Exploring the clinical benefits of novel radiotherapy system Halcyon™ – a narrative review of the evidence

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1. Background

- Approximately 50% of all cancer patients receive external beam radiotherapy (EBRT)[1]. A novel O-ring treatment delivery system, Halcyon™, was released in 2017[2]. Gantry rotation can be legally faster (for both treatment and imaging) due to being enclosed[2]. With a stacked/staggered higher leaf speed MLC, treatment delivery can be quicker with potential improvements in plan quality, clinical outcomes, and patient experience[3].
- **This poster will focus on one of the clinical outcomes explored in this review: early-disease control. Since loco-regional failure rates correlate strongly with the incidence of overall survival, measuring early disease control may give an indication of whether improved clinical outcomes are now being realised[4].**

AIMS

1. Identify and critically appraise the current clinical evidence relating to the potential of Halcyon™ to reduce treatment time and improve clinical outcomes, specifically acute toxicities, and early disease control.
2. Collate, examine, and critically engage with the clinical evidence, comparing the results to that of C-arm linear accelerators that are standardised in mainstream clinical practice.
3. Identify any potential clinical benefits that the implementation of Halcyon™ into radiotherapy departments would provide and determine how this may shape the future of radiotherapy.

2. Review Method

- A narrative review was conducted using online database PubMed to review the primary data, using the key search-terms; ''Halcyon'', ''O-ring linac'', ''toxicit*'', ''treatment time'' and ''clinical''.
- Pubmed is readily updated with printed literature and early versions of studies before publication – particularly advantageous when searching for literature on a system as novel as Halcyon™.
- Inclusion and exclusion criteria were then used to tighten focus onto studies identifying reported clinical results.

Inclusion criteria	Exclusion criteria
Papers written in English	Duplicated papers
Papers after 2017	In-silico studies
Full text availability	

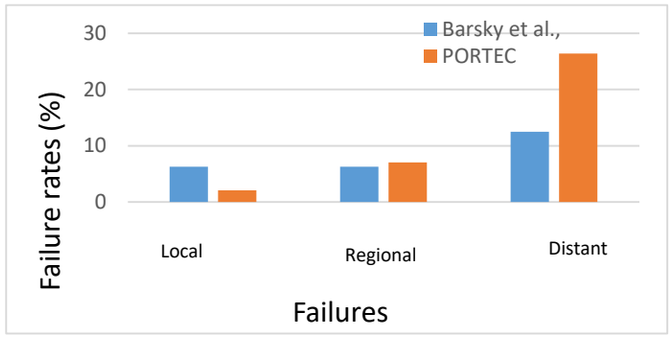
- Papers deemed not relevant were initially excluded by a manual screen of the paper's title and abstracts. Secondary to this, articles were then fully read to further remove any irrelevant or inappropriate studies.
- Once the final studies had been identified, they were critically analysed and reviewed, using the Critical Appraisal Skills Programme tool (CASP) as an aid. This helped to critically analyse papers and assess the quality of the studies.

3. Results and Discussion

- Of the papers identified (n=11), 2 reported on early disease control and their results are shown below.

Author	Failures (% of no. of patients)	Time point (months)
Barsky[5]	Local: 1 (6.25%) Regional: 1 (6.25%) Distant: 2 (12.5%) Death: 1 (6.25%)	12.4 2.7 5.9, 7.9 7.1
Barsky[6]	Local: 2 (6%) Regional: 5(16%) Distant: 8 (26%) Death: 7 (23%)	9.0, 10.9 X X 5.9 (median)

- Barsky et al., reported on early disease-control in terms of local, regional, and distant failures for patients with gynecological cancers treated on Halcyon™[5]. The one death occurred 7.1 months after the start of radiotherapy, was unrelated to the disease and all recurrences occurred outside of the radiation field[5].
- 16 patients in total were evaluable for this outcome, with a median age of 64 years, 14 of which had received surgery and 11 of which had received chemotherapy[5]. The early disease outcomes reported by Barsky et al., are somewhat comparable to published data, such as those originating from the Post Operative Radiation Therapy in Endometrial Carcinoma-3 trial (PORTEC-3-)[5,7]



- A direct comparison between these rates is complex due to the differences between studies.
- Barksy et al., used a relatively short follow-up time of no longer than 12.4 months, which contrasts to the median follow-up time of 72.6 months for PORTEC-3[5,7].
- PORTEC-3 was a large RCT, with a highly selected cohort of high-risk endometrial cancer patients, classified as grade 1, 2 or 3, whilst Barsky et al., had a small heterogeneous cohort of patients, some of which had medically inoperable gynaecological malignancies or metastatic disease[5,7].
- Considering the differences in cohorts and the fact that Barsky et al., reported results from some patients with already metastasised disease, the early disease control outcomes could arguably be classed as somewhat comparable[5].
- Barsky et al[6]., also discussed early disease-control outcomes amongst a different cohort of patients and reported on their initial clinical experience treating 30 patients with lung cancer on Halcyon™. (See previous table)
- The maximum follow-up time is 10.9 months, which makes like for like comparisons against other studies, which tend to report tumour control at the 1-year or 2-year mark, complex[6].
- Timmerman et al., report their local control rates after SBRT for early-stage lung cancer of 88.1% at the 3-year mark and Song et al., report their local tumour control rate of 85.3% at the 1-year mark[8,9].
- Despite the many differences between these studies and that of Barksy et al[5,6], which are beyond the scope of this study, it shows how most studies report early disease control at least 12 months post treatment.
- Whilst it remains difficult to make definite conclusions, it is promising that such early clinical data regarding Halcyon™ is not showing excessive failure rates compared to data from large RCTs.

4. Conclusion

- The potential of Halcyon™ to improve early disease control cannot yet be truly determined due to the paucity of clinical data and the time needed to accrue such data. This review did not highlight any papers that reported on 5-year survival rates, but as Halcyon™ reaches the fifth year since its release, it would be interesting to see papers start to report on this endpoint and use this is a comparison against standardised treatment.
- Halcyon™ is a novel system, and this study has identified the very initial clinical data that is coming through so it would be unreasonable to expect such data to be of the same quality and robustness as that from long-standing radiotherapy systems. This is worth bearing in mind when comparing between any clinical data and drawing conclusions from data that has arisen from such a novel system. Further follow-up of patients treated on Halcyon™ is necessary to truly evaluate clinical outcomes such as local control and it is potentially still too early to quantify exactly how local control rates compare to that of standardised treatment from C-arm linacs

1. Sung et al. *CA Cancer J Clin* 2021;71(3):209-49.
2. Cozzi et al. *Technol Cancer Res Treat* 2018;1(17):1-11
3. Lim et al. *J Appl Clin Med Phys* 2019;20(4):106-14.
4. Machtay et al. *J Thorac Oncol* 2012;7(4):716-22.
5. Barsky et al. *Adv Radiat Oncol* 2020;5(5):920-8.
6. Barsky et al. *Cureus* 2020;12(9):e10325. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7546605/
7. de Boer et al. *Lancet Oncol* 2019;20(9):1273-85.
8. Timmerman et al. *Jama* 2010;303(11):1070-6.
9. Song et al. *Lung Cancer* 2009;66(1):89-93.