Feasibility of frameless and maskless stereotactic cerebral radiotherapy with AlignRT InBore guidance on HALCYON v3.0 preliminary results

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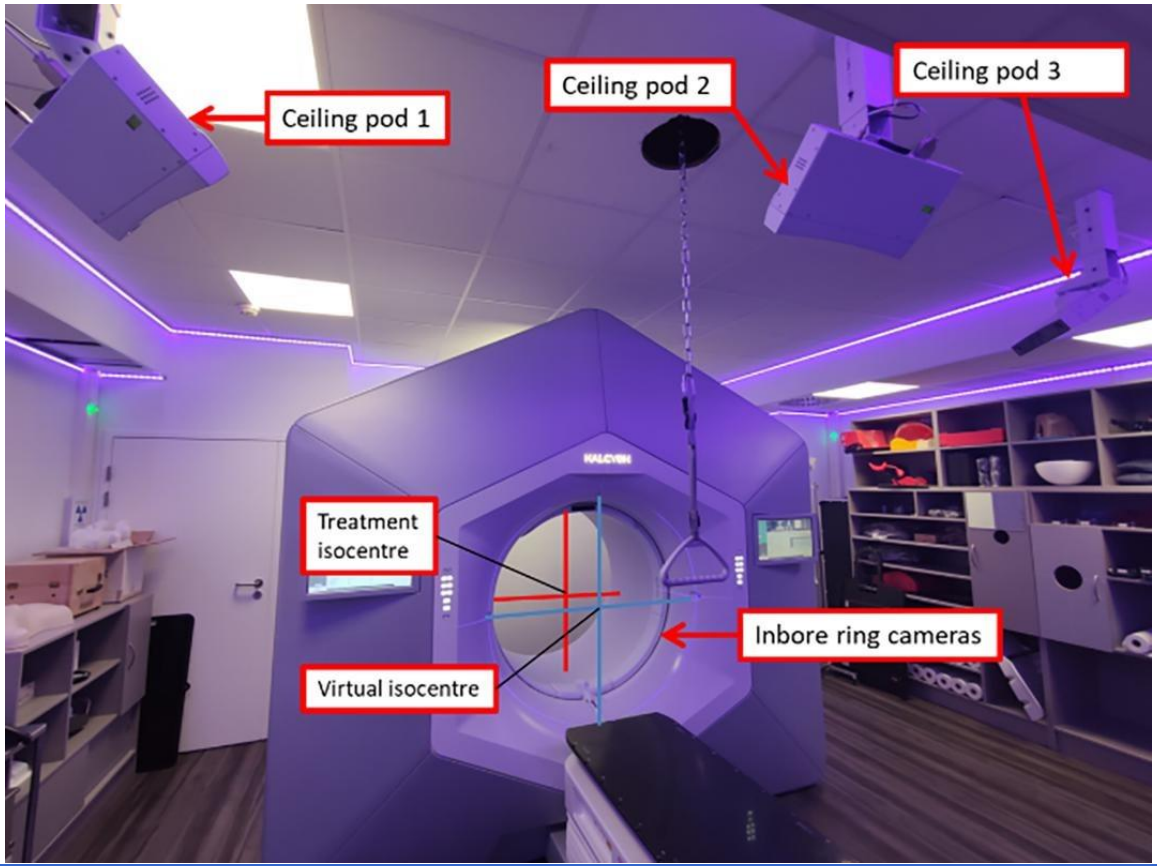
Sena YOSSI, Nicolas BARBET, Mustapha KHODRI

ORLAM Mâcon – Lyon - Villeurbanne - FRANCE



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Conflicts and Disclosure

- I have received sponsorship from Vision RT in order to attend this symposium
- Orlam Group works with Vision RT to develop a SGRT solution for Halcyon
- The views expressed in this presentation are my own and do not reflect Vision RT's official position

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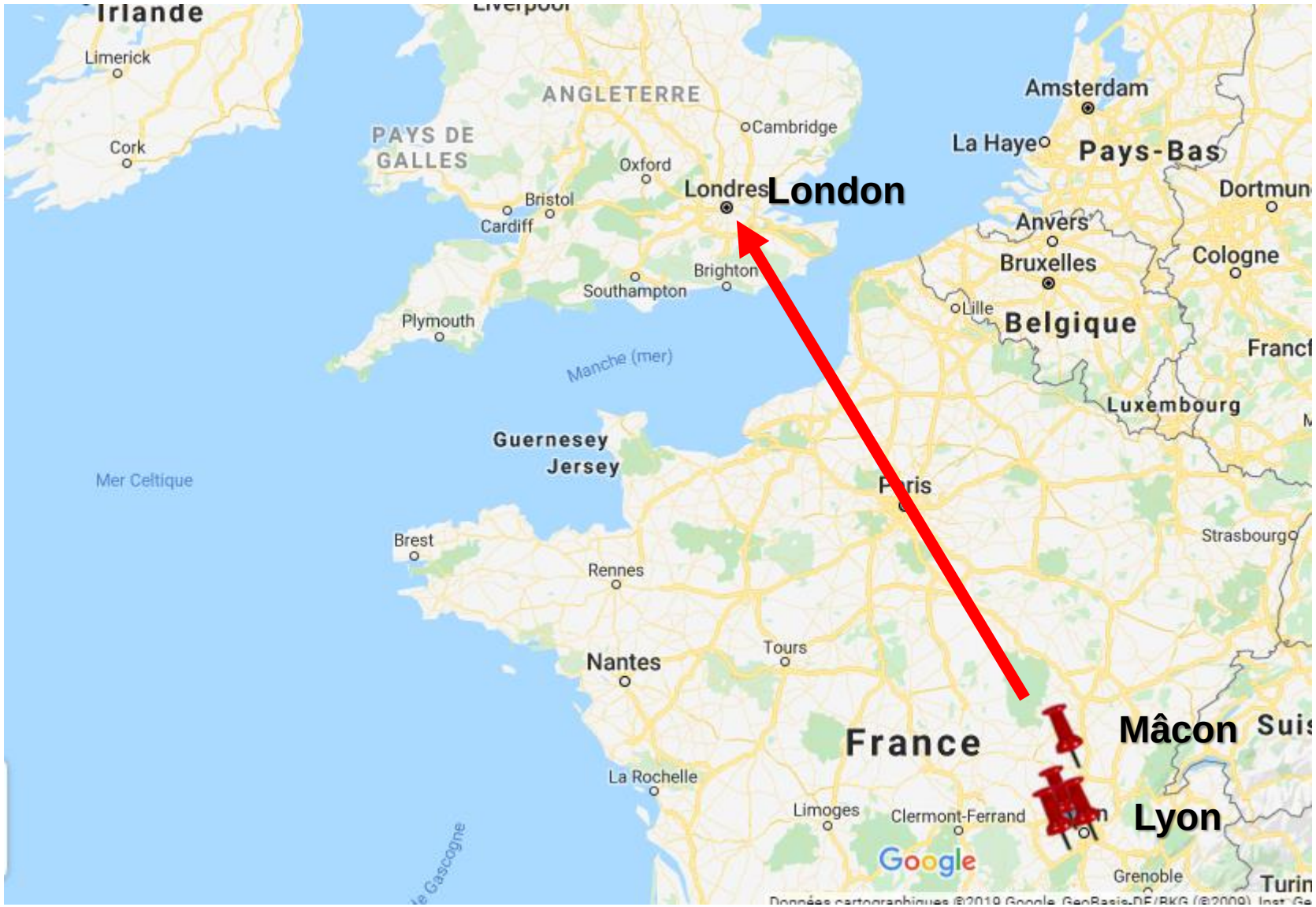
ORLAM's centers



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ORLAM's technical platform

2017

Clinac 2100 | Clinac 2100 | Clinac 2100 | Clinac 2100 | Clinac 2100 | Clinac 2100 | Clinac 2100 | Siemens | Siemens

2018-2019

Clinac 2100 | Clinac 2100 | Halcyon | Halcyon | Halcyon | Halcyon | Halcyon | Halcyon | EDGE

Machines «matched»

Machines «matched»

2023

1er patient 15 juin 2023

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Case study

- Claustrophobic patient with 5 brain metastases
- Stereotactic radiotherapy has been selected, with 3 fractions of 11 Gy for each metastasis.
- Strongly refusing to wear a thermoformed mask, even when open, due to trauma from a previous treatment with a mask.

Context

ELSEVIER

Int. J. Radiation Oncology Biol. Phys., Vol. 45, No. 1, pp. 205–213, 1999

0360-3016/99/$–see front matter

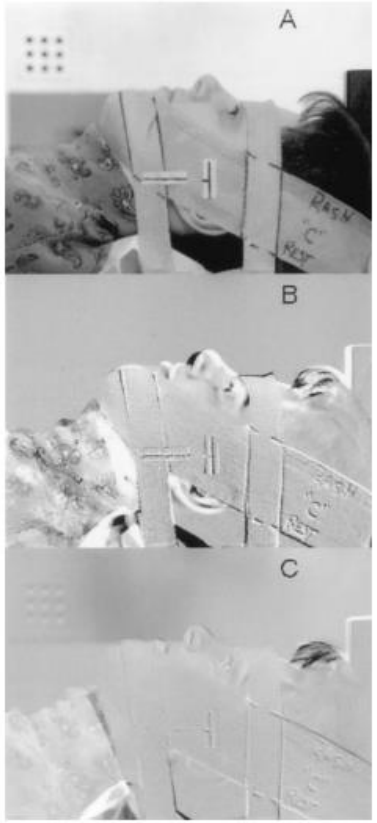
PII S0360-3016(99)00182-0

PHYSICS CONTRIBUTION

INITIAL CLINICAL EXPERIENCE WITH A VIDEO-BASED PATIENT POSITIONING SYSTEM

L. S. JOHNSON, PH.D.,* B. D. MILLIKEN, PH.D.,* S. W. HADLEY, B.S.,* C. A. PELIZZARI, PH.D.,* D. J. HARAF, M.D.,* AND G. T. Y. CHEN, PH.D.*

*Department of Radiation and Cellular Oncology, The University of Chicago, Chicago, IL



JOHNSON et al., 1999: Video-based patient positioning system was shown to reduce setup errors to within 1 to 3 mm in head and neck patients

Context

Frame-less and mask-less cranial stereotactic radiosurgery: a feasibility study

Laura I Cerviño[1], Todd Pawlicki[1], Joshua D Lawson[1] and Steve B Jiang[1]

Published 12 March 2010 • 2010 Institute of Physics and Engineering in Medicine

Physics in Medicine & Biology, Volume 55, Number 7

Citation Laura I Cerviño *et al* 2010 *Phys. Med. Biol.* **55** 1863

DOI 10.1088/0031-9155/55/7/005

Figure 4. A volunteer staying still during the 20 min monitoring time.

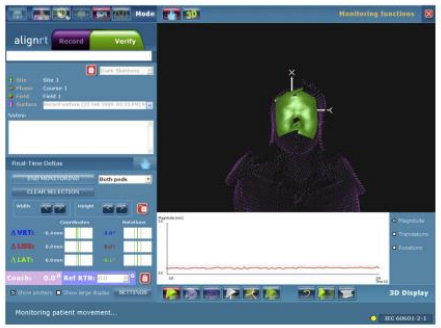


Figure 2. Surface imaging software showing the region of interest on a volunteer.

PAPER

Towards frameless maskless SRS through real-time 6DoF robotic motion compensation

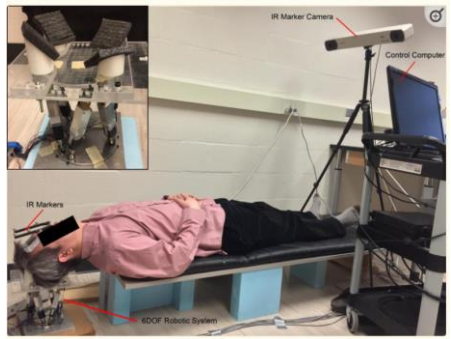
Andrew H Belcher[1], Xinmin Liu[1], Steven Chmura[1], Kamil Yenice[1] and Rodney D Wiersma[2,1]

Published 13 November 2017 • © 2017 Institute of Physics and Engineering in Medicine

Physics in Medicine & Biology, Volume 62, Number 23

Citation Andrew H Belcher *et al* 2017 *Phys. Med. Biol.* **62** 9054

DOI 10.1088/1361-6560/aa93d2



Cranial stereotactic treatment without a mask

- Frame-less and mask-less cranial stereotactic radiosurgery: a feasibility study (I Cerviño 2012)
  - Tests on volunteers, Monitoring with SGRT for 20 minutes: intra-fraction movements below 1mm/°

- Toward Frameless Maskless SRS Through Real-Time 6DOF Robotic Motion Compensation (Belcher 2017)
  - Tests on volunteers and use of a 6D robot to compensate for intra-surveillance movements: intra-fraction movements below 0.5mm/°

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Context

Received: 4 January 2017 | Revised: 24 February 2017 | Accepted: 5 April 2017
DOI: 10.1002/acm2.12101

RADIATION ONCOLOGY PHYSICS

WILEY

Cost-effective immobilization for whole brain radiation therapy

Ashley E. Rubinstein[1,2] | W. Scott Ingram[1,2] | Brian M. Anderson[1,2] | Skylar S. Gay[1] | Xenia J. Fave[1,2] | Rachel B. Ger[1,2] | Rachel E. McCarroll[1,2] | Constance A. Owens[1,2] | Tucker J. Netherton[1,2] | Kelly D. Kisling[1,2] | Laurence E. Court[1,2] | Jinzhong Yang[1,2] | Yuting Li[1,2] | Joonsang Lee[1] | Dennis S. Mackin[1] | Carlos E. Cardenas[1,2]

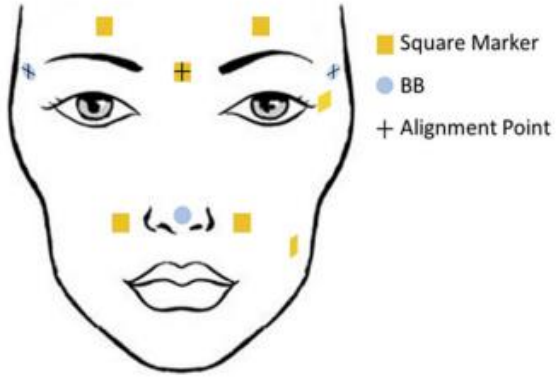

FIG. 1. Illustration of marker and BB locations. The square marker and BBs with crosses were used for setup.

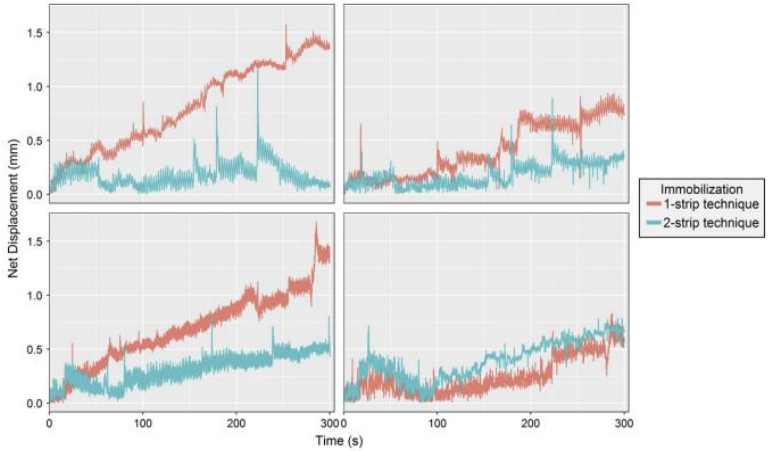

FIG. 4. Comparison of the intra-fraction motion for two immobilization techniques. The data shown are for two volunteers using the video from the lateral and anterior camera. The Euclidean (net) displacement was calculated and plotted for each frame of the video. Graphs for all volunteers and all camera views are available in the Supplementary Data.

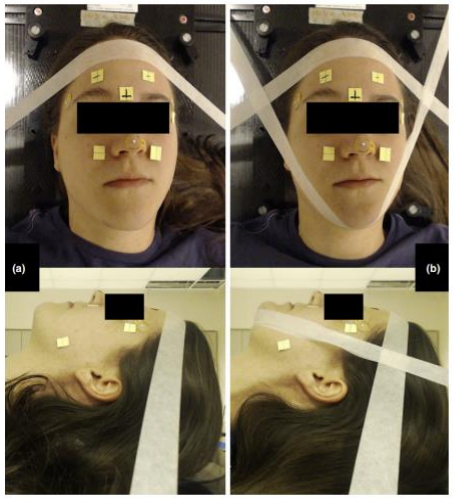

FIG 2. Volunteer setup. Volunteers were immobilized using a 1-strip (panel a) and 2-strip technique (panel b). Anterior (above) and lateral (below) photographs and videos were taken of the volunteers to assess inter- and intra-fractional reproducibility.

➔ 2 adhesive bands: intrafractional movements less than 1mm.

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Context

- Treated 5 patients without a mask on the TrueBeam Edge with the ability to automatically stop the beam when values are out of tolerance.
- Staff already has experience with maskless treatments

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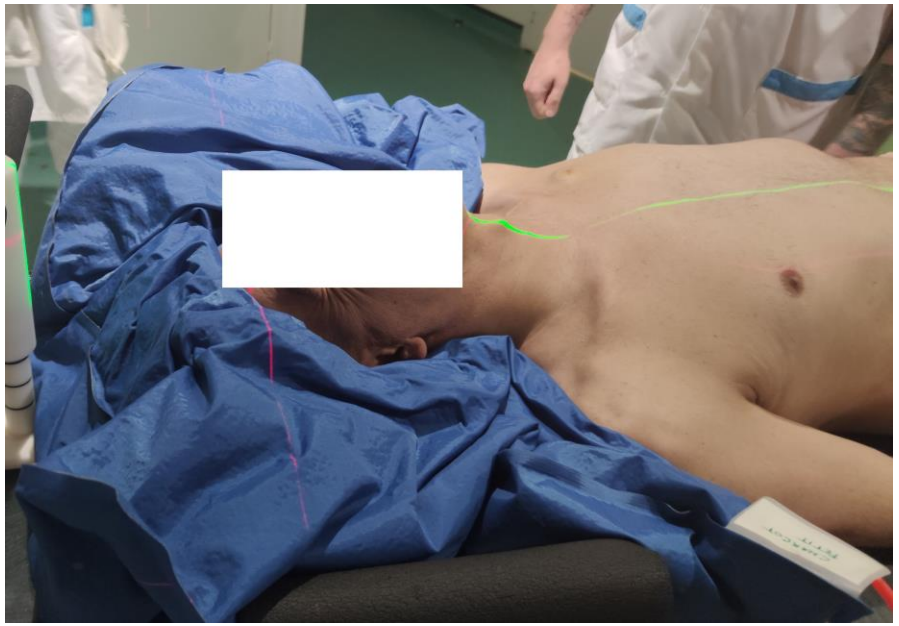
Case study

- A maskless dosimetric CT scan was performed with head and neck immobilization using a bead mattress system.
- The two adhesive bands are used only during the treatment.



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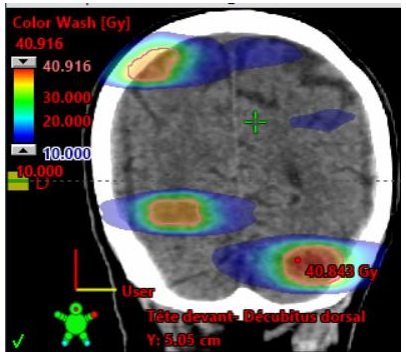
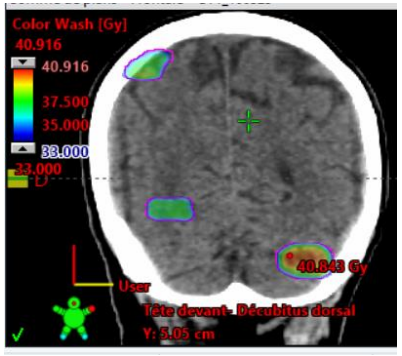
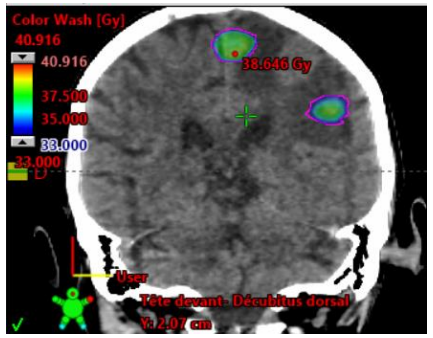
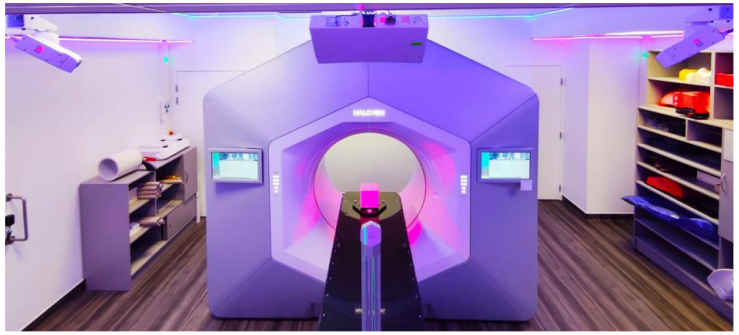
Methods

- The treatment was carried out on a HALCYON v3.0 accelerator.
- PTV = CTV + 2mm.
- Four treatment plans were implemented, utilizing 4 to 6 partial arcs of 6 MV FFF photons for VMAT.









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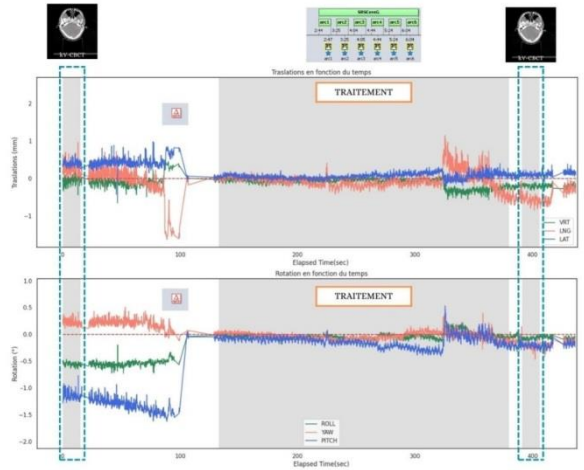
Methods

- ❑ The patient was repositioned using the AlignRT Inbore V7.2.
  ➔Rotation errors were corrected +++
- ❑ Cone-beam CT imaging was performed before and after each treatment.
- ❑ Continuous monitoring of patient movements during the session was conducted using the AlignRT Inbore V7.2.
- ❑ Tolerances of 1mm/1° were maintained, with manual intervention for deviations beyond the set tolerances.

Correction of rotation/translation errors



Methods

- The therapists position the two adhesive bands just before leaving the treatment room.

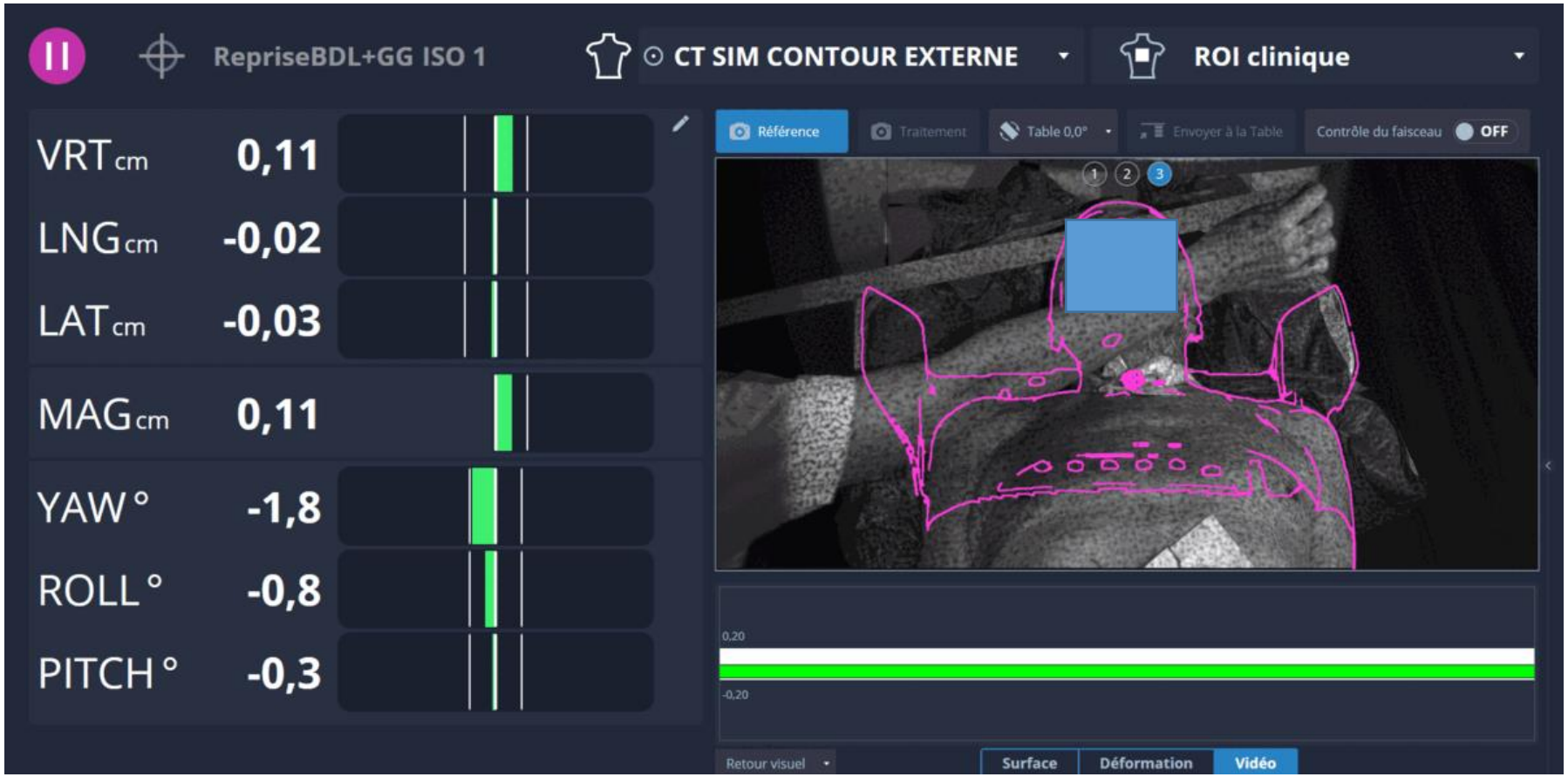


Image of a patient treated on the TrueBeam for illustration.

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Methods

- ❑ Analysis of 10 sessions due to the absence of end-of-treatment kV-CBCT for 2 sessions.
- ❑ Registration between kV-CBCT at the beginning of treatment and CT.
- ❑ Registration between kV-CBCT at the end of treatment and CT.

  ➔ Differences in 6 degrees of freedom between kV-CBCT at the beginning and end of treatment.

  ➔ Comparison between SGRT values and kV-CBCTs.

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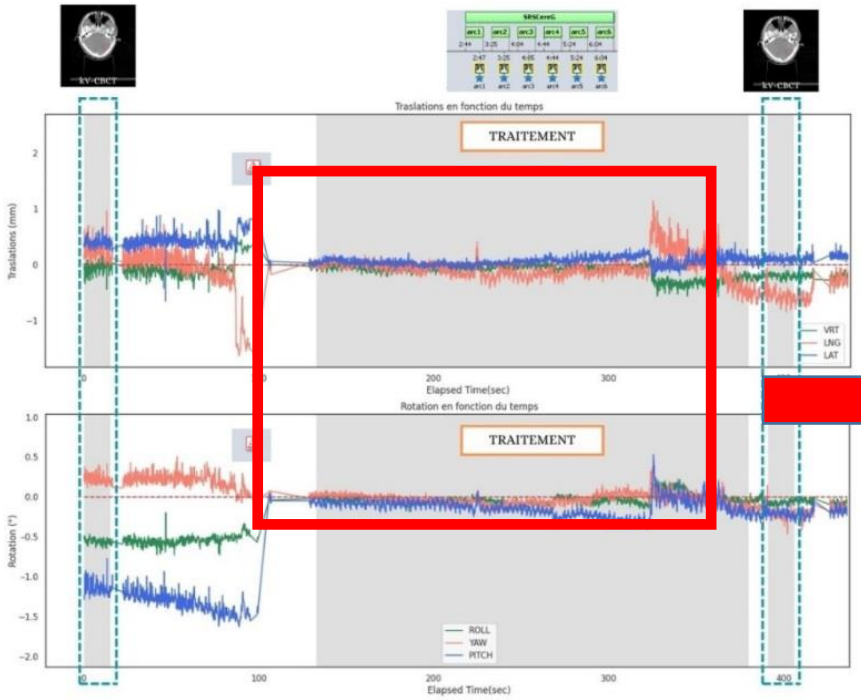
Results: during irradiation



Session number	VRT (mm)	LNG (mm)	LAT (mm)	ROLL (°)	YAW (°)	PITCH (°)
S1	0.1±0.1	0.6±0.3	0.0±0.1	-0.1±0.1	0.1±0.1	0.2±0.1
S2	-0.1±0.1	-0.1±0.2	0.1±0.1	-0.0±0.1	-0.0±0.1	-0.1±0.1
S3	-0.1±0.1	0.4±0.2	0.1±0.1	0.1±0.1	-0.1±0.1	0.5±0.1
S4	-0.4±0.3	-0.4±0.3	-0.2±0.1	0.5±0.3	-0.1±0.1	-0.6±0.3
S5	0.0±0.1	-0.0±0.2	-0.2±0.1	-0.1±0.1	-0.2±0.1	0.2±0.1
S6	0.0±0.1	-0.3±0.1	-0.3±0.1	-0.0±0.0	-0.2±0.1	0.0±0.1
S7	-0.2±0.1	-0.5±0.3	-0.4±0.2	0.1±0.1	-0.3±0.2	0.0±0.1
S8	0.9±0.4	-0.1±0.5	0.4±0.2	0.5±0.2	0.0±0.2	-0.8±0.5
S9	0.5±0.3	-0.9±0.5	-0.5±0.3	0.1±0.1	-0.4±0.2	-0.5±0.4
S10	0.3±0.2	0.0±0.2	0.2±0.2	0.3±0.2	0.0±0.1	-0.2±0.2

Average RTD (SGRT) values during the sessions

The average SGRT values observed during all sessions are below 1.5mm/°

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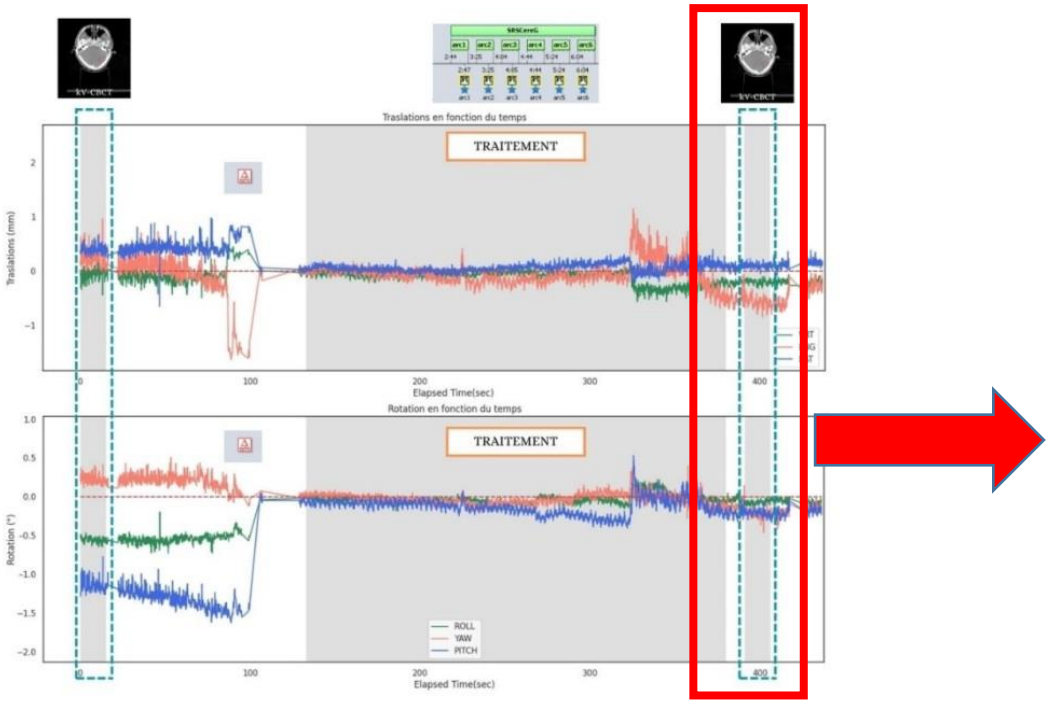
Results: kV-CBCT vs SGRT Comparison



	SGRT start/end	CBCT start/end	*p*
VRT (mm)	-0,13±0,45	-0.13±0.66	*1*
LNG (mm)	0,14±0,63	0.68±0.73	*0,027*
LAT (mm)	-0,23±0,81	-0.09±0.99	*0,65*
YAW (°)	0,9±0,38	0.41±0.52	*0,09*
ROLL (°)	-0,25±0,28	0.47±0.38	*0,07*
PITCH (°)	-0,39±0,63	0±0.68	*0,07*

Average differences in SGRT values during the CBCT at the initial/final of the 10 sessions.

- ❑ The differences between the initial kV-CBCT and the final kV-CBCT are less than 1mm/° in all directions except for the longitudinal direction .
- ❑ SGRT provides similar values compared to those of kV-CBCT

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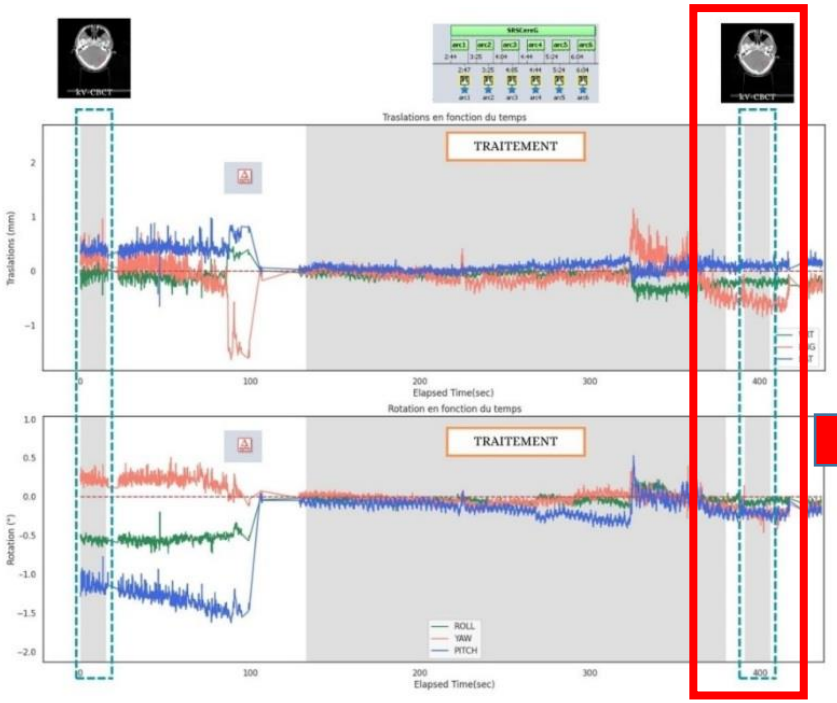
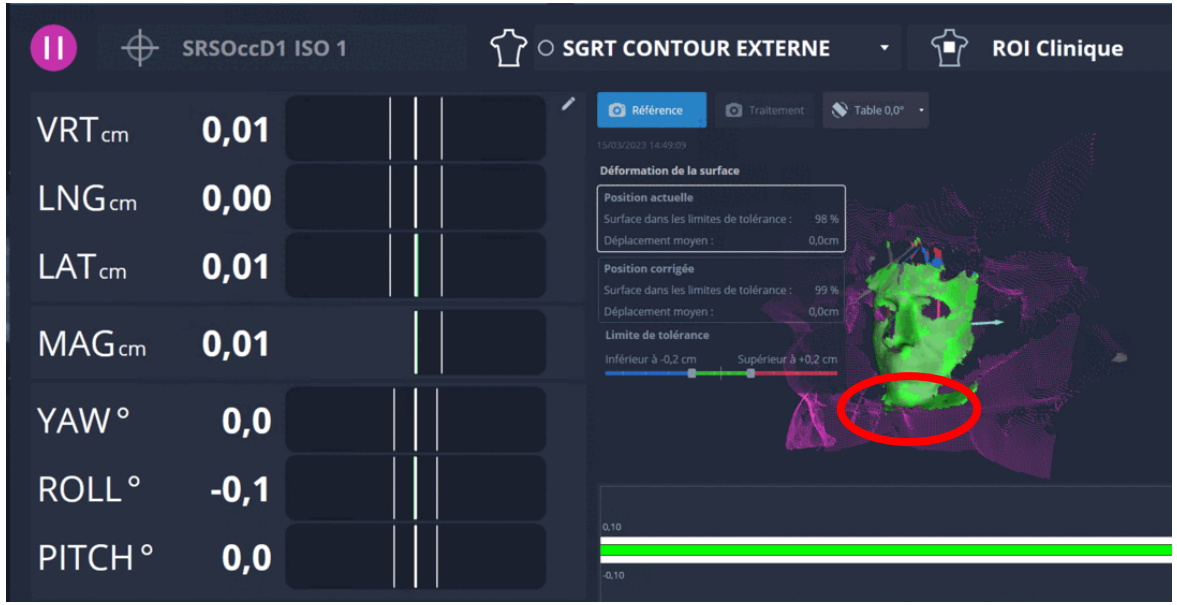
Wilcoxon Signed-rank Test for Paired Samples P-Value

Results: kV-CBCT vs SGRT Comparison





- ❑ The discrepancies in the longitudinal direction might be due to the patient slightly moving his chin.
- ❑ We are currently working to improve its stability.

Discussion

Advantages:

- ❑ Maskless treatments = ecological benefits +++
- ❑ Beneficial for claustrophobic patients

Limitations:

- ❑ The results of this study do not precisely establish the correspondence between SGRT values and irradiation because there is no connection between the two systems.
- ❑ Head immobilization restraint (chin) needs improvement for submillimetric precision.

Conclusion

- Stereotactic radiotherapy without immobilization mask, guided by AlignRT, appears feasible.
- Studies (cranial and head/neck) are ongoing in our centers to validate this treatment option.

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Thank you for your attention

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