therapy and radiosurgery.
Materials and Methods: The Beam Modulator consists of two sets of 40 leaves, each projecting to 4 mm at isocenter to give a 16 cm maximum field length. Each leaf can travel along the whole of the 22 cm maximum field width. The leaves replace the lower jaws of the linear accelerator and the whole field size is modulatable for IMRT. Film measurements were made on square and rectangular fields ranging from 2 x 2 cm up to the maximum field size, as well as selected shaped fields. Beam data has also been measured in order to design and validate models of the MLC on the ADAC Pinnacle3 treatment planning system.
Results and Discussion: For a 6 MV beam, 90 cm SSD and 10 cm depth in solid water, the 20-80% penumbral width along the leaf direction was 4 mm for the 2 x 2 field. The corresponding width perpendicular to the leaf direction was 3 mm. Further results including penumbral widths for larger field sizes, light/radiation field congruence, intra- and inter-leaf transmission and single-leaf dose profiles will be presented, in addition to the modeling of the Beam Modulator on Pinnacle3. Implications of the results for IMRT and stereotactic radiotherapy and radiosurgery beam delivery will be discussed.

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Minimizing field components for delivering of intensity-modulated radiotherapy step-and-shoot beam sequences

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In case of a long verification and overhead time of the multileaf-collimator, minimizing number of field components is equal to minimizing the treatment time. Therefore it is of practically interest to decompose clinical intensity maps into ensembles of field components with minimal field number.
A procedure is developed for minimizing number of field components for delivering intensity modulated radiotherapy following the step-and-shoot approach with multileaf collimators. The proposed procedure results in all cases in decompositions with fewest possible segments. The methodology leads to mathematically provable results. Only clinically relevant intensity maps, which were used in patient treatments at German Cancer Research Center, were investigated (head-and-neck cases, prostate cases). The numerical effort of the procedure is low. In principle it is possible to decompose all intensity maps without using a computer. Compared to the leaf sweep procedure the minimal field number is up to 50% lower for intensity maps calculated with KonRad inverse planning program. In most cases it is possible to minimize the beam-on time and the number of the segments at the same time. The statistical properties of the minimal solutions, like distribution of beam weights or intensity values, are investigated. Additional constraints like hardware constraints or tongue-and-groove constraints can be taken into account.

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Multi-margin optimization with daily selection (MMODS) for image-guided radiotherapy

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Purpose: A method is presented for fraction-specific margin reduction, utilizing on-board 3D images without need for contouring, deformable fusion, or re-optimization. The process of multi-margin optimization with daily selection (MMODS) differs from common IMRT planning in that multiple plans are optimized and approved, typically with a range of margins, instead of a single plan. On-board images (eg CT) acquired before each fraction are used to select an available plan best suiting the patient's daily anatomy.
Materials and Methods: This study was conducted retrospectively using a series of 17 daily CTs acquired during a prostate treatment. The prostate was identified as the CTV in a first "planning image" and PTVs were created for margins of 3, 5, 7.5, and 10mm. The bladder and rectum were identified as sensitive structures. IMRT optimizations were generated for these four PTVs.
The 16 other CTs were used as fraction images and were aligned to bony-anatomy using automatic fusion. The PTV contours were overlayed and a MMODS plan was selected to cover the prostate in each daily position. Dose was accumulated for the 17 days, with both a standard margin of 10 mm, and the daily-selected MMODS margins.
Results: The table compares the doses to the rectum, bladder, and prostate for a) the planned delivery, b) the delivery accumulated over 16 days using a 10 mm PTV margin, and c) the accumulated delivery with daily selection of a MMODS plan.
By only using margins necessary for each fraction, MMODS significantly reduces dose to the bladder and rectum. Only 1 fraction needed the 10 mm margin; with 8 uses of the 3 mm margin, and 7 of the 5 mm margin. Smaller-margin MMODS plans become even more feasible by using patient repositioning instead of larger margins to account for deformations and displacements.

Min	Max	Mean	Stdev	
3	78	54	20	Rectum, planned
2	79	56	19	Rectum, accum
2	79	49	20	Rectum, MMODS
23	78	61	15	Bladder, planned
7	79	60	16	Bladder, accum
6	78	52	18	Bladder, MMODS
76	78	78	1	Prostate, CTV
69	79	77	1	Prostate, PTV
73	80	78	1	Prostate, accum
69	80	78	1	Prostate, MMODS

Conclusions:
MMODS allows for fraction-specific margin reduction, using daily fraction images without need for contouring or re-planning. Results show reduced sensitive structure dose while maintaining target dose. Target-based patient repositioning can further benefit MMODS, as can more skillful creation of the MMODS plans.

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Evaluation of the effect of geometric uncertainties on IMRT plans for head and neck treatments

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Purpose: To evaluate the efficacy of the IMRT treatment of head and neck tumors by studying the actual effect of geometric treatment inaccuracies during treatment, using a newly developed tool to include these deviations in the dose calculation (PLATO External Beam, Nucletron B.V., the Netherlands, work in progress version).
Materials and methods: Eight cases of IMRT treatments of the head and neck region were considered, each case treated with 30 fractions. All plans were designed with 7 equally spaced beams. The target dose was 66 Gy. The constraints during the IMRT optimization (PLATO Inverse Treatment Planning) aimed at saving the parotid glands as much as possible.
The treatment planning system included the option of recalculation of the dose for a given number of fractions with a simulated setup deviation per fraction. The total dose is then obtained by computing the average dose distribution over the number of fractions.
The statistics of the deviations for this study were obtained from an earlier portal imaging study. Standard deviations (SDs) of random translations were 1.2 mm, 1.6 mm and 1.8 mm in the left-right, dorsal-ventral and cranial-caudal direction, respectively. For random rotations these values were estimated to be 1 degree around the 3 main axis. Systematic deviations of the translations of each case were randomly sampled from distributions with the same SDs as the distributions of the random deviations. Deviations were generated with a Monte-Carlo technique, using these statistics. The cases were calculated one time with a "static" plan, i.e. without any deviations and 5 times with a different systematic deviation and additional random deviations for 30 fractions, yielding "dynamic plans".
Results were analyzed in terms of the mean dose to the CTV, the PTV and the NTCP of the parotid glands.
Results : The mean dose to the CTV and the PTV in the "dynamic plans" for these cases hardly changed with respect to the original "static plan" (deviations < 1.5 %). The NTCPs of the parotid glands changed considerably from plan to plan (range: 9.3% to -4.2%, mean 0.3 %, SD 3.8 %), over all the cases.
Conclusion: The current treatment ensures a sufficient dose to the CTV. The changing NTCPs of the parotid glands indicate that the effect of geometric deviations should be taken into account during the planning. Ongoing investigation includes a reduction of the PTV margins, in view of the negligible effect of the deviations on the PTV.