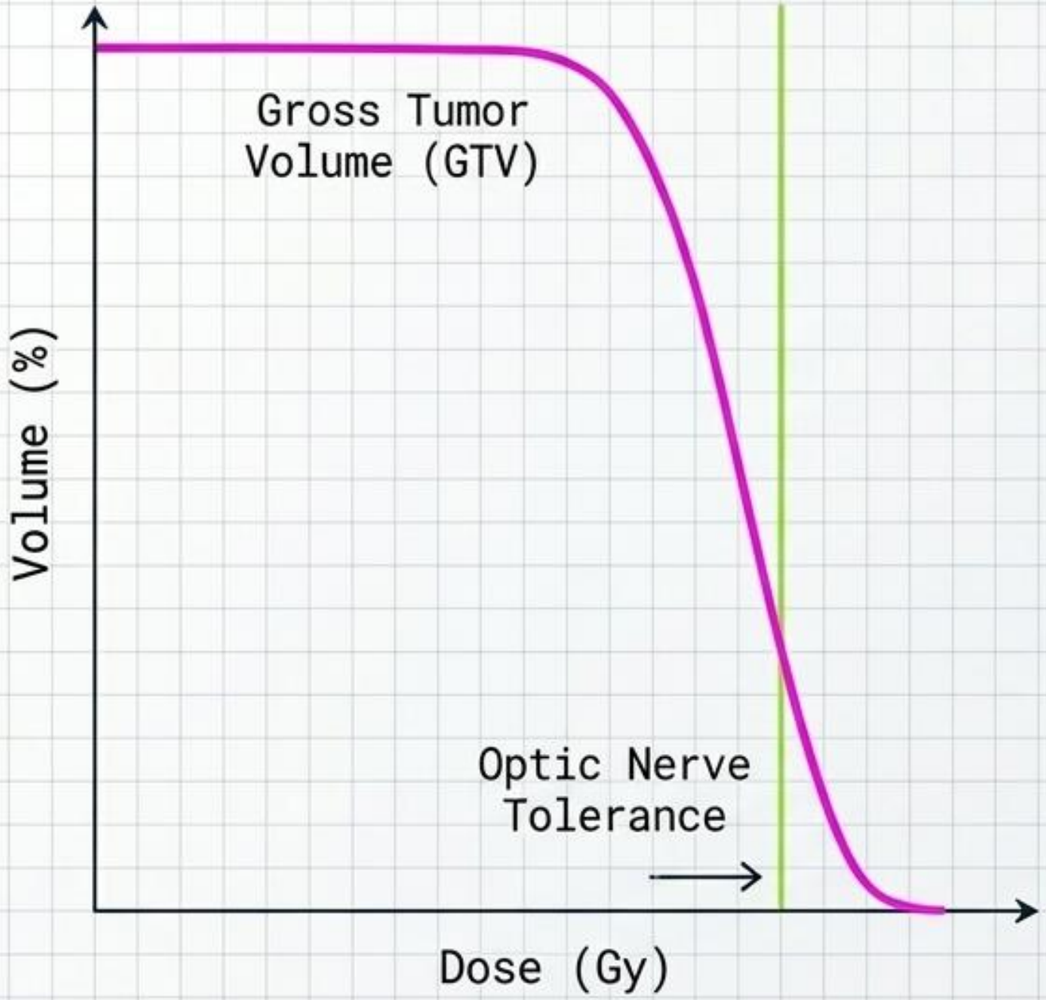
109 Patients
39.2%
Functional
Adenomas (FA)



169 Patients
60.8%
Non-Functional
Adenomas (NFA)

The cohort predominantly features NFA cases presenting with compressive symptoms, alongside a significant subset of hypersecretory refractory FA cases.

Dosimetric Strategy: Hypofractionated Dosing



Prescribed Dose

25.0 ± 5.0 Gy

Fractionation

Delivered in 3 to 5 fractions

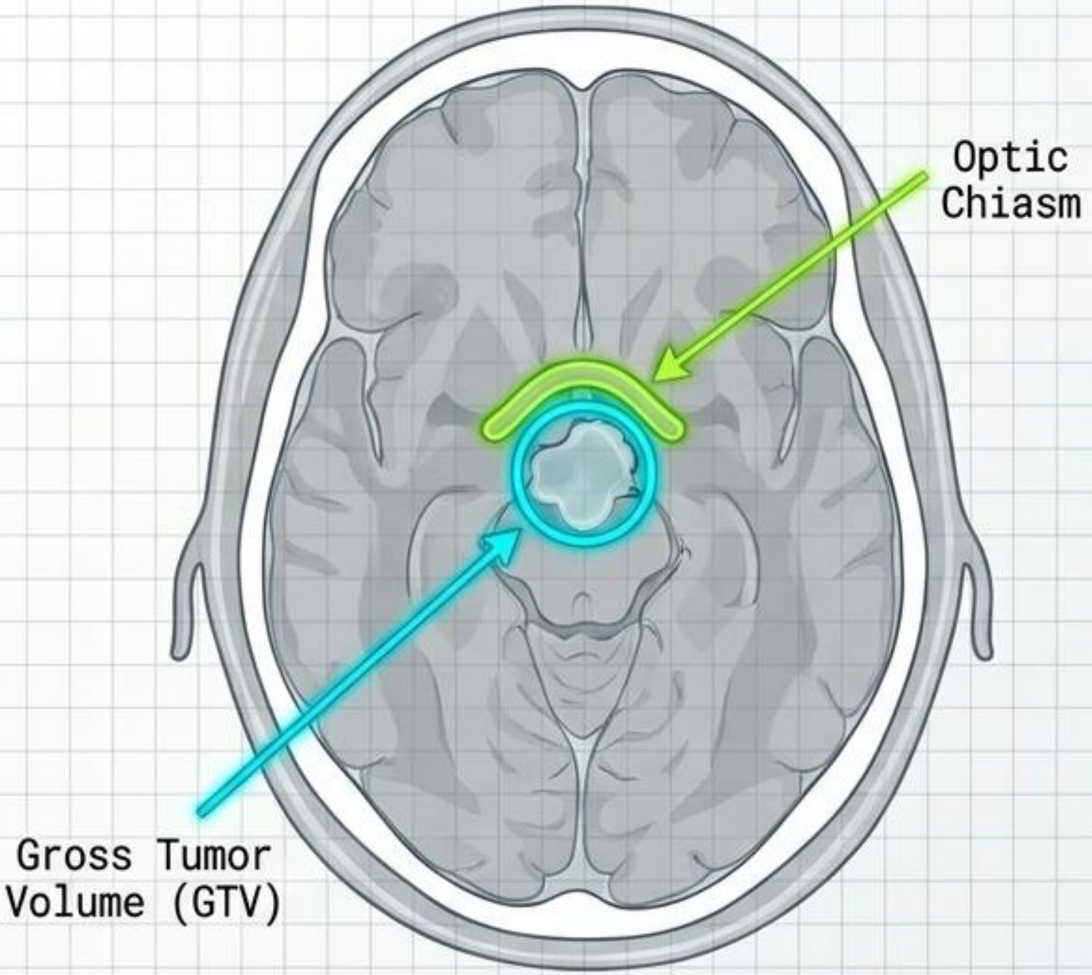
Radiobiology

Provides ablative Biological Equivalent Doses (BED) to the Gross Tumor Volume.

Critical Rationale

Multisession delivery preserves optic chiasm tolerance.

AAPM Guidelines: Target Delineation & Optics



Physics of Precision

Imaging Requirements

Strict co-registration of 1mm slice CT with high-resolution Gadolinium-enhanced MRI.

Volume Definition

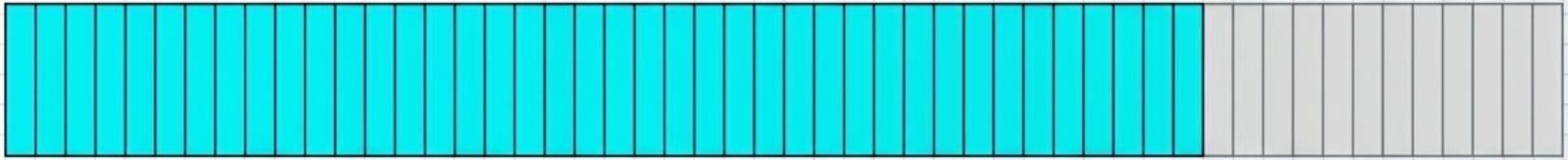
GTV is meticulously delineated on consecutive slices.

Zero-Margin Strategy

Unlike conventional radiotherapy, no additional expansion margin is applied from GTV to PTV, maximizing the protection of adjacent Organs at Risk (OARs).

Efficacy: Radiological Tumor Control

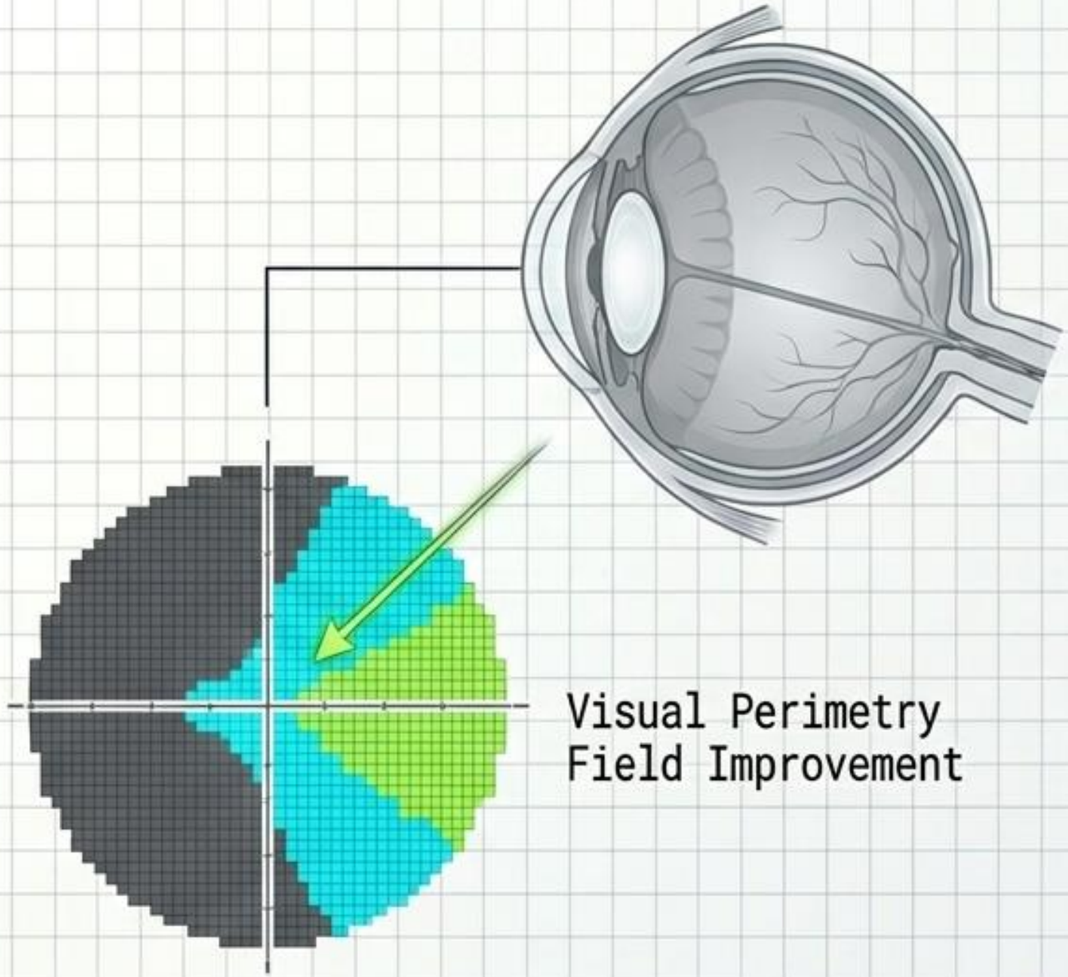
78.6%



Of the 278-patient cohort, nearly 80% demonstrated definitive reduction in gross tumor size on follow-up MRI.

Remaining cohort primarily achieved tumor stabilization, halting progressive growth.

Efficacy: Vision Restoration & Optic Relief



Visual Perimetry
Field Improvement

80.4%

Exhibited measurable improvement in visual perimetry.

Clinical Conclusion: Hypofractionated SRS successfully and safely reverses mass-effect induced optic neuropathy in the vast majority of refractory adenoma presentations.

Toxicity Profile: Neurological Safety

Optic Neuritis

Extremely low incidence.

Radiation Necrosis

Near-zero occurrence at 25 Gy.

Primary Morbidity Risk: Endocrine Deficits

While neurological structures are spared, the radiation dose required for tumor ablation naturally overlaps with functional pituitary tissue, risking hypopituitarism.

Specific Endocrine Deficits Post-CK SRS

NFA Cohort

17

Patients with Non-Functional Adenomas developed new-onset hormonal deficiencies.

FA Cohort

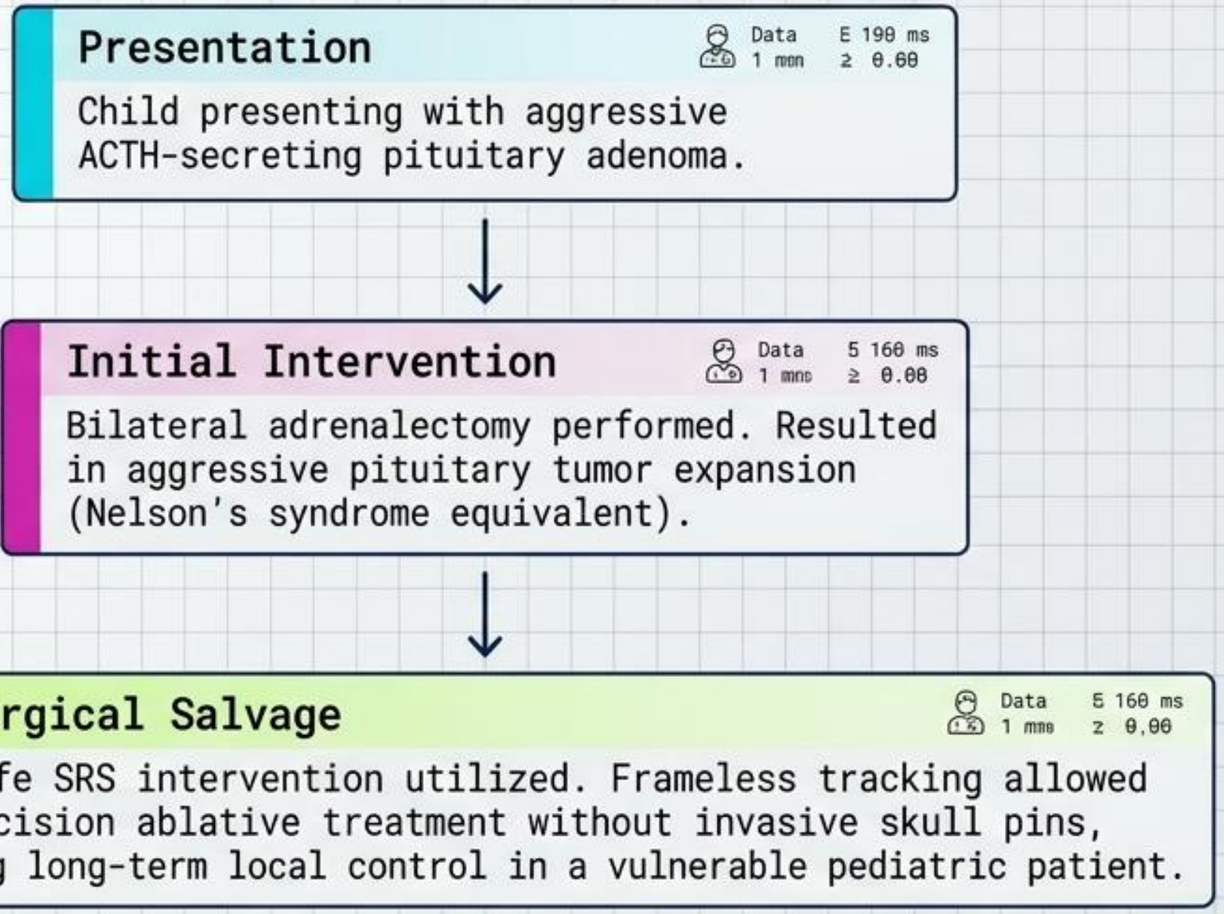
9

Patients with Functional Adenomas developed new-onset hormonal deficiencies.

Statistical Note: There is no statistically significant difference in post-CK SRS visual outcomes between hormone deficiency groups. Constant endocrinological monitoring is mandated.

Extreme Use Cases: Pediatric Application

Reference: ESPE 2015, Aversa Tommaso et al.



Extreme Use Cases: Pituitary Carcinoma

The Clinical Reality <0.2%

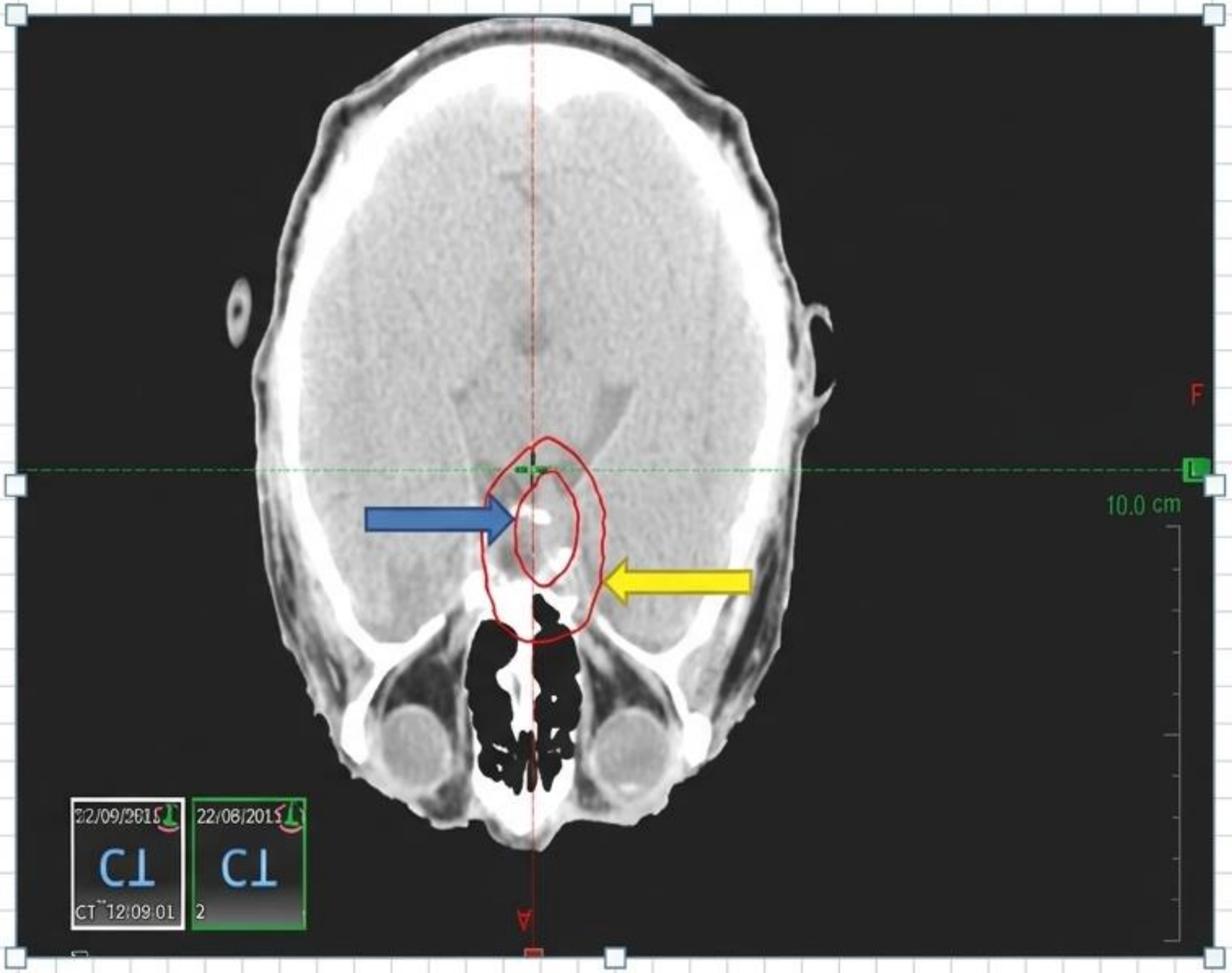
Accounts for <0.2% of tumors. Defined entirely by craniospinal or systemic spread.

Target Delineation 0.20

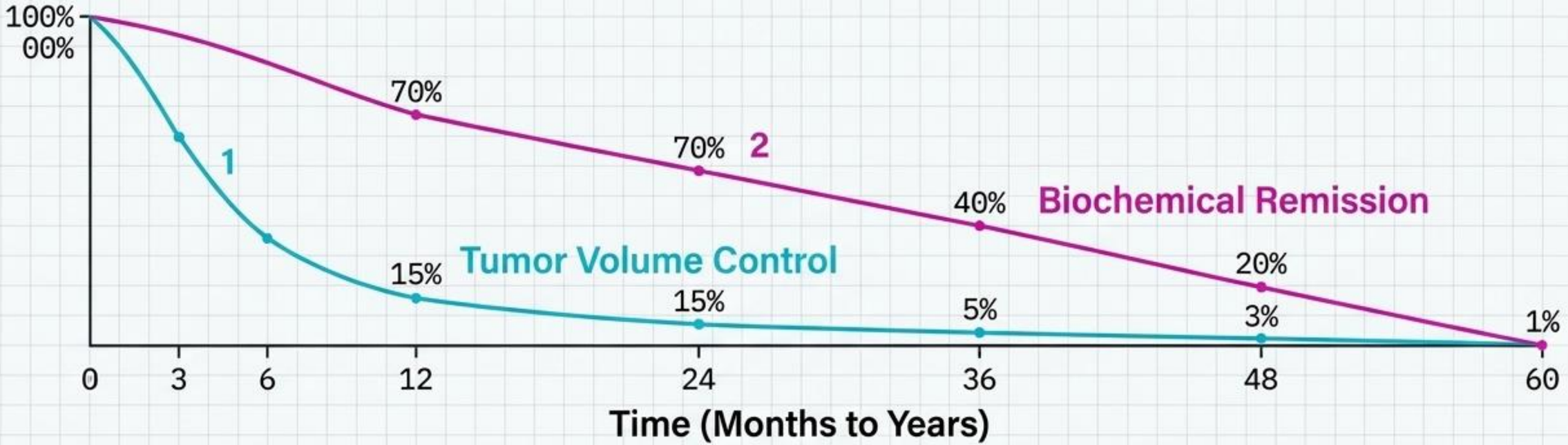
Imaging demonstrates the radiotherapeutic targeting of the primary sellar/suprasellar mass to palliate local destruction.

Multidisciplinary Integration .07

SRS is deployed concurrently with aggressive systemic chemotherapy (Temozolomide) for rapid local disease palliation.



The Dual Objective in Functional Adenomas



Clinical Blueprint Light Mode

The Disconnect

Morphological tumor control is achieved rapidly post-SRS, but normalization of hormone levels may take months to years as hypersecretory cells slowly die.

The Medical Bridge

Continuous adjuvant use of somatostatin analogs or dopamine agonists is strictly required while awaiting the full ablative effect.

Long-Term Survivorship & Secondary Risks

Hypopituitarism

The most common late toxicity. Demands lifelong endocrinological monitoring and dedicated hormone replacement therapy.

Secondary Neoplasms

Per ESE guideline data, there is a documented, albeit low, risk of secondary brain tumors arising in the irradiated field, typically observed >10 years post-radiotherapy.

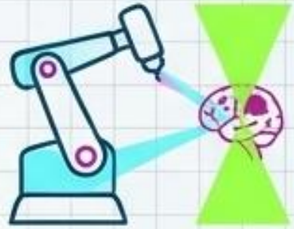
The Multidisciplinary Clinical Blueprint

Anatomical Debulking

Maximal safe surgical resection to immediately decompress optic pathways.

Systemic Suppression

Temozolomide (for carcinoma) and targeted receptor therapies to manage the biochemical environment.



Precision Ablation

CyberKnife SRS (25 Gy / 3-5 fractions) targeting 0mm margin GTV to secure definitive local control.

Redefining the Limits of Local Control.

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