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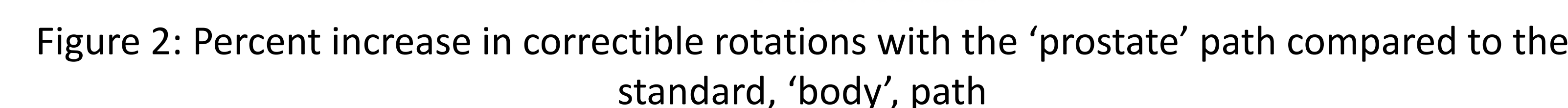
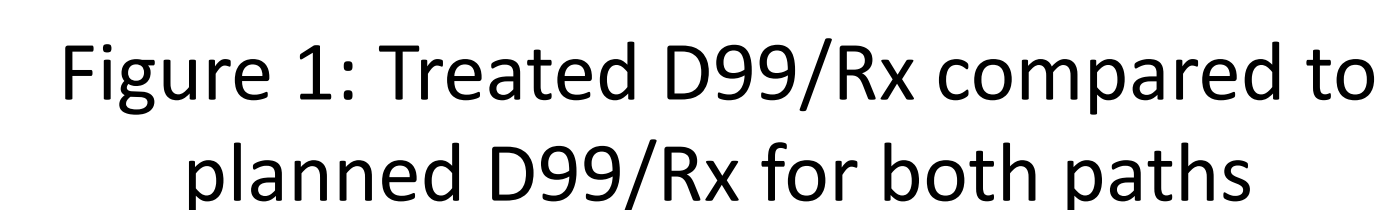
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- The CyberKnife system can adapt to target rotation during radiation therapy treatments
- Typically, Synchrony treatments are planned using the 'body' path allowing for rotational corrections up to ± 1.5 , ± 1.5 , ± 3.0 in roll, pitch and yaw
- Planning with the limited node 'prostate' path allows for rotational corrections up to ± 2.0 , ± 5.0 , ± 3.0 in roll, pitch and yaw
- Even with the higher correctible rotation threshold, many rotations may go uncorrected due to an imperfect fiducial implant which will not allow for the calculation of accurate rotational corrections (Fig. 3)

- CyberKnife log files were extracted for 70 previously treated liver patients planned with the standard 'body' path and treated with the Synchrony system
- The percent of observed rotations which are correctable using the 'body' and 'prostate' paths thresholds were compared (Fig. 2)
- Using the dose perturbation tool developed by Liu et al.¹, the change in D99/Rx for the GTV considering treatment delivery errors (such as uncorrectable rotations) was calculated for the two path sets (Fig. 1)




- Phantom dose measurements using Synchrony with the 'prostate' path agreed at 2%/2mm with rotations at the maximum threshold
- Treatment plans following the 'body' and 'prostate' path were equivalent in terms of target coverage, dose fall-off and dose to the organs at risk
- Use of the 'prostate' path was initially applied to a small cohort of patients. An example of the target rotations observed during treatment for one of these patients is shown in figure 4
- Planning protocols for Synchrony plans have been updated to include use of the 'prostate' path
- To improve the number of correctible rotations a 'feedback' form has been introduced to provide fiducial placement feedback to radiologists

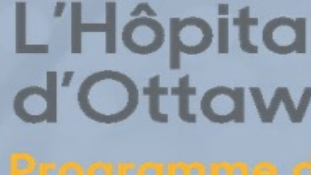


CyberKnife

Fiducial Implant Feedback Form



The Ottawa Hospital
Radiation Medicine Program



L'Hôpital d'Ottawa
Programme de Radio-Oncologie

Were changes made to plan due to fiducial placement? Yes ☐ No ☐

(if yes, select all that apply below):

Changes made to plan:	Margins increased to 7 mm
	Margins increased to 10 mm
	Prescription reduced
	Treatment moved off CyberKnife
	Patient delayed to implant additional fiducials
Other changes?	

Number of usable fiducials (3 required for rotations, > 3 ideal) <3 ☐ 3 ☐ >3 ☐

Software Warnings Present? Yes ☐ No ☐

(if yes, check all that apply below):

fiducials too far from target ☐

If too far, distance between fiducial and target center= mm (recommended max. distance = 50.00 mm)

Not enough fiducials to calculate rotations (<3) ☐

No three fiducials pass minimum angle (15°) test ☐

Number of fiducial pairs too close (< 2 cm) in patient 1 ☐ 2 ☐ >2 ☐

Number of fiducials too close in 2D projections 1 ☐ 2 ☐ >2 ☐

Other comments:

Figure 3: Example of fiducial implant form with feedback about the quality of the fiducial placement and changes made to the treatment plan to compensate for uncorrectable target rotations



- From the retrospective patient analysis, it was found that on average, by changing from the 'body' to the 'prostate' path 17% more rotations could have been corrected
- By perturbing the planned dose according to delivery errors and uncorrected rotations it was found that use of the 'prostate' path could have led to an increase in the D99/Rx of up to 7.7%
- It was also noted that, for some patients, the rotations could become uncorrectable only at the extreme phases of the respiratory cycle potentially impacting the accuracy of respiratory motion compensation
- Use of the 'prostate' path is being currently implemented when planning Synchrony treatments on CyberKnife

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[1] Liu, M., Cygler, J. E., Dennis, K., & Vandervoort, E. (2022). A dose perturbation tool for robotic radiosurgery: Experimental validation and application to liver lesions. *J Appl Clin Med Phys*.