Efficient DTI Protocol for Stereotactic Radiotherapy Planning: Balancing Acquisition Time and Axonal Fidelity

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The study aimed to optimize a Diffusion Tensor Imaging (DTI) sequence for use in stereotactic radiotherapy (SRT) planning, balancing acquisition time with the accuracy of critical axonal bundle mapping to minimize neurological risks in brain metastases treatment [1-4].

Material and methods

We developed a shortened (duration: 2.1 minutes) DTI sequence on a Siemens SOLA 1.5T MRI, adjusting spatial resolution to 3 mm (reconstructed to 1.5 mm, isotropic) and reducing directions to 20 without repetition. The sequence was evaluated, on a healthy volunteer, for accuracy in mapping key axonal structures—left/right corticospinal tracts, optic radiations, and the left arcuate fasciculus—using Brainlab's FiberTracking V2.0 software and compared to standard (20 directions with repetition, 4.1 minutes) and reference (256 directions, 26.5 minutes) sequences. Comparability has been assessed visually and quantitatively by looking at the proportion of the reference sequence that was covered by adding 1 or 2 mm margin around the short sequence tracts.

Results

The optimized sequence maintained visually comparable performance with standard and reference DTI protocols in identifying target axonal bundles essential for radiotherapy planning. >95% of the reference sequence structures were included inside the short sequence bundles with an additional margin of 2 mm (Figure 1 and Table 1). Remaining differences were mostly artifacts due to an automatic extraction of fibers. The reduction in acquisition time did not compromise the visualization of critical axonal pathways, making the sequence suitable for clinical workflow without anatomical fidelity loss.

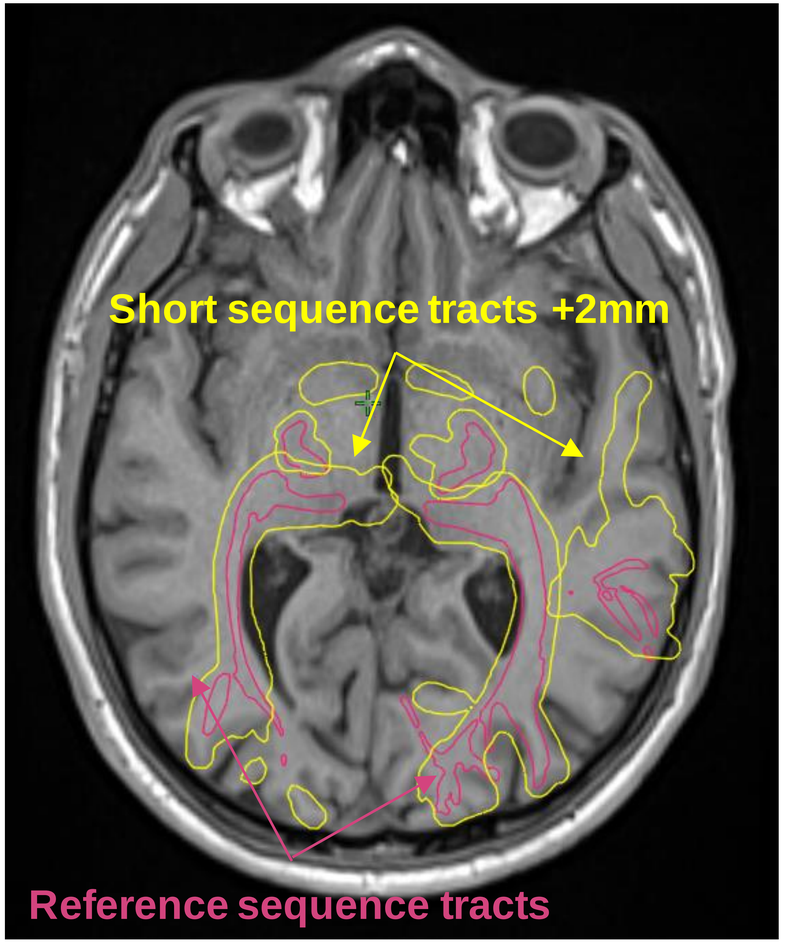

Figure 1. Axial view of axonal bundles extracted from the reference sequence (magenta) and from the short sequence with an additional margin of 2 mm (yellow)

Sequence name →	Volume [cc]			Relative volume [%]		
	Short	Standard	Ref.	Short - Ref.	Short+1mm - Ref.	Short+2mm - Ref.
Arcuate Fasciculus Left	7.7	6.2	4.1	36.6%	9.8%	4.9%
Cortico-spinal Left	11.4	11.6	12.5	24.8%	7.2%	2.4%
Cortico-spinal Right	10	7.7	13.5	54.1%	7.4%	3.0%
Optic Radiation Left	16.7	6.6	12.6	19.8%	5.6%	4.0%
Optic Radiation Right	10.9	7.8	6.2	17.7%	6.5%	4.8%

Table 1. Summary of some axonal bundles volumes [cc] and the relative volume [%] of the difference between the reference sequence (Ref.) and the short sequence without or with a 1 and 2 mm margin.

Conclusion

Our optimized DTI protocol offers a clinically feasible approach for accurate axonal mapping in SRT planning. This sequence enables robust identification of organs at risk with a reduced imaging time.

References

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