rectum during treatment for prostate immobilization, which positioned the imbedded detectors in direct contact with the anterior rectal wall. Prior to treatment, patients were scanned on the treatment couch of a CT-on-rails Linear Accelerator, which allowed precise localization of the detectors. During the patient treatment, dose information was collected and displayed in real time, providing a visual measure of dose rate and cumulative dose as a function of time. Patient treatment was re-planned with the two detectors contoured on the new CT dataset to calculate the expected cumulative dose to the detectors for that corresponding fraction. The daily recalculated dose was compared to the measurement of the delivered dose for the corresponding fraction.

**Results:** The average deviation between the measured dose and the treatment planning system calculated dose over the 58 measurements after removing 5 outliers was -1.5% with a standard deviation of 4.0%. The minimum deviation observed was 0.26% (calculated dose: 191.8 cGy, measured dose: 191.3 cGy). The maximum observed deviation for a detector positioned in contact with the anterior rectal wall was -8.1% (184.7 cGy versus 169.7 cGy) which could indicate organ motion. Patient in-vivo results are displayed in Table 1 with in-phantom results for comparison. Daily in-vivo results for patient number 2 are displayed in Figure 1. Due to the real-time nature of this detector it was also possible to distinguish the dose delivered by individual beams during treatment.

**Materials and Methods:** Nine patients were included in the study so far (six declined). Besides standard imaging for RT planning (4D computed tomography (CT) and DIBH CT), all patients had three additional imaging sessions including three consecutive DIBH CT at treatment fractions 2, 16, and 31. All DIBHs were visually guided. An optical marker based system was used for respiratory monitoring, enabling comfortable voluntary DIBH. Gating window of 2-3 mm was chosen at individual level, adjusted to each patient’s performance, when coaching prior to RT planning. The patients’ capability to increase lung volume and to perform repeated DIBH lasting 20 seconds or more throughout the RT course was considered a measure of feasibility. The reproducibility of DIBH level was evaluated as intra- and inter-fractional variations in DIBH lung volume and intra-fractional changes in tumour position. As changes in tumour position were evaluated by manual registrations, intra-observer uncertainty of the registration process was evaluated as well.

**Results:** Lung volume increased with DIBH compared to free breathing by 60% (range 35-87%; p < 0.0001; paired t-test). There was a slight non-significant trend (p=0.23; paired t-test) towards an increased lung volume at DIBH between the planning CT and the treatment days’ DIBH CTs: 4% ± 6% (mean ± SD). No further variations in lung volume were observed throughout the treatment course: changes on days 16 & 31 compared to day 2 were 0% ± 3%. Intra-fractional changes in lung volume were small, 1.1% ± 0.8%. Intra-observer uncertainty in tumour registration was small, 0.2 mm ± 0.6mm three-dimensionally (3D). Intra-fractional changes in 3D tumour position were 2.1 mm ± 1.4 mm. No trend was observed throughout the course. Intra-fractional 3D tumour position change exceeded 3 mm in two DIBH CT sets, one patient suffered pneumonia at the time, the other patient had a 2 mm difference in chest excursion between the DIBHs on the particular day. The patients, who refused to enter the protocol (6/15) were on average 10 years older (p=0.014; t-test), which could be a potential bias of the study.

**Conclusions:** DIBH seems feasible and reproducible intra- and inter-fractionally during a course of NSCLC RT and is well tolerated. We are continuously accruing more patients in the protocol in order to strengthen these encouraging first results on stability and reproducibility of visually guided DIBH with external optical system for respiratory monitoring.

**PO-0881**

**Implementation of helical and direct tomodotherapy techniques for total marrow irradiation**

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**Purpose/Objective:** The aim of the study was to increase total marrow irradiation (TMI) treatment effectiveness and time efficiency while minimizing the dose for non-skeletal structures.

**Materials and Methods:** Twelve patients with multiple myeloma were treated by the following TMI method. As a target, all skeletal bones were contoured (Eclipse, Varian Inc.) excluding hand bones, jawbone, mandible and ethmoid bone. Critical organs were contoured for conformal avoidance. Due to the limitation in the longitudinal couch travel (effectively up to 135 cm), the total marrow irradiation delivery had to be split into two independent plans: HFS and FFS patient orientation. To avoid an unnecessary second CT scan, the FFS CT volume was generated by flipping the original HFS CT volume with our in-house written software. The upper body TMI plan (UTMI) covered the body from the head to 11 cm above knee joint, for which the helical tomodotherapy technique was applied. The lower body TMI plan (LTMI) covered the body from the feet up to 6 cm below the knee joint, for which the direct tomodotherapy technique was applied (two opposite fields of 90°-270°). All plans were implemented using the TomoHD treatment planning system (version 1.02; Accuray Inc.). The optimization goal was to achieve that a minimum of 85% of the target volume receives at least 99% of the prescription dose (12 Gy). Fractionation scheme was 3 x 4 GY (three consecutive days, one irradiation a day).

**Results:** In twelve patients, the following mean doses were obtained [mean±SD, Gy]: UTMI-target 12.15±0.06; LTMI-target 12.35±0.08; brain 7.64±0.32; lenses 2.24±0.28; oral cavity 4.79±0.49; lungs 7.98±0.11; heart 7.64±0.32; kidneys 6.64±0.27; liver 7.90±0.29; kidneys 6.64±0.27; bladder 6.53±0.15. Mean irradiation time [mean±SD, minutes] for UTMI was 35.15±3.50, and for LTMI was 12.66±0.79 (Fig. 1).
Conclusions: Applying the described hypofractionated TMI (4 Gy dose per fraction) a dose reduction to the organs at risk ranged from 18.67%-66.48% of the prescribed dose and the effective time for one radiation session was 1 hour and 15 minutes (including patient positioning and imaging). The tomotherapy direct field angles arrangement instead of using the helical intensity-modulated radiation has allowed minimizing the delivery error associated with the setup of the leg positioning, especially in horizontal direction. An additional benefit was the shorter irradiation time. A disadvantage of the direct technique was poor conformity, as a result of which the non-skeletal structures in legs (mostly muscles and vessels) received a higher dose in order to ensure hitting the target. In conclusion, the applied 4 Gy fractionation is feasible using TomoHD system and time-efficient in a busy radiotherapy department, requiring only a single patient setup a day on three consecutive days. Through hypofractionation, the biological equivalent dose is also effectively increased. Further observation of patients treated with this scheme is necessary to evaluate the treatment response.

PO-0882
Current status of IMRT verification in the UK: Survey Results
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Purpose/Objective: Data from the National Radiotherapy Implementation Group (NRIG) suggests that the provision of IMRT has improved from around 2% of patients in 2008 to around an estimated 15% in 2012 (Cooper and Williams 2012). The objective of this survey was to determine how each centre currently carries out the quality assurance (QA) processes for these IMRT treatments. For the purposes of this survey IMRT is defined as inverse planned treatments and includes linac based, Tomotherapy and Cyberknife delivery. The aim was to collect information on equipment, approach and tolerances as well as how QA approaches may change in the future.

Materials and Methods: Questions were divided into the following categories: Background and equipment, machine based QA, machine based verification, software based verification, future plans. Results: 57 responses were received from 53 centres (4 centres or less than today's proton-only facilities, combined with enhanced therapeutic radiobiology. The new light ions technology provides a compact and very efficient system for curative treatment of several common malignant tumors of: head and neck, lung, liver, prostate, bone/soft tissue sarcoma, cervix, and brain tumors. A facility cost less than or less than today's proton-only facilities, combined with enhanced throughput, the cost per treatment is reduced.

PO-0884
Frameless radiosurgery: less invasive, more accurate
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Purpose/Objective: Stereotactic radiosurgery using frame-based positioning is a well-established technique for the treatment of benign and malignant lesions. By contrast, a new trend towards frameless systems using image-guided positioning techniques is gaining mainstream acceptance. This study was designed to compare the overall accuracy of the frameless with the frame-based radiosurgery technique and to evaluate the immobilization characteristics of a commercially available frameless mask, more specifically, the setup errors and the intrafraction motion, to the invasive fixation of the frame-based technique.

Materials and Methods: Multiple hidden target tests (HTTs) were performed to measure the overall accuracy of the two positioning techniques for radiosurgery (i.e. frameless using stereoscopic-CBCT imaging and 6Dof registration/positioning and frame-based using invisible ring and localizer box). Forty patients with 66 brain metastases were enrolled for frameless stereotactic radiosurgery using X-ray imaging and a 6Dof robotic couch. To analyze the frameless characteristics positioning results were collected before and after treatment to assess patient setup error and intrafraction motion. The obtained data was bench marked to literature for comparison with frame-based techniques.