Educational Point
Counter/Point: Has Photon RT Hit the Limits?

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Introduction
Has Photon RT Hit the Limits?
No!
Can Photon RT catch up dosimetrically with proton therapy?
No!
Photon RT has reached its limit in terms of catching up dosimetrically* with proton therapy!

* unclear whether this matters clinically

Introduction
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Where are we today?
- The achievable target dose conformity is often not significantly different between photon and proton techniques
- In-room imaging technology is (still) more advanced in photon RT
- Dose to critical structures is overall lower with protons
- Although the dosimetric gap seems to close at times, photon RT can not reach proton RT

**Protons are always** superior dosimetrically: Integral dose

* not necessarily at depths beyond 15 cm

**Protons are always** superior dosimetrically: Integral dose

*Sarcoma – 12 year old boy*

Single field IMPT

9 field IMRT

Factor 6 lower integral dose for protons
Protons are always* superior dosimetrically: Integral dose

![Graph showing dosimetric index for protons and photons across different years.]

Future advances in proton RT: Monte Carlo based planning

![Image of range uncertainty margins with Monte Carlo and typical case curves.]

Future advances in proton RT: Intensity modulated proton therapy

![Images of beams 1, 2, and 3 with total dose map.]

Mitigating range uncertainties using robust planning in IMPT

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**Future advances in proton RT: Intensity modulated proton therapy**

Mitigating range uncertainties using robust planning in IMPT

Future advances in proton RT: Dose painting

Molecular imaging to assess complex radiation treatment regimens.

- Cu-ATSM PET
- FLT PET
- DCE CT

before bevacizumab monotherapy (timepoint 1), after 3 wk of bevacizumab (timepoint 2), and after 1–2 wk of chemoradiation therapy (timepoint 3)


**Future advances in proton RT: Dose painting**

Head and neck cancer patients over-express the epidermal growth factor receptor (EGFR) which is linked to poor prognosis. Targeted molecular therapy against EGFR could play a pivotal role as adjunct therapy.

Future advances in proton RT: Biological dose painting

**Inter-patient variability on RBE can be utilized**

“Links Fanconi Anemia/BRCA pathway defects to elevated proton RBE”

“Repair kinetics in HR-deficient cells were significantly delayed after proton irradiation, with elevated amounts of residual gH2AX foci”

Future advances in proton RT: Biological dose painting

**LET times dose: Base-of-skull Chordoma**

reference plan  
re-optimized

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Future advances in proton RT: In vivo range verification for ART

Monte Carlo PET  
Measured PET

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Future advances in proton RT: In vivo range verification for ART

Photon RT has narrowed the gap to proton therapy (without closing it entirely due to the integral dose difference).

Further improvements in photon therapy are either marginal or can be utilized on the proton side as well.

As both photon as well as proton therapy technology will continue to improve, the ceiling for proton therapy is higher because several advances in RT will be proton specific.

The dosimetric gap between photon and proton RT will increase

It is likely that this will have an impact on treatment outcomes.

Conclusion