Dosimetric accuracy of CyberKnife Stereotactic Radiosurgery for Perioptic lessions

KyoungJun Yoon[1], Chiyoung Jeong[2], Minjae Park[2], Youngnmoon Goh[2], Seongwoo Kim[2],

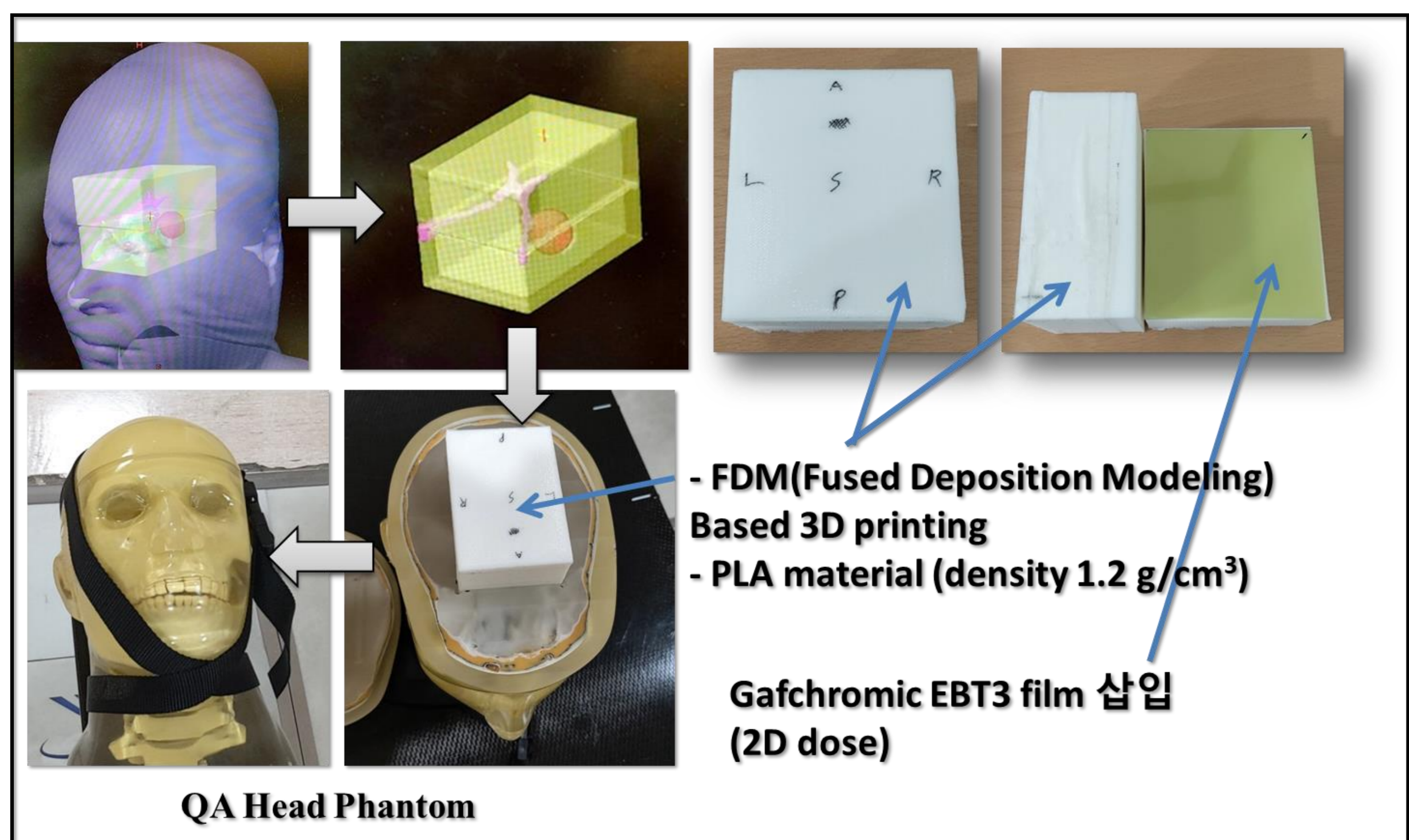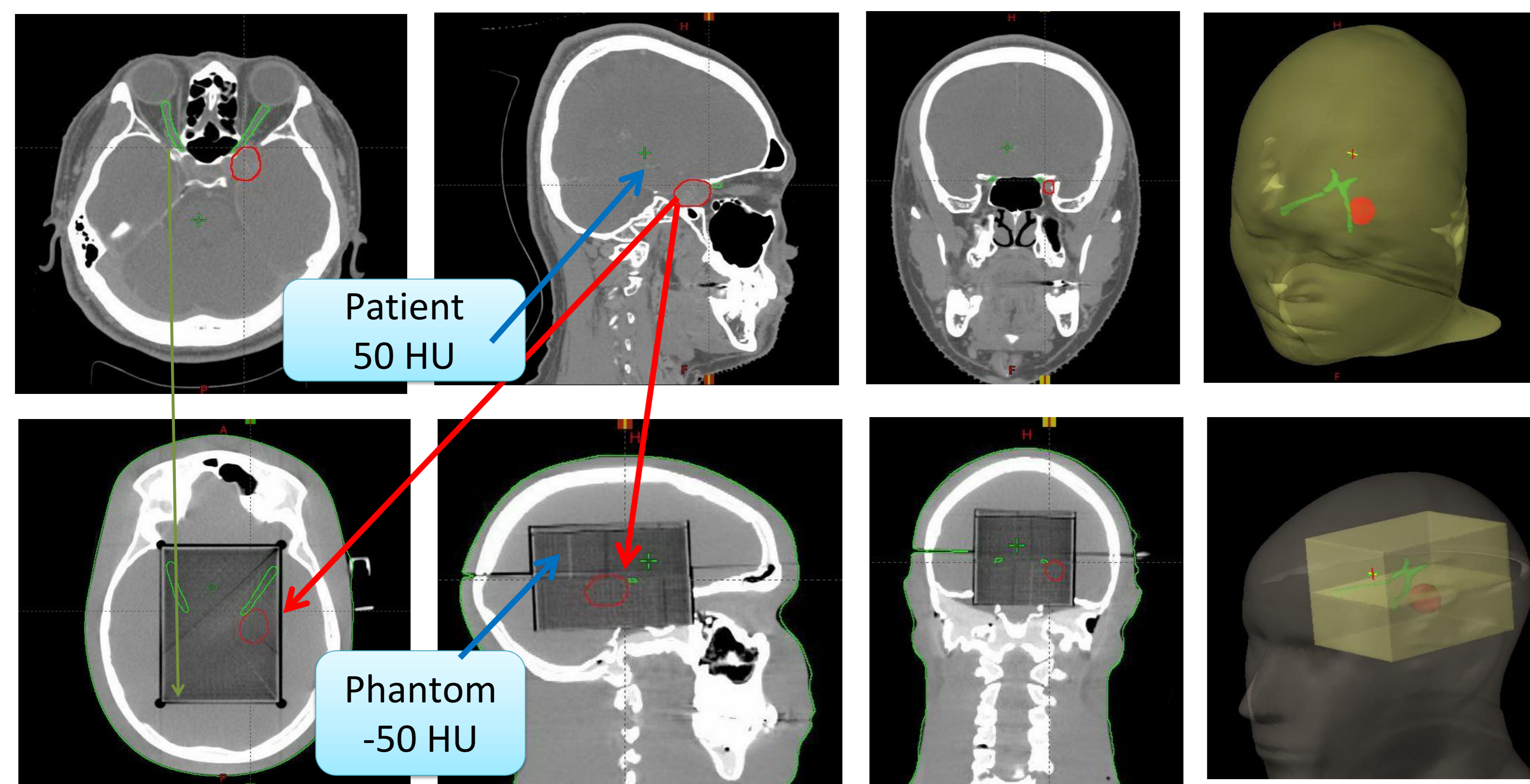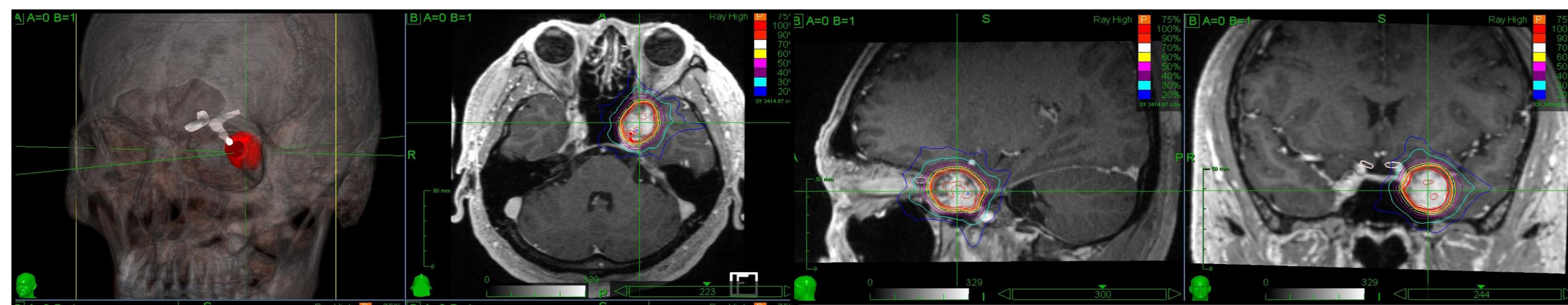Byungchul Cho[2], JungWon Kwak[2], Young Hyun Cho[3]

Department of [1]Radiosurgery Center, [2]Neurosurgery, and [3]Radiation Oncology, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Republic of Korea

Purpose

- This study aimed to evaluate the dosimetric accuracy of Cyberknife (CK) for benign perioptic tumor using patient specific QA head phantom.

Material and Methods

- Patient specific head phantoms was fabricated using a 3D-printer to be dosimetrically equivalent to actual target regions of benign perioptic tumor case treated via Cyberknife radiosurgery.

- Using the patient specific QA head phantom, film dosimetry was performed for Cyberknife beam delivery. The measured results were analyzed with the gamma passing rates (GPRs) of 2%/1 mm criteria, by comparing with the calculated dose via the ray-tracing algorithms of the MultiPlan Treatment Planning System (version 5.6).

- After moved rotating (1 degree) and translating (1-5mm) the couch table prior to beam delivery, we checked the 6D skull tracking accuracy according to the beam irradiation.

- Phantom QA plan was produced using the original CK contour set (target and optic nerve).
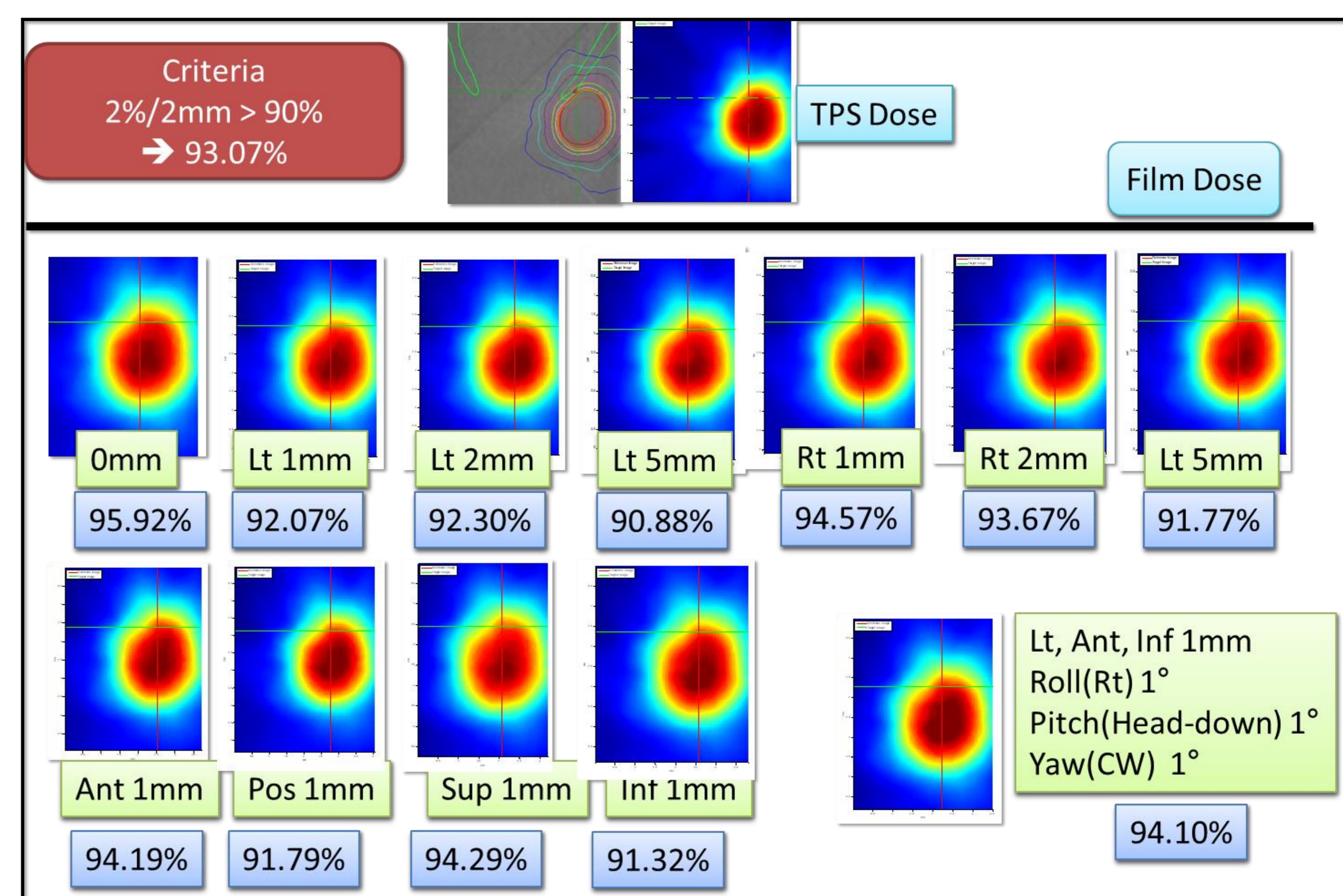

Patient 50 HU
Phantom -50 HU

- FDM(Fused Deposition Modeling) Based 3D printing
- PLA material (density 1.2 g/cm³)

Gafchromic EBT3 film 삽입 (2D dose)

QA Head Phantom

Beam delivery	Phantom shift	Film scan
Original	0 mm	1
Left	1mm, 2mm, 5mm	3
Right	1mm, 2mm, 5mm	3
ANT, POS, SUP, INF	2mm	4
Lt + Ant + Inf Roll(Rt) +Pitch (Head-Up) + Yaw (CW)	1mm 1°	1
		12
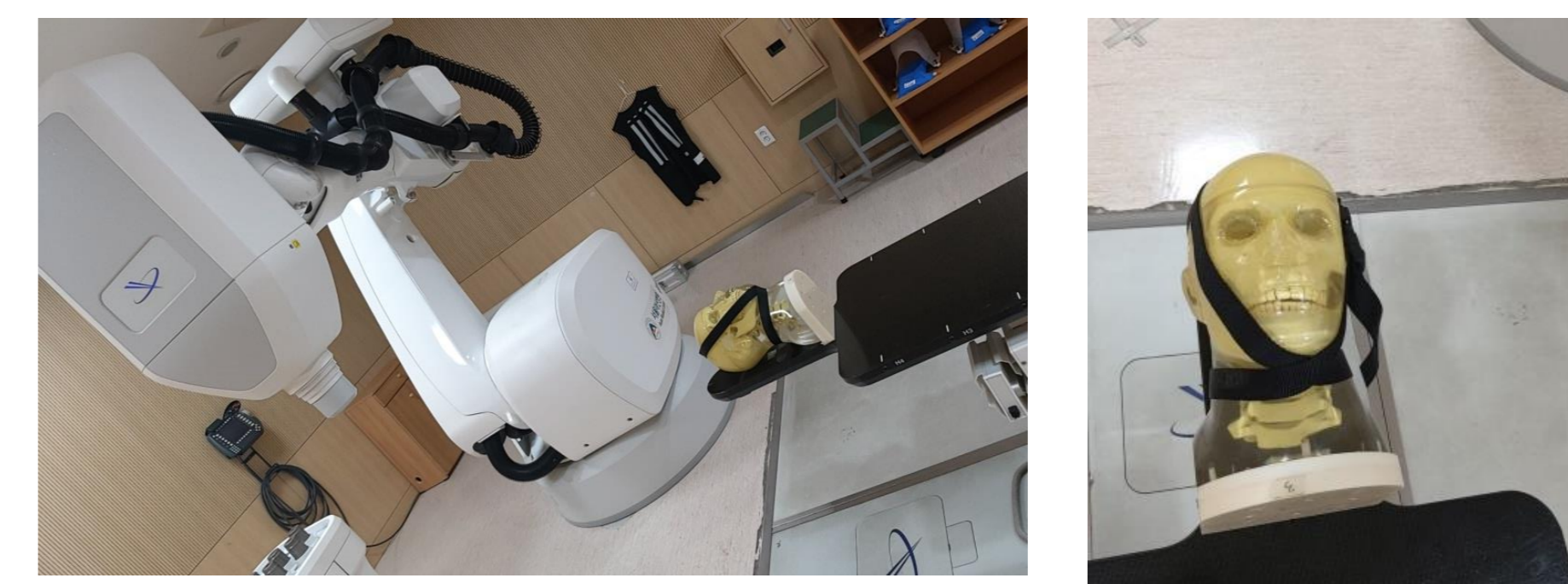
Results

- GPRs were greater than the acceptance criteria 80% (2%/1mm) and 90% (2%/2mm) for all film measurements with the patient specific QA head phantoms in CK perioptic tumor QAs.

- The difference between measured and calculated dose to the optic nerve in contact with the tumor was less than 3%.

			2%/2mm	2%/1mm	Dose difference(%)			
					vertical		horizontal	
			90%<	80%<	mean+SD	Optic Nerve	mean+SD	Optic Nerve
1	without Shift	0mm	95.92	88.83	0.82±1.84	<2%	0.16±2.69	<2%
5	Lt	1mm	92.07	81.13	0.53±2.11	<2%	1.34±2.92	<2%
6	Lt	2mm	92.30	83.10	0.19±2.37	<3%	0.34±3.72	<3%
7	Lt	5mm	90.88	80.56	0.08±2.35	<3%	0.9±3.51	<3%
2	RT	1mm	94.57	87.20	0.03±1.92	<2%	0.9±2.72	<2%
3	RT	2mm	93.67	85.26	0.26±2.14	<3%	0.1±3.22	<3%
4	RT	5mm	91.77	83.63	0.03±1.83	<2%	0.81±3.24	<2%
8	ANT	2mm	94.19	83.99	0.93±1.54	<2%	1.86±2.77	<2%
9	POS	2mm	91.79	84.69	0.88±1.49	<2%	1.09±2.55	<2%
10	SUP	2mm	94.29	82.40	0.19±2.18	<3%	0.79±4.11	<3%
11	INF	2mm	91.32	81.31	0.67±1.61	<2%	2.19±2.67	<2%
12	Lt,Ant,Inf, Roll,Pitch,Yaw	1mm, 1degree	94.10	84.04	1.24±1.24	<2%	2.01±2.58	<2%
	Average		93.07	83.85	<3%		<3%	

Criteria 2%/2mm > 90% → 93.07%

TPS Dose

Film Dose

0mm	Lt 1mm	Lt 2mm	Lt 5mm	Rt 1mm	Rt 2mm	Lt 5mm
95.92%	92.07%	92.30%	90.88%	94.57%	93.67%	91.77%

Ant 1mm	Pos 1mm	Sup 1mm	Int 1mm	Lt, Ant, Inf 1mm Roll(Rt) 1° Pitch(Head-down) 1° Yaw(CW) 1°
94.19%	91.79%	94.29%	91.32%	94.10%

Conclusion

- Dosimetric verification with patient-specific head phantoms could be successfully implemented as the evaluation method for CK perioptic tumor radiosurgery delivery.