# Absolute validation of MR versus radiation iso-center on a high-field MR linac

Bernchou, U.; Bertelsen, A.; Riis, H. L.; Jensen, H. R.; Hansen, C. R.; Mahmood, F.; Brink, C.

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the agreement with 3D couch shifts was within 0.05 ±0.02mm. Beam hold can be achieved until threshold of 1mm and the gating coincidence between beam hold signals was estimated less than 1 second. Table 1 shows our planning data. In BH plans, as compared with FB, a decrease of 1.5±0.3Gy in mean heart dose and of 7.5±2.9Gy in maximum LAD dose was reported. Only for one patient the BH plan was not advantageous. On average, an extra CBCT in BH was acquired per session, due patient stability. On average, treatment delivery in BH was 26min, twice the FB value. Differences between BH CBCT before and after treatment delivery were well within the CTV-PTV margin (fig1d).

| | | FB Plan | | BH Plan | | Differences BH-FB | | p value |
|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD | |
| CTVBoost | V(100%) % | 99,8 | 0,3 | 99,9 | 0,2 | 0,1 | -0,1 | 0,67 |
| | Volume (cc) | 15,5 | 10,3 | 17,1 | 11,4 | 1,6 | 1,1 | 0,75 |
| | Dmax (Gy) | 50,8 | 0,8 | 50,6 | 0,7 | -0,2 | -0,1 | 0,48 |
| PTVBoost | V(95%) % | 99,5 | 0,6 | 99,5 | 0,6 | 0,0 | 0,0 | 0,76 |
| | Volume (cc) | 29,0 | 16,3 | 31,8 | 18,6 | 2,9 | 2,3 | 0,73 |
| | Dmax (Gy) | 50,9 | 0,9 | 50,6 | 0,7 | -0,2 | -0,2 | 0,39 |
| PTVBreast | V(95%) % | 99,2 | 0,5 | 99,4 | 0,5 | 0,2 | -0,1 | 0,32 |
| | Volume (cc) | 683,2 | 252,0 | 702,3 | 248,8 | 19,2 | -3,2 | 0,95 |
| | Dmax (Gy) | 50,9 | 0,9 | 50,6 | 0,7 | -0,2 | -0,2 | 0,40 |
| Left Lung | V(18,07Gy)% | 13,9 | 3,2 | 12,8 | 3,6 | -1,1 | 0,4 | 0,34 |
| | V(4,82Gy)% | 47,9 | 4,7 | 43,9 | 5,9 | -4,0 | 1,2 | 0,03 |
| | Mean(Gy) | 8,1 | 0,8 | 7,3 | 0,8 | -0,8 | 0,0 | 0,01 |
| | Volume (cc) | 1205,3 | 292,3 | 2133,9 | 388,8 | **928,6** | 96,5 | <<0,001 |
| Right Lung | V(4,82Gy)% | 1,8 | 2,4 | 1,8 | 2,7 | 0,0 | 0,3 | 0,95 |
| | Mean(Gy) | 1,6 | 0,4 | 1,4 | 0,5 | -0,2 | 0,0 | 0,20 |
| | Volume (cc) | 1421,0 | 259,2 | 2404,9 | 329,6 | **983,9** | 70,4 | <<0,001 |
| Heart | V(9.38Gy)% | 11,6 | 3,7 | 3,9 | 3,2 | **-7,7** | -0,5 | <<0,001 |
| | V(30,6Gy)% | 0,1 | 0,1 | 0,0 | 0,0 | -0,1 | -0,1 | 0,05 |
| | Mean(Gy) | 5,1 | 0,5 | 3,6 | 0,8 | **-1,5** | 0,3 | <<0,001 |
| | Volume (cc) | 533,5 | 81,0 | 492,8 | 83,4 | -40,7 | 2,4 | 0,14 |
| Right Breast | V(4,82Gy)% | 0,7 | 0,7 | 0,7 | 0,7 | -0,1 | -0,1 | 0,75 |
| | Mean(Gy) | 1,1 | 0,3 | 1,1 | 0,3 | 0,0 | 0,0 | 0,65 |
| | Volume (cc) | 663,7 | 235,1 | 667,5 | 232,3 | 3,8 | -2,8 | 0,96 |
| LAD | Dmax (Gy) | 25,3 | 1,6 | 17,8 | 4,5 | **-7,5** | 2,9 | <<0,001 |

**Table1** – Dose and volume differences calculated for the dosimetric plans in free breathing and breath hold for 19 patients. The statistical results, as calculated with the student t-test, are also shown (in green the values considered statistically significant, $p<0.05$).

**Conclusion**

The OSMS system has been validated for continuous monitoring patient inspiration during treatment and is now being used clinically. DIBH with IMRT technique leads to better cardiac sparing as compared to FB. In the near future, we plan to extend DIBH to left breast patients with LN.

**PO-1028 Absolute validation of MR versus radiation iso-center on a high-field MR linac**

U. Bernchou[1], A. Bertelsen[1], H.L. Riis[1], H.R. Jensen[1], C.R. Hansen[1], F. Mahmood[1], C. Brink[1]
[1]*Odense University Hospital, Laboratory of Radiation physcis, Odense, Denmark*

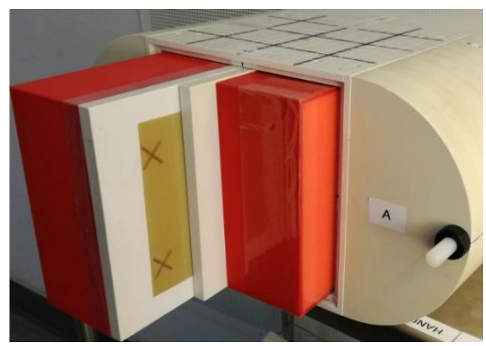
**Purpose or Objective**

The superior soft-tissue contrast offered by the newly introduced MR linacs allows the localization of the tumour and surrounding normal tissue while the patient is on the treatment couch. However, in order to rely on the daily MR images for guidance of radiotherapy, there is a need to validate the positional accuracy between the planned and delivered dose distribution including all potential uncertainties of MR imaging and dose delivery. This abstract demonstrates a method to perform end-to-end validation of the dose delivery on a high-field MR linac based on an in-house 3D printed, MR visible phantom.

**Material and Methods**

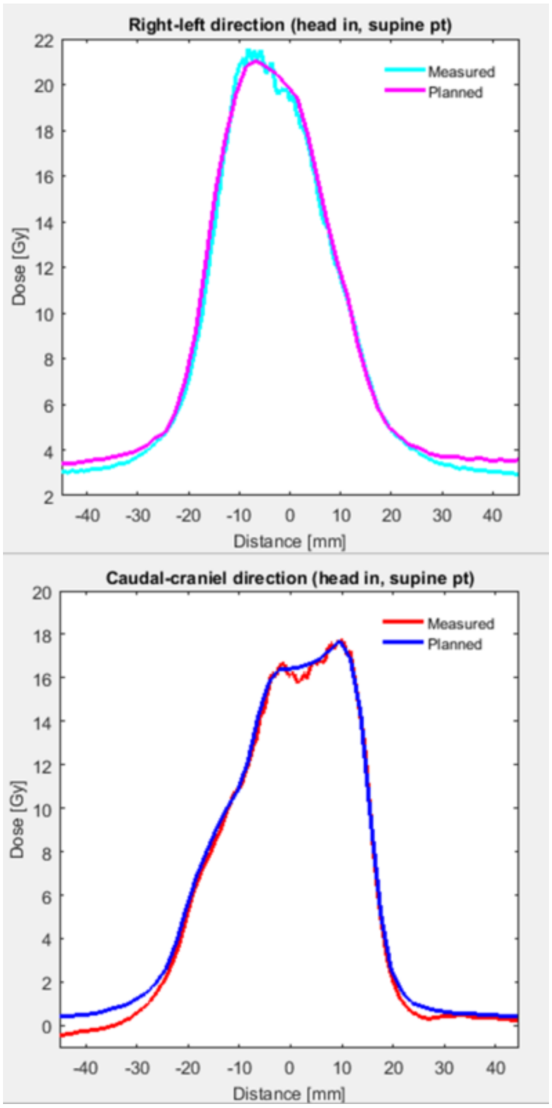
MR visible phantom inserts were created for the I'mRT phantom (Scanditronix Wellhöfer). The MR visible parts were made of a bi-component silicone rubber (Eurosil 10 Orange) with added softener. The silicone is MR visible and the signal strength depends upon the amount of softener. Perspex rods were cast into silicone rubber with varying amounts of softener within 3D printed containers, creating an inhomogeneous MR visible phantom insert. Two such inserts were created and sandwiched around a radiochromic film supported by two solid water plates (see figure 1). The solid water plates contained copper crosses such that their positions were visible on the film after irradiation. The phantom supports both vertical and horizontal film alignment.

A seven beam stereotactic IMRT plan based on a CT scan of the entire phantom was created in the treatment planning system Monaco v 5.40 (Elekta AB, Sweden). At a high-field MR linac, T2 weighted 3D spin echo MR scans of the phantom were performed. Rigid registration of the MR position relative to the CT scan was performed in Online Monaco. The registration was used to calculate the current position of the treatment planning iso-center within the phantom as predicted by the entire treatment chain. After irradiation, the films were scanned in a flatbed scanner and gray levels were converted to dose (Lewis MedPhys 2012). The fixed copper crosses were visible on the film and were used to define the exact position of the film within the phantom.




**Results**

An example of comparisons of relative profiles obtained from the film and the planned dose is shown in figure 2. The observable differences in dose are partly due to uncertainties in the conversion of optical density to dose. The high positional precision between the two dose profiles reflects the positional accuracy of the entire system. At our local MR linac, the end-to-end phantom measures a lateral offset of 0.4 mm, a longitudinal offset of 0.1-0.6 mm, and a vertical offset of 0.3 mm.




**Conclusion**
Using 3D printed MR visible silicone inserts it was possible to create an end-to-end validation phantom for MR linacs. The phantom has been used in our department and the uncertainty of the dose positions is around half a millimeter, which is needed to make precise MR linac treatments.

**PO-1029 The use of Elekta Agility MLC Dynamic log files for VMAT QA**

M. Picioli[1], K. Torzsok[1], A. Ruiz Plata[1], F. Marangoni[1], H. Broque[1], J. Aponte[1]
[1]*Fundacion Arturo Lopez Perez, Medical Physics, Santiago, Chile*

**Purpose or Objective**
The usage of massive dynamic parameters during VMAT treatments requires the implementation of new QA mechanisms. One major contributor potentially leading to mistreatments if not properly calibrated is the MLC. Following TG142 recommendations we have created a simple method in order to measure the constancy of leaf speed and positioning accuracy through Elekta Dynamic log files interpretation.
**Material and Methods**
For MLC quality control a set of fields has been created using Elekta *iComCAT V.13.0* software and loaded up in Linac Synergy console. In order to evaluate leaf speed constancy a sweeping gap of 2cm x 24cm capable of sweeping 20 cm from X1 to X2 has been used. In order to calculate the theoretical MU value for this field, the following equation was applied:

$$UM = \frac{(\Delta UM/\Delta t)_{max}(x_f - x_i)}{(\Delta x/\Delta t)_{max}}$$

The MU above calculated took into consideration leaf banks at maximum nominal speed and maximum dose rate. Rising up the MU for this field in the software means that MLC should slow down. On the other hand, reducing this value means dose rate will slow down automatically.Once the desirable leaf speed has been calculated through a specific MU, it was compared against the logs from the machine.Regarding leaf positioning accuracy, a picket fence containing 3 segments of 6cm x 24cm was created and irradiated at 4 cardinal angles. For both field configurations, each leaf was analyzed individually and the actual values found in the logs were reported and compared against iComCAT theoretical values. Images for both field configurations were also acquired with IviewGT and compared against the logs providing a more reliable qualitative analysis than simple image visual inspection.
**Results**
Figure 1 represents the real leaf speed constancy for both leaf banks obtained from the logs files. Leaf absolute positions were measured in 0,25 s time intervals and are represented by Y and X axis respectively. X1 bank starts moving at -10cm and bank X2 at -8cm (Elekta scale).


Figure 1 - MLC Speed Test
From Figure 1 we can see that both leaf banks have the same constant speed through the field. Any deceleration caused by lack of lubrication or issues with the motors could be easily recognized by deflections in the lines. The real leaf speed gathered from the graph differs less than 1% with respect to the calculated value in iComCAT. For the picket fence field, whilst irradiation of gantry 180 degrees, logs have shown maximum deviation of 0,4 mm for leaf 57 of X2 bank with respect of it nominal position. Leaf bank X2 also presented major differences in average for the same angle.
**Conclusion**
Although the utilization of dynamic log files for Elekta linacs is not known in the clinical environment, this work shows it could be a very reliable and powerful tool for accuracy in positioning and speed constancy determination of the Agility MLC, also providing a quantitative complement of simple visual MLC Picket fence image inspection.

**PO-1030 Absolute validation of Multi Leaf Collimator (MLC) positions on a high-field MR linac.**

A. Bertelsen[1], U. Bernchou[1], H.L. Riis[1], C. Brink[1]
[1]*Odense University Hospital, Laboratory of Radiation Physics, Odense, Denmark*