High-resolution CMOS detector array for robotic SRS treatment plan verification

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Objective

Robotic stereotactic radiosurgery (SRS) is able to deliver spatially precise, very small dose distributions. To verify these complex treatment plans a 2D dose measurement with a sufficient resolution has to be performed.
For this purpose, we have examined the usability of the IBA myQA SRS array which is based on a CMOS technology as it offers a resolution of 0.4 mm with no pixel spacing.

Methods

I. Adding X-ray dense markers (fiducials) to the myQA SRS array to be able to track its position with the Cyberknife (Accuray Inc.) system
   - Testing different fiducial configurations to achieve lowest positioning uncertainty and highest flexibility for treatment plan verification.

II. Investigating the array characteristics: angular dependence / dependence on the SAD
   - Adding the possibility to correct for these effects to the evaluation software myQA (IBA)

III. Measurements of 14 typical patient treatment plans
   - Performing a gamma index analysis with 1mm/3% criterion and 20% low dose threshold comparing the measured data with the data provided by TPS were performed (see Fig. 2)
   - Comparing the results to the results from an IC array which has been used for treatment plan QA in our clinic so far

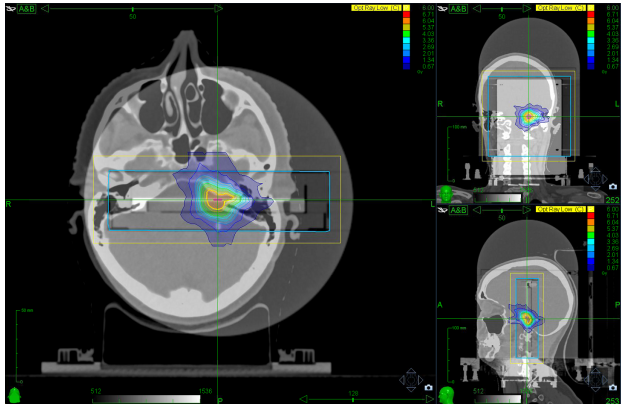

Fig. 1: *Registration of a patient treatment plan on the myQA SRS*

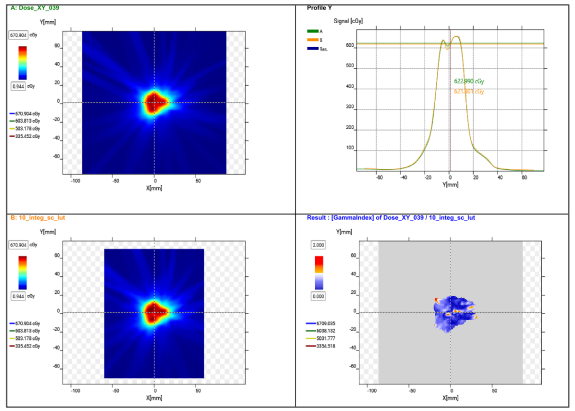

Fig. 2: *Evaluation in the myQA software; upper left: TPS dose, lower left: measured dose, upper right: profiles, lower right: Gamma Index distribution*

Results

- Best positioning results: Additional plate added on top of the array containing eight fiducials and one fiducial below the active area (see Fig. 3)
- Angular dependence of the myQA SRS resulting in deviations in the measured values of up to 20%; SAD dependence 1-2%

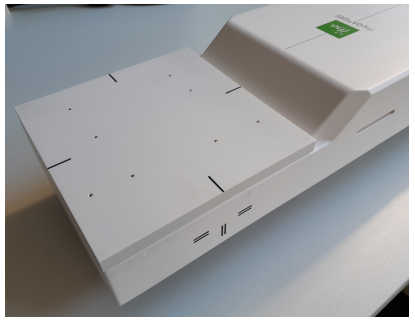

Fig. 3: *myQA SRS array with the fiducial plate added on top of it*

- Without any correction: Deviation of the measured dose distributions from the TPS data with 22-78% gamma pass rate
- Applying the corrections in the myQA software: Significantly improved results with >95% pass rate for nearly all plans
- IC array: pass rates of only 60% in some cases (see Table 1)

Table 1: *Parameters of the patient treatment plans applied and gamma pass rates (1mm/3% criterion) of the comparison of the IC array used in routine today (grey) / the IBA myQA SRS array (green) with the TPS data.*

				Gamma Pass Rate (1mm/3%)	
Indication	**Prescription (Isodose)**	**Collimator (Ø/mm)**	**No. Beams**	**IC array**	**myQA SRS**
Acoustic neuroma	3 x 6 Gy (80%)	Fix (7,5; 12,5)	184	96,4%	95,7%
Arteriovenous malformation	1 x 17 Gy (65%)	Fix (5)	103	100,0%	100,0%
Brain metastesis	6 x 5 Gy (70%)	Iris (15; 20; 25)	126	95,9%	98,5%
Brain metastesis	6 x 5 Gy (70%)	Iris (10; 15; 20; 25)	131	58,4%	97,3%
Brain metastesis	5 x 5 Gy (70%)	Iris (15; 20; 25; 30)	130	63,0%	97,4%
Brain metastesis	6 x 5 Gy (70%)	Fix (7,5)	62	100,0%	100,0%
Brain stem metastesis	6 x 5 Gy (70%)	Fix (12,5)	82	93,0%	97,7%
Brain stem metastesis	6 x 5 Gy (70%)	Fix (12,5)	71	98,0%	100,0%
Resection cavity	7 x 5 Gy (70%)	Iris (20; 25; 30; 35)	105	61,6%	97,4%
Resection cavity	7 x 5 Gy (70%)	Iris (20; 25; 30; 35)	105	61,6%	98,5%
Resection cavity	7 x 5 Gy (70%)	MLC	15	53,1%	98,9%
Resection cavity	7 x 5 Gy (70%)	MLC	48	52,5%	100,0%
Trigeminal neuralgia	1 x 60 Gy (80%)	Fix (5)	200	100%	99,7%
Vertebral body metastesis	4 x 6,5 Gy (70%)	MLC	115	92,8%	93,10%

Conclusion

With angular and SAD corrections applied, the myQA SRS array provided very good results with significantly higher agreement with the TPS data than the IC array. With the fiducials added, it is therefore well suited for the verification of CK SRS plans.

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