2D and Simple 3D Dose Calculation Algorithms Struggle with Complex Plans

The report of AAPM's Task Group 219[1] on plan second check emphasizes independent 3D dose recalculation as an essential part of patient-specific QA. While measurement QA is important, it cannot address calculation errors resulting from the complexity of increasingly common treatments like SRS or SBRT. Similarly, less robust algorithms struggle to model dose in regions with air-tissue interfaces or small field sizes. Only the Monte Carlo class of dose calculation algorithms can deliver the precision needed to validate complex plans.

Systematic Errors Can Affect Plan Calculation

Without independent dose calculation, your QA process can only validate the linac's capability to deliver the treatment plan. It cannot validate the planning process or identify any errors which result from the initial plan calculation. Furthermore, by simply copying over TPS parameters to construct second check beam models, many vendors are importing uncertainty about the clinical significance of a failed recalculation, compromising the check across all patients. To ensure the independence of your second check, you must address these systematic errors between the TPS and the second check tool.

Adaptive Therapy Assessment Lacks Quantitative Rigor

Objective decision-making requires moving from simple visual inspection of daily images towards a data-driven approach using Monte Carlo dose calculation. Automating this dose calculation for every fraction of every plan is necessary for this approach to be clinically feasible. Manually performing this process has traditionally required a heavy time investment to QA each patient, given that it is difficult to know beforehand which patients will require a replan. What is needed is a balance between the clinical efficiency of a subjective approach and the accuracy of a data-driven approach.

TG-219's Recommendation on Algorithms

PENCIL BEAM

"Pencil-beam type algorithms systematically overestimate the dose by 4.9% on average compared to measurement."

COLLAPSED CONE SUPERPOSITION/CONVOLUTION

"Superposition/convolution algorithms also overestimate the dose to the center of the target by 3.7%."

MONTE CARLO

"MC algorithms show agreement within 1% compared to measurement."

[1]Talcott, W.J. & Lincoln, H. & Kelly, J.R. & Tressel, L. & Wilson, L.D. & Decker, R.H. & Evans, Suzanne. (2019). A Blinded, Prospective Study of Problematic Plan Detection During Physician Chart Rounds. International Journal of Radiation Oncology*Biology*Physics. 105. S23-S24. 10.1016/j.ijrobp.2019.06.425.

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