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Surface-guided radiotherapy for lung cancer can reduce the number of close patient contacts without compromising initial setup accuracy

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ABSTRACT

Surface-guided radiotherapy (SGRT) can assist with patient setup by providing a real-time feedback mechanism over the whole patient treatment surface. It also has the potential to reduce the number of close contacts between staff and the patient, which is advocated for infection control during the COVID-19 pandemic. Residual translations and rotations (post-CBCT) were acquired following a conventional setup protocol (using permanent marks and lasers) and an SGRT setup protocol. The SGRT protocol resulted in one of the two therapeutic radiographers not having any close contact (<2m) with a patient during setup. Data from 702 imaging sessions showed similar setup accuracy with either protocol, fewer large translations and fewer repeat setup occurrences using the SGRT protocol. The potential of SGRT for infection control should be recognised alongside other benefits.

Introduction

Surface-guided radiation therapy (SGRT) uses stereo vision technology to track a patient's surface in 3D and can be used for both initial patient setup and intra-fraction motion tracking or gating [1,2]. In various sites, SGRT can reduce the time and dose from concomitant imaging by providing a large surface and real time feedback mechanism during patient setup [1,2,3]. X-ray or MRI-based imaging remains the gold standard for localisation of internal structures, but SGRT can reduce the need for repeat imaging by minimising the subsequent corrections needed or repeated patient setup, especially for superficial tumours. In treatment of breast cancer or other thorax patients, it can remove the need for permanent skin marks (PMs), which can be debilitating to patients long after treatment [1,2,4]. Finally, SGRT can also provide on-treatment monitoring and automated gating for techniques such as deep inspiration breath hold (DIBH) or stereotactic radiosurgery (SRS) of brain lesions where very high spatial accuracy is paramount [1,2].

The Coronavirus outbreak worldwide has led to new guidelines in clinical practice to keep patients and staff safe and to reduce the spread of infection. In the UK in March 2020, government advice emerged on the benefits of social distancing, keeping at least 2 m apart from other people, in helping to reduce the transmission of coronavirus [5,6]. Further guidance suggested using additional Personal Protective

Equipment (PPE) for those with an increased risk of coughing, which included lung cancer patients during radiotherapy. In our institution, SGRT was already used for DIBH breast and SRS treatments, with a plan to introduce SGRT for PM-free breast treatment, lymphomas and other thorax and limb treatments. It soon became apparent that use of SGRT for lung cancer patient setup had the potential to reduce the number of close patient contacts, in addition to the benefits listed above.

The conventional setup protocol (CP) uses three PMs (one anterior and two lateral) to set up by aligning these with fixed lasers by moving the patient. The PMs are positioned at the level of the xiphoid process, therefore requiring two therapeutic radiographers, one each side, to remain in very close contact (<0.5 m) with the patient whilst setting up. One therapeutic radiographer moves the treatment couch so the laser aligns with the PM whilst the other physical moves the patient to the position of their lateral PM and the anterior PM, repeating the process until all the PMs align. The only way this can be done is for two therapeutic radiographers to remain in very close contact at all times during this process, which can take a few minutes. Following this translations to the isocentre position for that patient are calculated and applied, which can be done with therapeutic radiographers distancing themselves more than 2 m from the patient by using the hand pendant at the end of the treatment couch. Verification cone beam CT (CBCT) imaging is performed as the gold standard for alignment, and any residual differences from the reference image for translation or rotation (except pitch and

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roll) are applied.

The aim of this study is to assess whether it is feasible to introduce SGRT for pre-CBCT initial setup of lung cancer patients to reduce the number of close contact incidences that therapeutic radiographers have, to improve the safety of the treatment protocol in light of COVID.

Materials and methods

A pilot study was conducted to use a new SGRT protocol (SGRTP) for lung patients treated between 24th March and 17th July 2020 on one Varian Truebeam linear accelerator (linac) in our centre. Displacements needed following CBCT were retrospectively compared to a patient group on a similar unit during the same time period, that were setup using the conventional protocol. The study was performed as an opportunistic service evaluation during the first wave of the COVID pandemic, given that SGRT was already used in our centre for breast treatments, and CBCT was still being used as the definitive check for patient alignment accuracy.

The SGRT protocol requires only one therapeutic radiographer to be in close contact (<2m) whilst setting the patient up. The patient gets onto the treatment couch as with the CP, either unaided or with assistance from one radiographer. Then the treatment couch is autoset to the isocentric position and AlignRT (Vision RT Ltd, London, UK) is then used to compare the current patient position with that expected from the reference treatment plan render. Standard action thresholds were set on AlignRT aligning to our breast protocols; translations 5 mm and rotations 3 degrees. If AlignRT shows displacements of up to 5 mm the treatment couch is moved in the relevant direction. This can be done with both therapeutic radiographers standing more than 2 m away from the patient. If the displacement is greater than 5 mm the patient is asked to move themselves physically in the direction required. If the patient is not able to move to within 5 mm that one therapeutic radiographer would then come into close contact with the patient to adjust them manually and move them into position. If any rotation was greater than 3 degrees, the patient is asked to either relax their shoulders or adjust hips slightly. Smaller rotations in jaw could be corrected by couch rotation, but a six degree of rotation couch was not available, so rotations less than 3 degrees in pitch or roll were not corrected post-CBCT. The second therapeutic radiographer would stand more than two metres away at all times (actually 2.8 metres in this treatment room) and operate the software system while also assisting in interpreting the AlignRT data.

Patient immobilisation used for all patients was in house manufactured thoracic immobilisation boards, with ankle and knee support. All patients were of a curative intent and were a mix of Non-small cell and Small Cell Lung cancer. None of the patients required any additional manual handling assistance and were therefore able to get onto the treatment couch either unaided or with the assistance of one therapeutic radiographer.

The pre-treatment process remained the same, and the image verification process of daily CBCT remained the same for both protocols. There was an additional preparation step where planning staff export the plan and structure set to AlignRT, then the therapeutic radiographers import the plan and create a standard region of interest shown in Fig. 1.

A comparison of translations and rotations post CBCT of each protocol group was made and two-sided Student's *t*-test was performed to compare the results from each protocol group, with a *p*-value of 0.05 taken for significance. It was not possible to acquire exact timings of close contact for these patients alongside the complexities of treating during the pandemic, but a short survey was performed of all staff treating patients using the SGRTP to assess their experiences of the expediency of this method.

Results

In total there were 19 patients and 351 individual setup sessions in



Fig 1. Example region of interest for SGRT localisation.

the CP group, compared to 17 patients and 351 setup sessions in the SGRTP group. The difference in number of patients was because of slightly different fractionations across the patients in each group. Table 1 shows the residual differences measured after CBCT acquisition for the two setup protocols. There were statistically significant differences ($p < 0.05$) between the two protocols for roll and vertical displacements only, and moderate significance for yaw rotations. The number of occasions requiring complete repeat patient setup (off and onto the couch again) were 12 (3.4%, CP) and 1 (0.3%, SGRTP). The proportion of occasions with residual translations greater than 5 mm in any one direction were 18.6% (CP) and 14.6% (SGRTP). 21 therapeutic radiographers completed the survey, with the results shown in Table 2.

Discussion

A new setup protocol using SGRT for lung cancer patients was introduced in our centre to minimise close contacts (and hence infection risk) during the COVID pandemic. SGRTP resulted in one of the two therapeutic radiographers not having any close contact (<2m) with a patient during setup. This represents a 50% reduction in the number of people with which the patient has close contact for each fraction, which will be substantial over the whole course of treatment. In addition, over 85% of SGRTP treatment sessions had residual translation corrections post-CBCT of less than 5 mm, which could be corrected by automatic couch motion instead of manual intervention (and hence close contact) as in the conventional (laser and PM based) approach. In fact the proportion may be even higher as some patients were able to self-adjust using SGRT when larger displacements were observed, but it was not possible to collect this data retrospectively. This reduction was aided by the fact that none of the CP or SGRTP group required any additional manual handling requirements. Had there been a manual handling requirement case it still would be possible to reduce close contact for one

Table 1
Summary of translations and rotations comparing the different setup protocols.

| | Mean ± standard deviation | | | | | |
|-----------------------|---------------------------|------------|-----------|---------------|-------------------|--------------|
| | Pitch (°) | Roll (°) | Yaw (°) | Vertical (cm) | Longitudinal (cm) | Lateral (cm) |
| Conventional protocol | 0.4 ± 1.2 | −0.4 ± 1.3 | 0.2 ± 1.4 | −0.1 ± 0.2 | 0.0 ± 0.5 | 0.0 ± 0.3 |
| SGRT protocol | 0.3 ± 1.1 | 0.0 ± 1.3 | 0.3 ± 1.5 | 0.2 ± 0.3 | 0.0 ± 0.3 | 0.0 ± 0.3 |
| p-value | 0.20 | <0.01 | 0.05 | <0.01 | 0.12 | 0.86 |

Table 2
Results of staff survey regarding experience of SGRT.

| | Yes | No | No difference |
|--|-----|-----|---------------|
| Do you think setting patients up using AlignRT is more accurate than a conventional set up with PMs? | 76% | 12% | 12% |
| Do you find setting patients up using AlignRT easier than a conventional set up with PMs? | 84% | 8% | 8% |

therapeutic radiographer for part of the time however this would be on a case by case basis.

Feasibility testing of the SGRT protocol was initially done for pragmatic reasons during the pandemic, because the final setup was still being verified during CBCT with either approach. However, in order to support the hypothesis that SGRT setup was similar to conventional setup with regard to residual shifts needed post-CBCT, a retrospective analysis was performed of 36 patients and 702 individual treatment sessions divided between the two approaches. These results suggest that CP and SGRT achieve similar residual rotations and translations. Differences were statistically significant for roll rotations and vertical shifts, however absolute differences were small in every axis. Residual differences in translation greater than 5 mm were reduced using the SGRT (15% vs 19%), as were the number of times a complete re-setup was needed (0.3% vs 3%). It is easier to observe the entire patient position with SGRT compared to lasers and PMs, so rotations can be more easily corrected at this stage, which will also have an impact on gross setup differences. These findings are similar to other studies that have shown that using SGRT to position patients provides similar or improved accuracy to using permanent marks or planar x-ray imaging [7,8,9,10].

It was not possible to acquire detailed timings of the close contact time with each approach during the feasibility study, however the staff survey results suggest that SGRT is a more straight-forward approach. Other studies have shown reduction in time when using SGRT, however it has not been the main focus of those studies but has been indicated as an additional benefit of using SGRT [11,12].

Since performing this pilot, the SGRT protocol has been implemented clinically across all our treatment linacs for all lung patients, retaining a 15 min appointment time for each fraction. Initially action thresholds were set for rotations at 3 degrees and translations to 5 mm but these have since been reduced to 2 degrees and 3 mm, since these levels were achievable for the majority of patients and should reduce the need for subsequent interventions. Batista *et al* [12] comments that using SGRT has the benefit of being able to correct aspects that are not apparent using PMs alone, such as the position of the shoulder.

SGRT systems are not always being used their full potential, but after initial implementation for breast cancer patient setup, and once workflow consistency and fluency is developed, then this may be applied to other patient cohorts [12,13]. This echoes our experience with the implementation and expanding the use of SGRT, and it will continue to be reviewed and introduced where appropriate. One of the limitations in our centre is that the AlignRT system is not installed on all treatment linacs. Although to date there has not been a major software or hardware

failure that has resulted in delaying any patient's treatment, there does need to be a robust contingency plan. With this current cohort of patients we would be able to revert back to CP using the PMs if necessary when setting up. The next step would be to investigate a PM free solution for these patients considering any additional risks and benefits this may have.

In conclusion, SGRT for lung patients enables therapeutic radiographers to minimise close patient contact giving greater safety to patients and staff without compromising on established standards for setup accuracy as confirmed by CBCT imaging.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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