

# Nabaa Efficiency Index (NEI) for Improved Cross-Modality Plan Quality Assessment in Gamma Knife & Linac-based SRS

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## Background

Current quality assurance (QA) workflows in stereotactic radiosurgery (SRS) are time-consuming, resource-intensive, and primarily dependent on post-planning measurement-based verification. Although multiple dosimetric indices such as conformity and gradient indices are routinely used, they remain descriptive rather than predictive and do not provide an integrated estimation of treatment plan acceptance.

As treatment complexity increases across Gamma Knife and LINAC-based SRS platforms, there is a growing need for a rapid, clinically meaningful, and predictive metric capable of estimating plan quality and QA performance before measurement execution.

## Objective

To develop and evaluate the Nabaa Efficiency Index (NEI), a unified predictive metric integrating geometric conformity and dose efficiency for rapid cross-modality assessment of stereotactic radiosurgery treatment plan quality and QA performance.

## Method

Stereotactic radiosurgery (SRS) treatment plans for 100 brain metastatic patients generated using Gamma Knife (50) and LINAC-based (50) platforms were evaluated using dose-volume histogram (DVH)-derived parameters. Conventional dosimetric metrics, including conformity-related parameters and dose distribution efficiency, were analytically integrated to formulate the Nabaa Efficiency Index (NEI).

The proposed index was defined as:

$$\eta_{Nabaa} = CI \times DER = \left( \frac{V_{TV}}{V_{PIV_x}} \right) \left( \frac{\bar{D}_{TV}}{\bar{D}_{PIV_x}} \right)$$

Where:

- **CI** = Conformity Index
- **$PIV_x$**  = Prescription Isodose Volume corresponding to the selected isodose percentage x (e.g., 50% or 90%).
- **$V_{TV}$** : Target volume
- **$V_{PIV_x}$** : Prescription isodose volume at x isodose
- **DER** = Dose Efficiency Ratio
- **$\bar{D}_{TV}$**  = Mean dose delivered to the target volume (TV)
- **$\bar{D}_{PIV_x}$**  = Mean dose within the prescription isodose volume

Higher NEI values indicate superior conformity, improved dose efficiency, and increased predicted likelihood of QA acceptance.

## Results

The proposed Nabaa Efficiency Index (NEI) demonstrated a strong positive relationship with treatment plan quality and simulated QA pass-rate trends across Gamma Knife and LINAC-based stereotactic radiosurgery plans.

Higher NEI values were consistently associated with improved conformity, enhanced dose efficiency, and increased likelihood of treatment plan acceptance. The index provided a rapid predictive estimation of QA performance, approximating the probability of plan success before measurement-based verification.

These findings suggest that NEI may substantially reduce the workload and time required for routine dosimetric QA by supporting early decision-making and minimizing dependence on repeated measurement-based evaluations.

## Conclusion

The Nabaa Efficiency Index (NEI) introduces a predictive approach for stereotactic radiosurgery QA by integrating conformity and dose efficiency into a single unified metric. NEI demonstrated the potential to approximate treatment plan acceptance prior to measurement-based verification, potentially reducing physicist workload and accelerating clinical decision-making across Gamma Knife and LINAC-based SRS platforms. Ultimately, NEI shifts radiotherapy QA from verification toward prediction.

**NEI ≈ Predicted QA Pass Probability**

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