Machine record parameters or Epid based data for dose recalculation in Adaptive Radio Therapy QA. A comparison of two scenarios.

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Purpose:

Using machine record files and EPID based dosimetry is a popular task for machine and patient related QA, as this may also work for adaptive treatment approaches. The Siemens Artiste treatment machine used here, allows a comparison of both methods in one session. Exit images and all relevant machine parameters are included in the image header collected during treatment. Here we present results of a comparison between QA dose recalculations based on the two data sources, exit images and machine recorded parameters.

Material and Methods:

A software tool was developed that allows for the extraction of the relevant parameters (MLC-positions, MU, etc.) from the machine records as well as from the EPID measured exit fluences. While machine data just had to undergo a reformat to be used for recalculation, the exit fluencies need more attention. The algorithm uses a EPID based MIP image (Lit 1) to separate the attenuation followed by a combination of Edge detection (Canny, Lit 2) and 50% position value to receive reliable leaf positions (Fig. 2). MU's were used from the parameter file, as the fluence based Mu's have shown to have larger uncertainties. The extracted parameters are then inserted in a DICOM RT-Plan for the replanning of the dose in the TPS (Raystation, Raysearch). Dose distributions (EPID based, parameter file based and originally planned) for 5 patient cases are then compared.

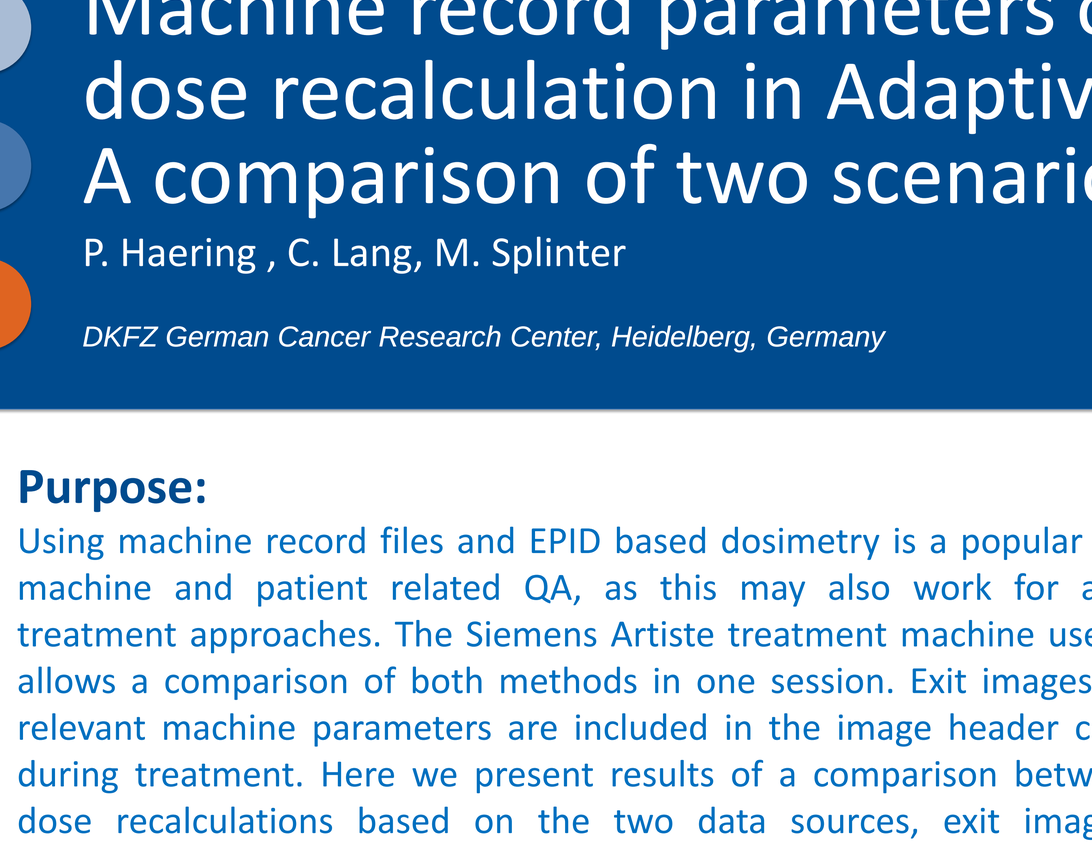
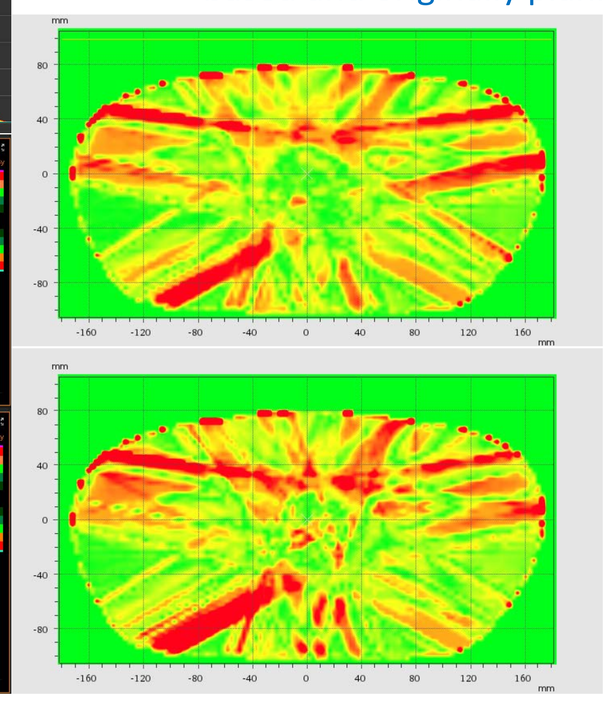


Fig 1: First column: original plan dose (OD), dose based on record file(RD), dose based on EPID image (ED) (top to bottom).
Second column: DVH of the 3 Doses, Subtraction dose OD-RD and OD-ED in color wash
Third column: Gamma distribution (1mm/ 1% max) of OD vs RD and OD vs ED.



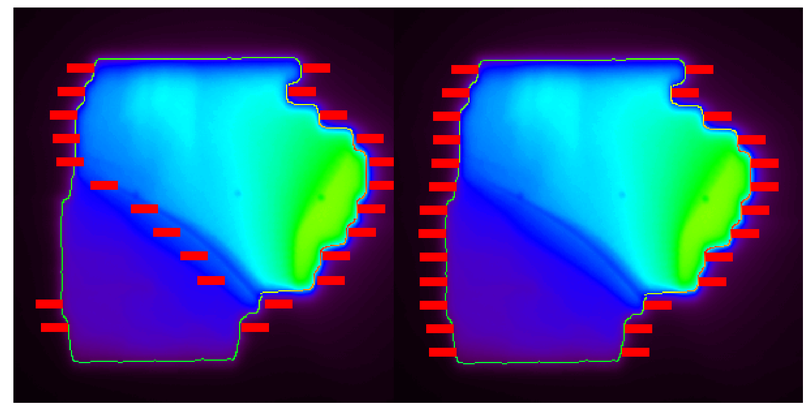


Fig 2: Difficulties in detecting leaf positions.
Left: 50% profile dose leaf detection after image correction.
Right: Canny edge detection is successful but has higher uncertainties (see Fig 5).

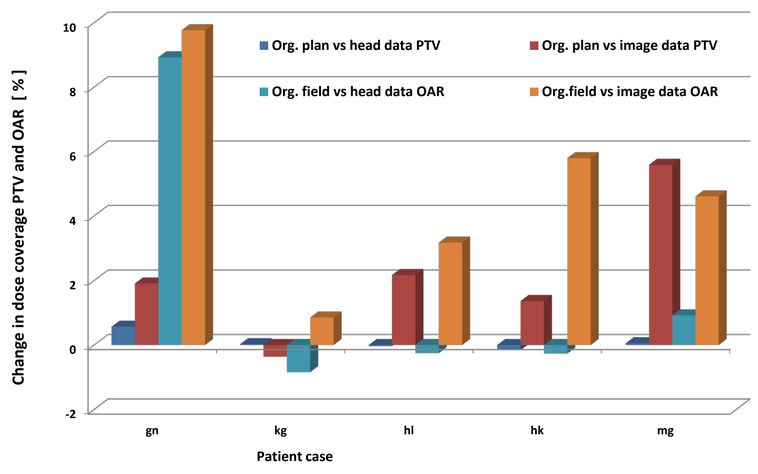


Fig 3: Effect on PTV and main OAR for the 5 cases under evaluation.

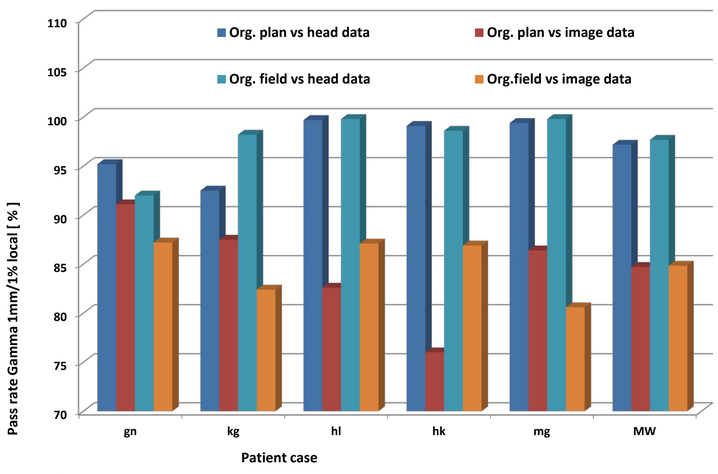


Fig 4: Effect on pass rate for Gamma (1mm/1% max). EPID dose is always worse.

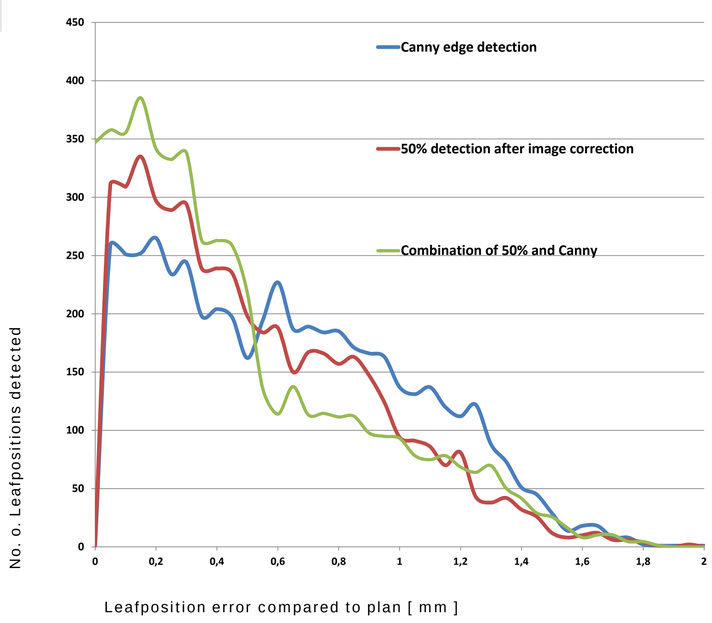


Fig 5: Typical histogram of leaf position errors found for patient gn. Combination method performs best.

Results:

Measuring exit doses with the EPID was a simple task and could be done for all coplanar field sets. The software tool made it simple to extract all needed parameter from the files and images resulting in 2 new DICOM plan files. The combined leaf detection method for the EPID images was beneficial (Fig 5). Dose recalculation was done by just importing the new plan files to Raystation. Comparing the original dose distribution (OD) to the machine file based one (RD) showed almost no difference at all (< 0.7%), as MU and leaf position differences where quite small. MLC positions derived from EPID images show much larger differences even with the special leaf detection algorithm used. Here detection uncertainties, EPID positioning and the resulting image resolution do play a major role as well. This resulted in in noticeable differences in the dose gradients regions. Absolute dose differences where below 2.0%. The evaluation of PTV and main OAR for the 5 patient cases show larger differences. This is of course related to shape and size of the volumes (Fig 3). Pass rates of a Gamma evaluation show the same tendency (Fig 4).

Conclusion:

Recalculating doses based on EPID (ED) and machine based parameters (RD) is a possible way for QA in an adaptive treatment approach as it does not need extra machine time. As QA parameters are taken from information that is available but not used or that can be easily generated, it does not complicate the procedure of adaptive radio therapy relevantly. Results are as expected quite good for the machine file approach (RD) while higher discrepancies were found using EPID data (ED). Main problem we face here is that especially for the machine file based version, we do not have full independent data sources. So the authors would prefer the EPID image based method even though effort and uncertainties are a little higher.

Literature:

<1>: Haering P; Schwahofer A; Lang C; Rhein B: Reconstruction of portal images from IMRT fields for patient setup verification. In: IFMBE Proceedings of the World Congress on Medical Physics and Biomedical Engineering 2009, Munich, Germany, Vol. 25/I. Hrsg.: Dössel O., Schlegel W.C. Springer, Heidelberg, (2009) 389-391.

<2>: Canny, J. F (1986) "A computational approach to edge detection", IEEE Transaction on Pattern Analysis and Machine Intelligence, 8, 679-714.