A Study of Displacement due to Patient Movement Prior to and During Radiation Treatment

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Purpose/Objective

The purpose of this study is to examine the magnitude of patient movement prior to (between T_0 and T_2) and during radiation treatment (between T_2 and T_3). In particular, the percentage of radiation treatment that requires corrective action before the treatment ends.

Background

Discomfort such as coughing, sneezing, itching, and/or pain can induce involuntary patient movement. Such movements have been observed by technologists during external-beam radiation treatment set-ups. Little attention, however, has been paid to such movements in the interval between when the technologist leaves the treatment vault and when the treatment sequence begins, and how that in turn may affect treatment accuracy.

Figure 1 illustrates a typical timeline of events occurred when patient underwent radiation treatment. The initial setup is most likely a typical three-point landing method using the pre-calibrated laser lights and skin markers. The verification process could be the use of either conventional portal film, BAT or latest KV or MV cone beam CT technologies. No matter which technology that was used, the result of verification process reflected only the target location at the time when the verification process was initiated. Patient could move accidentally since then due to any one of those mentioned discomforts. The target as well as critical structure thus might no longer at the location that was anticipated/planned even after corrective action was taken such as shift.

Materials/Methods

A real-time image tracking system consisted of three video cameras developed by DART was employed for this study. Patient movements relative to the laser cross-hair were semi-quantified through measurements using a specifical fabricated skin marker (see Figure 1A). The radius of each concentric circle was predetermined i.e. 5mm and 10mm. Through simple observation on monitor, one can easily monitor patient movement throughout the treatment session and determine whether the patient movement is beyond the predetermined limit whether it is 5mm or 10mm.

There were two parts of this study: First, the magnitude of movement, if any, between the initial three-point setup and the time to start the radiation treatment was quantified and recorded. Secondly, a similar measurement was made and recorded at intervals during the subsequent radiation treatment session. As these movements were monitored in real-time, the radiation tech was instructed to take a corrective action by pausing treatment and repositioning the patient if one of the three skin marker was found to be more than 5mm away from the initial three-point set-up marks.

Twenty-nine patients were included in this study. One hundred nine measurements were conducted for both parts one and two of the study. Repeat measurements were often conducted on some of the patients, ranging from one up to nine times.

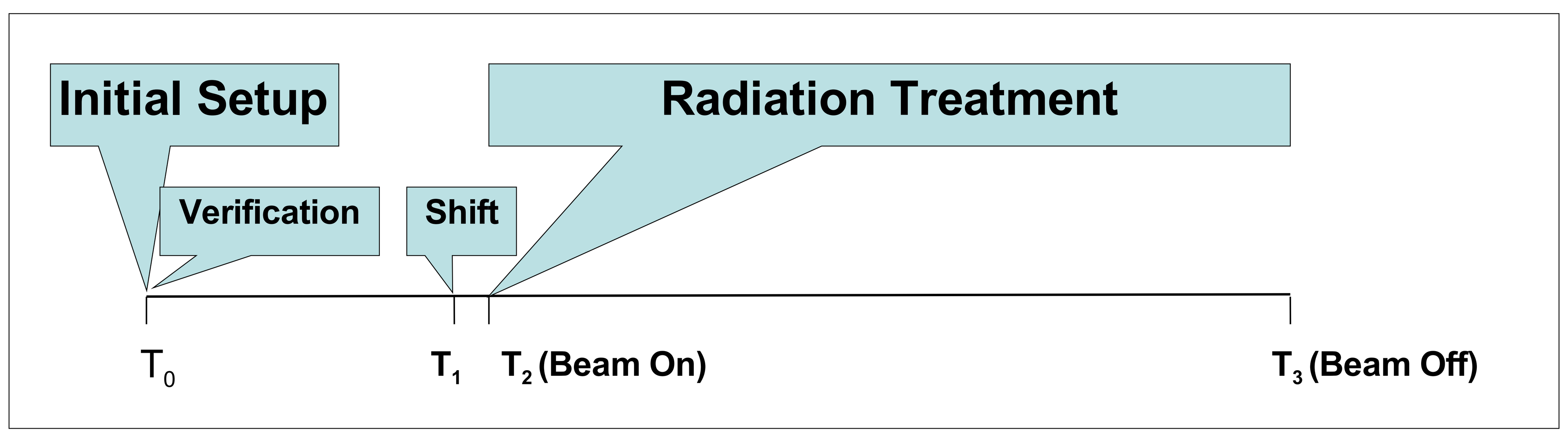

Figure 1: Events occurred during a typical radiation treatment.

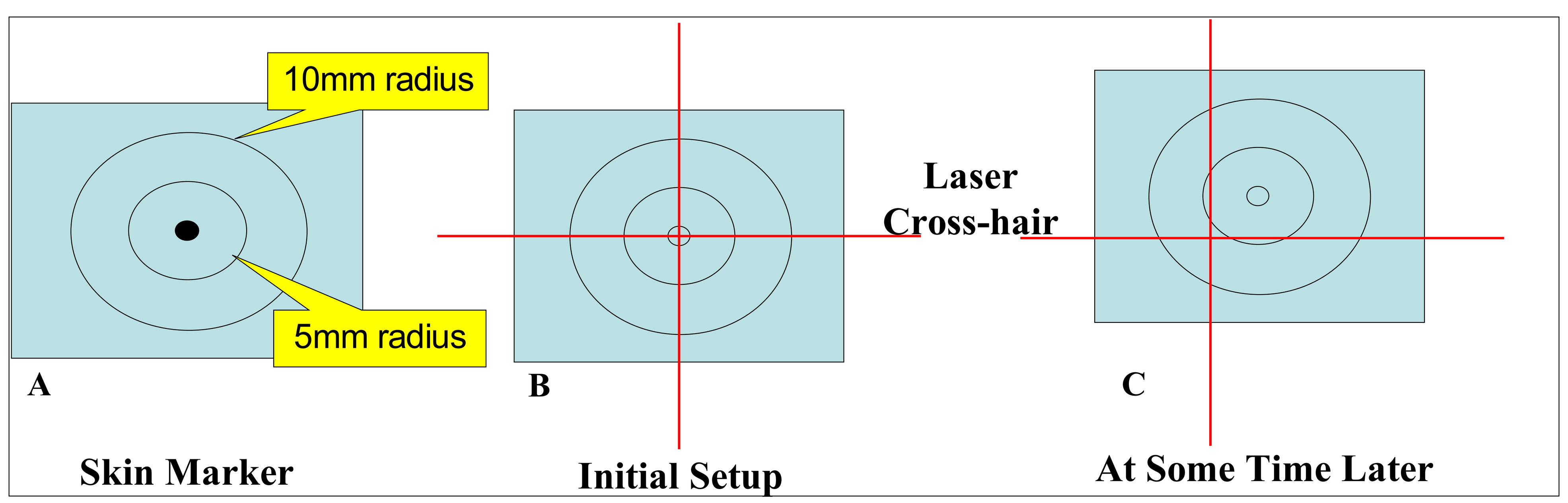

Figure 2: Pre-Fabricated skin marker and the graphic relationship between the skin marker and the calibrated laser cross-hair at initial setup as well as at some later time while the patient was moving out of the initial location.

Results

The results of this study are summarized in Table 1 and Table 2. Out of the one hundred and nine treatment sessions investigated, seventeen required corrective actions (15%) due to movements exceeding the 5mm threshold; seven and ten from 1st part and 2nd part of the study respectively. The average magnitude of movement was 0.4±0.5mm for a duration of 3.9±1.5min (1st part study) and 1.7±1.1mm for a duration of 7.1±3.7min (2nd part study).

Site	Number of Corrective Action			Period Duration (min)	
	Total Number of Investigations	1st Part (T_0 to T_2)	2nd Part (T_2 to T_3)	1st Part avg±s.d.	2nd Part avg±s.d.
Breast	23	1	0	4.4±2.9	6.0±3.1
Thorax	41	2	5	3.8±1.8	6.6±4.2
H&N	28	2	4	3.7±1.9	9.3±5.9
Pelvis	17	2	1	3.5±2.3	6.2±3.2
Total	**109**	**7**	**10**		

Table 1: Summary of the number of corrective action taken during the course of treatment and the averaged duration with respect to the area of treatment.

	Duration avg±s.d. (min)	Displacement avg±s.d. (mm)
1st Part	3.9±1.5	0.4±0.5
2nd Part	7.1±3.7	1.7±1.1

Table 2: Summary of average magnitude of patient movement during radiation treatment.

Conclusions

The relatively high percentage (15%) of treatments needing to be paused for repositioning during this study was alarming. The ability to verify patient position in real-time during an entire radiation treatment session can provide a great assurance that the patient will not be mistreated due to patient's unexpected movement on the table. Although this study is not capable of addressing any internal structure displacement such as that of the targeted tumor or a critical structure, this real-time tracking system nevertheless can provide valuable information of exterior displacement from which internal displacement can be derived. The overall displacement of targeted tumor or critical structure away from its anticipated location thus can be minimized
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Disclosure

Jen Chang, John Wells, and Shyam Paryani are principals of DART.