Research Letter

Strategic Reduction of Package Time in Head and Neck Cancer

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Abstract

Purpose: Total package time, or the time from diagnosis to completion of definitive treatment, has been associated with outcomes for a variety of tumor sites, but especially to head and neck (HN) cancer. Patients with HN cancer often undergo a complex diagnosis and treatment process involving multiple disciplines both within and outside of oncology. This complexity can lead to longer package times, and each involved discipline has the responsibility to maintain an efficient and effective process. Strategic intervention to improve package time must involve not only new technology or tools, but also “soft” components such as accountability, motivation, and leadership. This combination is necessary to truly optimize radiation therapy for HN cancer, leading to shorter total package times for these patients.

Methods and Materials: Two interventions were strategically executed to improve radiation therapy workflow: upgrade of the treatment planning system and implementation of an automated patient management and accountability system. The radiation therapy–related timelines of 112 patients with HN cancer treated over 2 years were reviewed, and the average time differences were compared between the patient populations before and after the strategic interventions.

Results: Purely upgrading the treatment planning system did not show significant improvements, but when combined with the patient management system, significant improvement in radiation-related package time can be noted for every time point. The overall reduction of radiation-related package time was statistically significant at 22.85 days ($P = .002$).

Conclusions: On face value, the patient management system could be credited as responsible for the improvement, but on qualitative analysis, it is noted that the new system is only a tool that can be ignored or underused. Owing to the addition of important “soft” components such as accountability, motivation, and leadership, the patient management system was optimized and implemented in such a manner as to have the desired effect.

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Introduction

Importance of total package time in cancer care

Cancer is an insidious and formidable disease. Based on its biology, it might be intuitive that the time from initial diagnosis to treatment completion is critical for each
patient. This period, known as total package time, involves various medical disciplines and can be quite complex for a given patient. Despite its complexity, general consensus among peer-reviewed literature seems to indicate that the intuitive assumption is remarkably true.1,2 This fact is evident among a variety of cancers and patient types when evaluating 5- and 10-year mortality.1,2 Especially investigated among patients with head and neck (HN) cancer, indications are that lower package times often correlate to better patient outcomes, though the issue is quite complex and not guaranteed for all patients.2,4-9 Shorter timelines may be inherent to lower stages, which are already correlated to better outcomes and less treatment complexity as an argument; however, not many practitioners are willing to argue that avoidable delays are not potentially detrimental to any one patient’s care.1,2 Unfortunately, it seems that hardline guidance on what are the valuable metrics to meet as cancer care providers has been somewhat ill defined or is still in development.1 What is clear, though, is that any reductions in package time that can be achieved are worthwhile for many cancer patients.

Optimizing radiation therapy package time

While radiation oncology departments have shown success at improving operations and implementing interventions to avoid delays outside of their own immediate workflow,10 internal interventions are the probably least complex to implement.11 According to the experience of others, success is correlated with increasing both standardization and accountability.10-15 However, despite the general agreement on the need for standardization, practitioners are divided on the extent and level of standardization that will prove truly effective, and even some published methods are perhaps not well defined with pre- and postintervention data.14,15 Nevertheless, general conclusions can be drawn and used to initiate departmental interventions: (1) a method of patient tracking must be implemented (automation preferred), (2) healthy accountability must be defined and established, and (3) resource commitment for implementation, oversight, and intervention utilization must be realized. This may take the form of faculty or staff, workflow changes, or even equipment or software purchases.10-13

Methods and Materials

Our department uses Epic for the global hospital records and the Mosaiq record and verify system (Elekta, Stockholm, Sweden) for radiation therapy—related records. Qualitatively, leadership identified the need for improvement in efficiency and package time for patients with cancer treated at our institution and noted several common time delays: initial planning workup between consultation and simulation, contouring of targets and organs at risk, and complex treatment planning.

Intervention: Treatment planning system upgrade

Upon evaluating the root cause of these delays, the decision was made to make a departmental change to the treatment planning system moving from Pinnacle (version 16.2; Philips) to RayStation (version 9A; Raysearch Laboratories, Stockholm, Sweden). RayStation offered several enhancements that were seen as essential to our ability to be more efficient. Instead of using a central processing unit, RayStation performs dose calculations on a graphics processing unit, which is far more expedient and offers tremendous speed improvements, especially for complicated intensity modulated radiation therapy (ie, multigetarget HN). Even with the advanced autoplanning module of Pinnacle optimization to a “final” HN plan would take at least 2 to 3 hours, whereas with graphics processing unit calculation, 1 round of optimization can be completed in 2 to 3 minutes, even for a complex HN. RayStation also offered future opportunity for enhancement to further address identified issues, such as artificial intelligence—assisted contouring for normal tissues and plan optimization.

Intervention: Patient management system

The SmartClinic system and its module, SmartBoard (Fig. 1), were designed specifically for our department to both visualize and track how well patients were hitting expected time points for each stage of their treatment workflow, relying on a combination of mostly automatic input from work already being captured in Mosaiq and a few manual input points. Additionally, an alternative view of the SmartBoard was designed to effectively replace paper cards that had been the previous system for physicians to keep up with and track their patients. The design incorporated both the logistical workflow requirements as well as important input from the various stakeholders who would use the SmartBoard. Once the software had been customized for our clinic, the adoption process began where the SmartBoard was reviewed most mornings during our daily huddle, was often visible on a screen in the conference room area, and the end users were trained on its use for adoption into their workflows. The SmartBoards are accessible via any computer, even remotely, and plans are in place to adopt mobile functionality including optional notifications sent to end users.

Figure 2 demonstrates the basic intent of SmartClinic’s role in the clinic as well as the flow of a patient through our department. The last step to a systematic implementation was the assignment of accountability through 3
methods: department policy to move to the new workflow led by the department chair, setting of initial color-coded due dates for major workflow steps, and open and honest communication between project leadership and department members regarding expectations and process flow. Additionally, the department demonstrated flexibility to modify the global workflow and for minor changes as needed to ensure an effective implementation. A short

**Figure 1**  Example of SmartClinic SmartBoard for our clinic demonstrating how each workflow step is represented and accountability is offered regarding deadlines.

**Figure 2**  Basic flow of patients through our radiation therapy clinic and illustration of SmartClinic’s role.
3-question survey was conducted within the department well after implementation regarding faculty and staff impressions of the new system in its effect on each individual’s workflow, the overall department, and its ease of adoption. Each respondent was asked whether SmartClinic had a positive, neutral, or negative effect on the individual and the department and then on a scale of 1 to 10 (with 1 being easiest) how hard was SmartClinic to implement for that individual.

Retrospective radiation therapy package time review

This work involved retrospective review of patient charts, which was approved by an academic institutional review board. All research was conducted in accordance with the defined regulations and guidelines with the approved methods including the informed consent process for each patient.

RayStation was placed into clinical use in September 2020, offering opportunities for treatment planning efficiency. The first clinical SmartBoard managing patient flow from time of consult to beginning treatment was activated fully in March of 2021 with an emphasis on accountability and meeting deadlines (Fig. 1). Using Mosaïq and Epic records, data was recorded for 2 years of patients with HN cancer before August 30, 2021 (institutional review board 2010-0252) for the critical time points for radiation therapy package time (RTPT): initial consult, simulation, ready for treatment, first treatment, and final treatment. The data was then analyzed based on whether the simulation was before or after RayStation and then whether the consult was before or after both the SmartClinic and RayStation implementation. We then ran general statistics assuming normal distributions on the number of days between each time point and then the overall radiation package time from consult to final treatment. The mean time between each time point was compared from after each intervention to that before any intervention entirely. Patients were only included in the analysis for a time point if the given patient completed the radiation portion of the care path. For mean differences that were found statistically significant, the median of said population was also evaluated, and Mood’s median test was used to evaluate the difference in medians for significance.

Results

Intervention: Patient management system

The results of the informal, intradepartmental survey among 13 faculty and staff demonstrated an overwhelmingly positive impression of SmartClinic’s effect on each individual and the department as a whole. Only 4 and 3 responses indicated their impression as neutral for individual effect and overall department effect, respectively, and every other respondent indicated a positive impression in these 2 areas. Regarding ease of implementation and learning, the median response was 2 demonstrating a relatively easy learning curve overall while the experience was also user specific with 2 responses of 5 and 1 as high as 7. Qualitative responses volunteered with those requested indicate perceived increases in comfort, ability, and teamwork. One respondent even excitedly shared, “SmartClinic has been one of the single-best things that has happened to our clinic!”

Retrospective RTPT review

The analysis included a total of 112 patients with 54 being treated before any intervention, 39 after RayStation but before SmartClinic, and 19 after SmartClinic implementation to July 30, 2021 (see Table 1 for full demographic analysis). For patients after RayStation implementation but before SmartClinic, the mean elapsed time only mildly changed for both positive and negative depending on the time point of interest, but no change was found to be statistically significant. However, after combining the RayStation intervention with SmartClinic in March 2021, elapsed time decreases are notable in every analyzed category. Importantly, 3 of those mean differences reached statistical significance. The significant mean differences can be seen in the periods of “Consult to first treatment,” “Simulation to first treatment,” “Simulation to treatment completion,” “First treatment to treatment completion,” and “Total radiation oncology package time,” with mean reductions of 13.4, 4.2, 13.3, 9.0, and 22.9 days, respectively. The full statistics of mean analysis can be seen in Table 2.

While mean is useful for identifying potential trends, this statistic alone is sensitive to outliers and may not be as accurate, especially with small data sets. For this reason, the median was also reported for the data that appeared to have a statistically significant trend with just the mean difference. Within the aforementioned periods significant with respect to the mean difference, only the periods of “Consult to first treatment” and “Total radiation oncology package time” were found to have statistical significance with reduction of 8.5 and 14 days, respectively. The analysis of the medians can be seen in Table 3.

Discussion

RayStation by itself demonstrates no discernible effect in any category that is either clinically or statistically significant. This may not be surprising as it seems the
software only has the capability to affect the period between simulation and treatment and then subsequently that portion of the total RTPT. RayStation also holds no accountability aspect, but it should be noted that the next intervention includes RayStation as part of the new workflow. Encouragingly, the intervention of SmartClinic with accountability and RayStation appears to have drastically affected our clinic in a positive fashion. It should have the

| Table 1 | Demographics and clinical analysis of patients within this study |
|---------|---------------------------------------------------------------|
| Characteristic | Median (RTPT) days | n (%) |
| **Sex** | | |
| Male | 83.0 | 80 (71.4%) |
| Female | 83.5 | 32 (28.6%) |
| **Age (y), median (range)** | | |
| 61 (20-92) | | |
| **Ethnicity** | | |
| White | 75.5 | 50 (44.6%) |
| Black | 90.0 | 60 (53.6%) |
| Other race | 63.5 | 2 (1.8%) |
| **Body mass index** | | |
| Underweight (<18.5 kg/m²) | 88.0 | 25 (22.3%) |
| Normal (18.5-24.9 kg/m²) | 88.0 | 43 (38.4%) |
| Overweight (25.0-29.9 kg/m²) | 83.0 | 29 (25.9%) |
| Obese (>30 kg/m²) | 79.0 | 15 (13.4%) |
| **Distance traveled** | | |
| ≤30 miles | 83.0 | 55 (49.1%) |
| 30-75 miles | 86.5 | 36 (32.1%) |
| >75 miles | 77.0 | 21 (18.8%) |
| **Household income** | | |
| ≤$30,000 | 90.0 | 31 (27.7%) |
| >$35,000 | 78.0 | 81 (72.3%) |
| **Insurance** | | |
| Medicaid | 91.0 | 33 (29.5%) |
| Medicare | 80.5 | 40 (35.7%) |
| Private | 83.0 | 26 (23.2%) |
| Self-pay | 84.0 | 13 (11.6%) |
| **TNM stage** | | |
| I | 75.0 | 12 (10.7%) |
| II | 83.0 | 14 (12.5%) |
| III | 79.0 | 27 (24.1%) |
| IVA | 82.0 | 37 (33.0%) |
| IVB | 95.0 | 20 (17.9%) |
| IVC | 99.5 | 2 (1.8%) |
| **Pathology** | | |
| Squamous cell carcinoma | 83.0 | 104 (92.9%) |
| Adenocarcinoma | 102.0 | 4 (3.6%) |
| Others | 78.0 | 4 (3.6%) |

*Abbreviations: HN = head and neck; RTPT = radiation therapy package time; TNM = tumor, node, metastasis.*
| Clinic time point | Workflow time point | Mean (SD), d | 95% CI | Mean difference (from before intervention), d | P | Sig |
|-------------------|---------------------|-------------|--------|---------------------------------------------|---|-----|
| No intervention   | Consult to simulation | 20.06 (20.62) | (14.56, 25.56) |                                      |   |     |
|                   | Consult to first treatment | 38.02 (21.77) | (32.21, 43.82) |                                      |   |     |
|                   | Simulation to ready for treatment | 12.74 (8.33) | (10.52, 14.96) |                                      |   |     |
|                   | Simulation to first treatment | 17.96 (6.48) | (16.23, 19.69) |                                      |   |     |
|                   | Simulation to treatment completion | 71.85 (19.28) | (66.70, 76.99) |                                      |   |     |
|                   | First treatment to treatment completion | 53.79 (16.29) | (49.44, 58.13) |                                      |   |     |
|                   | Total RTPT            | 92.27 (28.18) | (84.75, 99.78) |                                      |   |     |
| After RayStation only | Consult to simulation | 24.51 (20.31) | (18.13, 30.89) | 4.46                                      | .311 | No  |
|                   | Consult to first treatment | 46.16 (22.55) | (39.08, 53.24) | 8.14                                      | .087 | No  |
|                   | Simulation to ready for treatment | 14.36 (5.81) | (12.54, 16.18) | 1.62                                      | .300 | No  |
|                   | Simulation to first treatment | 21.42 (10.51) | (18.12, 24.72) | 3.46                                      | .054 | No  |
|                   | Simulation to treatment completion | 68.97 (17.37) | (63.52, 74.42) | −2.87                                     | .473 | No  |
|                   | First treatment to treatment completion | 48.14 (10.57) | (44.82, 51.45) | −5.65                                     | .068 | No  |
|                   | Total RTPT            | 95.61 (26.03) | (87.44, 103.78) | 3.34                                      | .574 | No  |
| After SmartClinic and RayStation | Consult to simulation | 10.89 (8.61) | (7.02, 14.77) | −9.16                                     | .092 | No  |
|                   | Consult to first treatment | 24.63 (4.02) | (20.61, 28.66) | −13.39                                    | .019 | Yes |
|                   | Simulation to ready for treatment | 9.21 (4.28) | (7.29, 11.13) | −3.53                                     | .113 | No  |
|                   | Simulation to first treatment | 13.74 (3.53) | (12.15, 15.32) | −4.23                                     | .013 | Yes |
|                   | Simulation to treatment completion | 58.53 (12.17) | (53.05, 64.00) | −13.32                                    | .009 | Yes |
|                   | First treatment to treatment completion | 44.79 (10.63) | (40.01, 49.57) | −9.00                                     | .035 | Yes |
|                   | Total RTPT            | 69.42 (13.35) | (63.42, 75.42) | −22.85                                    | .002 | Yes |

Abbreviations: CI = confidence interval; RTPT = radiation therapy package time; Sig = significant. Bold rows are to further indicate statistical significance.
least bearing on time between the start of treatment and the end, which showed up as significant, but less so than the others. With only 19 patients having completed treatment since both interventions, more data are desired, but even from this current data, a compelling argument can be made in favor of the effect of the interventions on our patient workflow in the clinic. These interventions would have similar capability in other clinics. An astonishing mean reduction of 22.9 days ($P = .002$) and reduction in median of 14 days ($P = .006$) for RTPT (number of days from radiation consult to final radiation treatment) cannot be ignored. While these authors hypothesize that package time improvement will lead to improvements clinically (ie, overall survival), our limited data set and follow-up data (about 1 year) makes good clinical assessment on this endpoint impossible. However, our plan is to continue not only adding to this data set, but also comparing the clinical endpoints for them as our follow-up time increases for these patients (about 2 years is desired at a minimum).

In addition to the implementation of SmartClinic and RayStation, we highlight a few general principles at work that were introduced earlier: patient management strategy, healthy accountability, and resource commitment. SmartClinic was our specific tool, but, in general, we recognized weak points in our patient workflow and designed our system to monitor and alert us regarding problems in those areas. This same methodology could be done with other commercially offered solutions or even with a spreadsheet. Admittedly, our own previous attempts at a nonautomated solution were unsuccessful. Our new system also gave us an opportunity to establish healthy accountability. As a department, we regularly review the SmartBoard together, making it obvious when patients are experiencing delays, and we all rejoice at a “clean green” board. Additionally, our whole department, and especially our leaders, demonstrated a commitment to this new process based on provided resources both to make it a reality and to truly implement our strategy with accountability in place. Indeed, when software or hardware needs improvement, a line of code, maintenance, or replacement will do, but when it is people who must improve, it requires humility, motivation, and commitment. These “soft” skills or principles should be considered as essential as any software solution presented in this work.

### Conclusions

Improvement efforts are never easy and require both effort and sacrifice, and official timeline goals are often elusive and ill defined, but any reduction in total package time has been shown to translate to better outcomes.\textsuperscript{3,13} It should be noted that our department’s commitment to high quality output did not change from a quality assurance perspective. Because our department emphasizes the use of pretreatment peer review practices outlined in peer-reviewed literature,\textsuperscript{16-19} shortening the RTPT did not result in modification to any of the planning quality

| Clinic time point | Workflow time point               | Median, d | Difference in medians (from before intervention), d | $P$   | Sig |
|-------------------|----------------------------------|-----------|--------------------------------------------------|-------|-----|
| No intervention   | Consult to simulation            | 14.00     |                                                   |       |     |
|                   | Consult to first treatment       | 33.50     |                                                   |       |     |
|                   | Simulation to ready for treatment| 10.00     |                                                   |       |     |
|                   | Simulation to first treatment    | 16.00     |                                                   |       |     |
|                   | Simulation to treatment completion | 65.50   |                                                   |       |     |
|                   | First treatment to treatment completion | 48.50 |                                                   |       |     |
|                   | Total RTPT                       | 83.00     |                                                   |       |     |
| After SmartClinic and RayStation | Consult to simulation         | 11.00     | $-3.00$                                           | .134  | No  |
|                   | Consult to first treatment       | 25.00     | $-8.50$                                           | .029  | Yes |
|                   | Simulation to ready for treatment| 9.00      | $-1.00$                                           | .495  | No  |
|                   | Simulation to first treatment    | 13.00     | $-3.00$                                           | .076  | No  |
|                   | Simulation to treatment completion | 60.00   | $-5.50$                                           | .076  | No  |
|                   | First treatment to treatment completion | 48.00 | $-0.50$                                           | .416  | No  |
|                   | Total RTPT                       | 69.00     | $-14.00$                                          | .006  | Yes |

Abbreviations: RTPT = radiation therapy package time; Sig = significant.
steps already implemented into our process. Future work will seek to improve upon the efforts here through continued accountability within our own discipline and fostering collaboration with other departments as other time points, such as accurate and timely diagnosis and staging, are crucial and even cost-effective to the reduction of overall package time.  

References

1. Cone EB, Marchese M, Paciotti M, et al. Assessment of time-to-treatment initiation and survival in a cohort of patients with common cancers. *JAMA Netw Open*. 2020;3: e2030072.

2. Graboyes EM, Kompelli AR, Neskey DM, et al. Association of treatment delays with survival for patients with head and neck cancer: A systematic review. *JAMA Otolaryngol Head Neck Surg*. 2019;145:166-177.

3. Houlton J]. Defining optimal treatment times in head and neck cancer care: What are we waiting for? *JAMA Otolaryngol Head Neck Surg*. 2019;145:177-178.

4. Zumer B, Pohar Perme M, Jereb S, Strojan P. Impact of delays in radiotherapy of head and neck cancer on outcome. *Radiat Oncol*. 2020;15:202.

5. Schutte HW, Heutink F, Wellenstein DJ, et al. Impact of time to diagnosis and treatment in head and neck cancer: A systematic review. *Otolaryngol Head Neck Surg*. 2020;162:446-457.

6. Dahlke S, Steinmann D, Christiansen H, et al. Impact of time factors on outcome in patients with head and neck cancer treated with definitive radio(chemo)therapy. *In Vivo*. 2017;31:949-955.

7. Ghanem AI, Schymick M, Bachiri S, et al. The effect of treatment package time in head and neck cancer patients treated with adjuvant radiotherapy and concurrent systemic therapy. *World J Otorhinolaryngol Head Neck Surg*. 2019;5:160-167.

8. Shaikh T, Handorf EA, Murphy CT, Mehra R, Ridge JA, Galloway TJ. The impact of radiation treatment time on survival in patients with head and neck cancer. *Int J Radiat Oncol Biol Phys*. 2016;96:967-975.

9. Fareed MM, Galloway TJ. Time abides long enough for those who make use of it. *Cancers Head Neck*. 2018;3:11.

10. Divi V, Chen MM, Hara W, et al. Reducing the time from surgery to adjuvant radiation therapy: An institutional quality improvement project. *Otolaryngol Head Neck Surg*. 2018;159:158-165.

11. Agazaryan N, Chow P, Lamb J, et al. The timeliness initiative: Continuous process improvement for prompt initiation of radiation therapy treatment. *Adv Radiat Oncol*. 2020;5:1014-1021.

12. Chowdhry V, Jangro P, Goldberg S, et al. Quality improvement program in radiation oncology: Understanding patient hospitalizations, treatment breaks, and weight loss in patients receiving radiotherapy. *Radiat Oncol*. 2018;13:161.

13. Khorana AA, Tullio K, Elson P, et al. Time to initial cancer treatment in the United States and association with survival over time: An observational study. *PLoS One*. 2019;14: e0213209.

14. Vieira B, Hans EW, van Vliet-Vroegindeweij C, van de Kamer J, van Harten W. Operations research for resource planning and -use in radiotherapy: A literature review. *BMC Med Inform Decis Mak*. 2016;16:149.

15. Halvorsen P, Gupta N, Rong Y. Clinical practice workflow in radiation oncology should be highly standardized. *J Appl Clin Med Phys*. 2019;20:6-9.

16. Bhandari RP, Duggar WN, Yang C, et al. A sustainable model for peer review and utility of at-a-glance analysis of dose volume histogram in radiation oncology. *J Am Coll Radiol*. 2018;15:310-312.

17. Albert A, Duggar WN, Bhandari R, et al. Analysis of a real time group consensus peer review process in radiation oncology: An evaluation of effectiveness and feasibility. *Radiat Oncol*. 2018;13:239.

18. Duggar WN, Bhandari R, Yang CC, Vijayakumar S. Group consensus peer review in radiation oncology: Commitment to quality. *Radiat Oncol*. 2018;13:55.

19. Vijayakumar S, Duggar WN, Packianathan S, Morris B, Yang CC. Chasing zero harm in radiation oncology: Using pre-treatment peer review. *Front Oncol*. 2019;9:302.