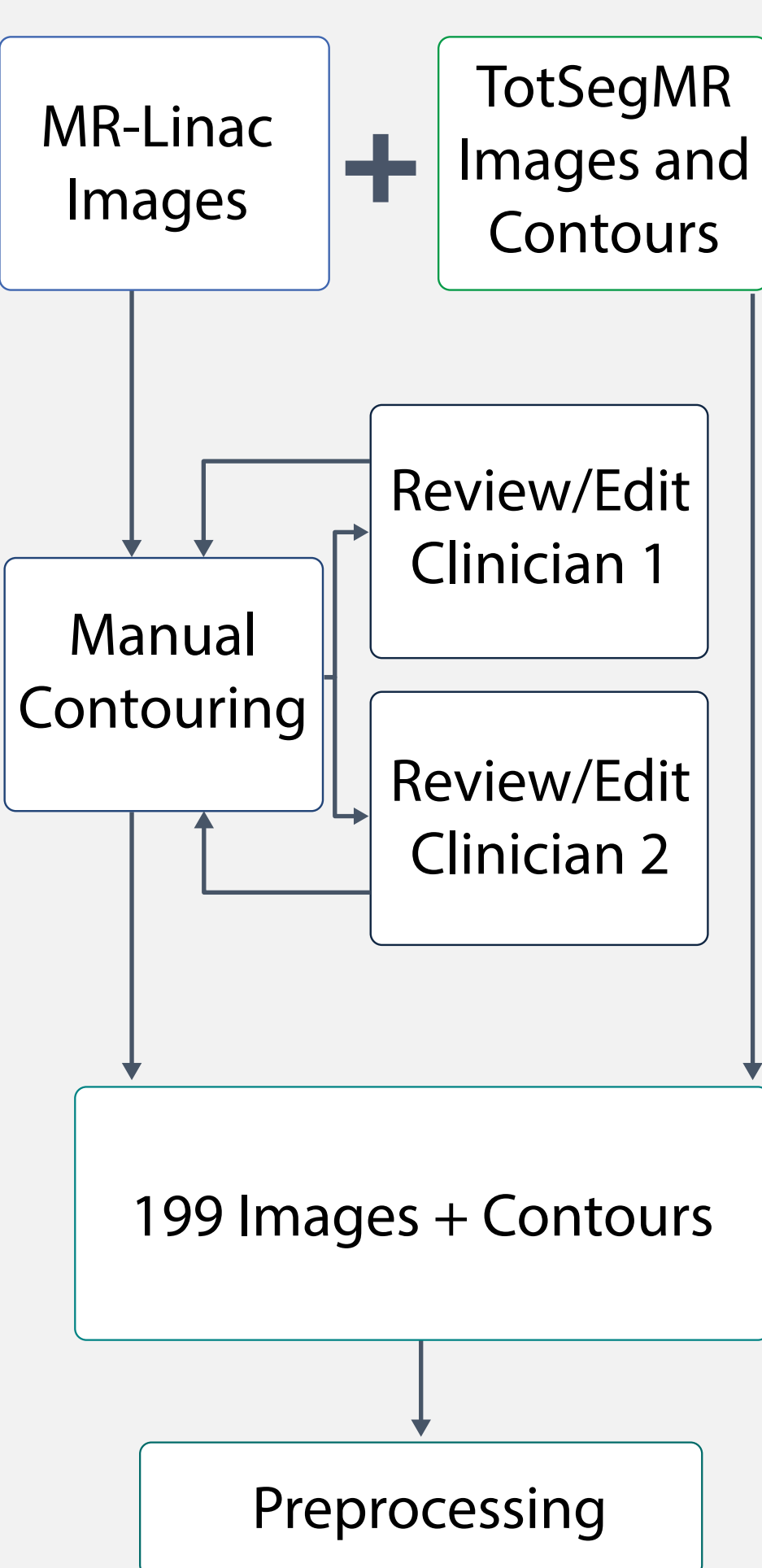


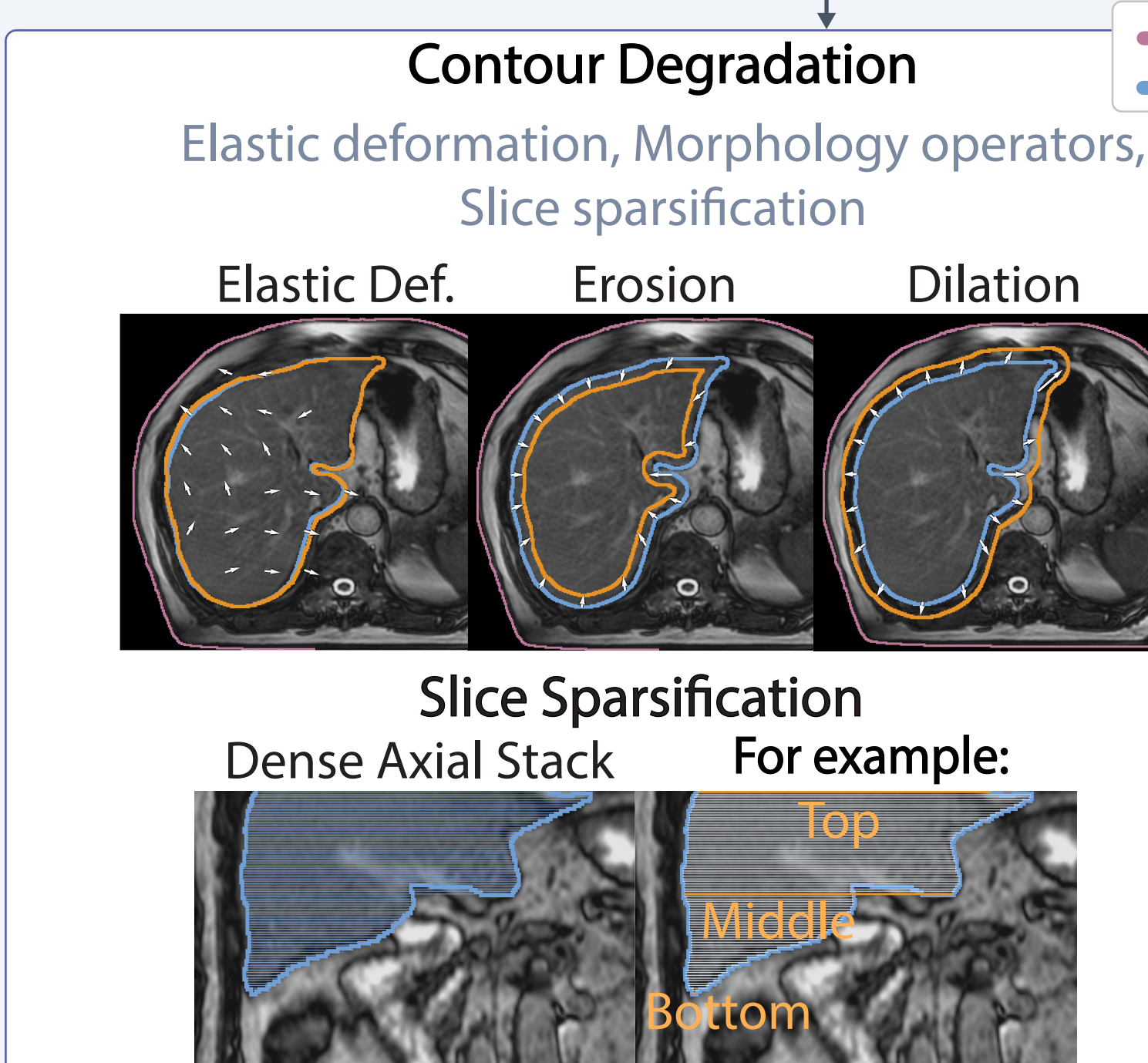
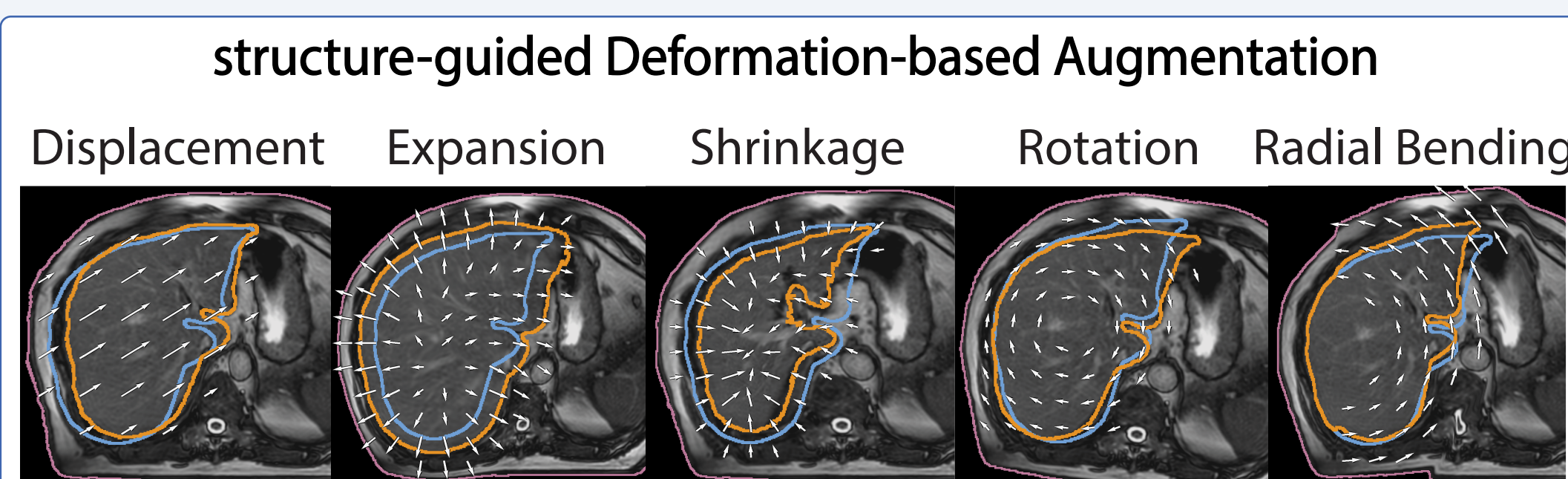
ABSTRACT: Limited expert contours remain a major barrier to reliable auto-contouring in pancreatic MR-guided radiotherapy (MRgRT). We developed mSPOCK, a conditional segmentation framework that converts a few rough drawn 2D contours into full-volume OAR contours across multiple MR image contrasts. mSPOCK required only 2–5 sparse slices per OAR, was robust to sparse contour quality, achieved high geometric accuracy, and outperformed other baselines. With targeted editing near the high-dose region, clinically acceptable contours were achieved in ~14 min with near-zero dose discrepancy, supporting a practical human-guided AI workflow for online and offline adaptive MRgRT.

Methods

1 Data Preparation



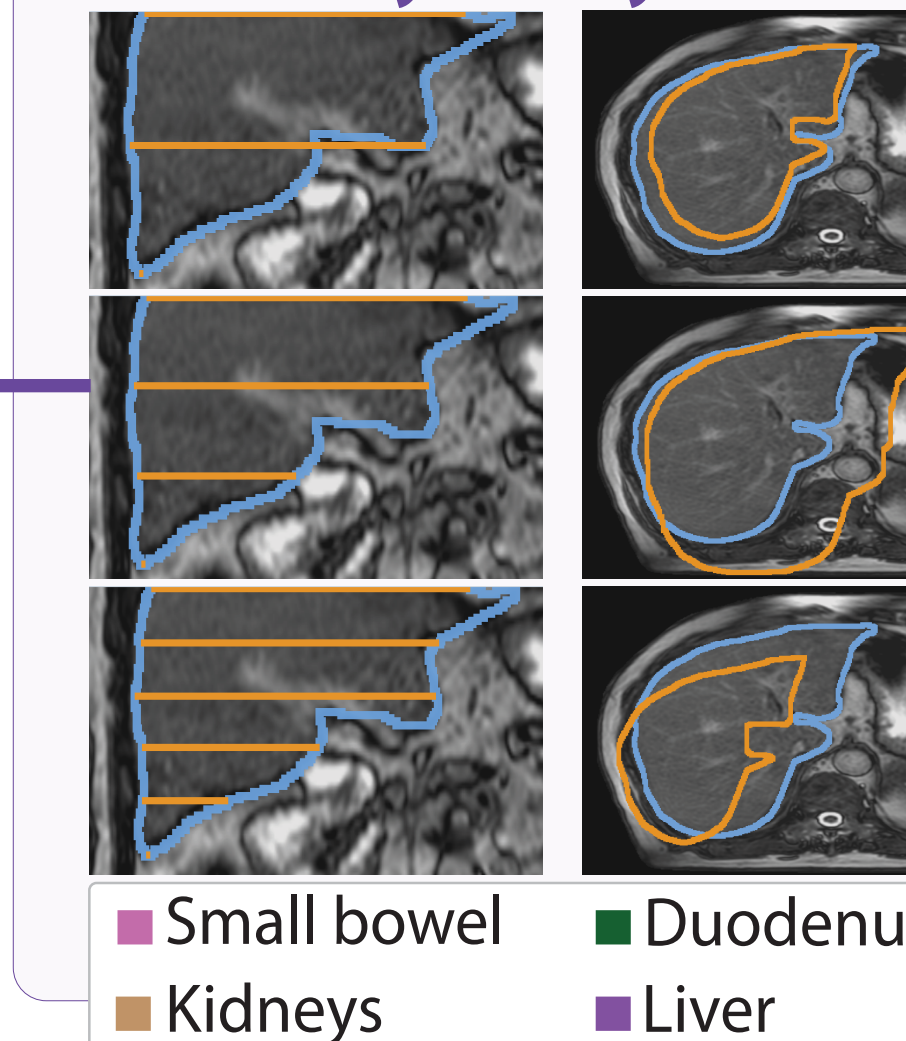
2 Augmentation and Clinician-like Sparse Contour Simulation



Body
Original Liver Contour
Deformed/Sparse Contour
Interpolated Contour

- Sparse inputs generated using 2–40 contoured slices
- Performance plateau identified using geometric metrics

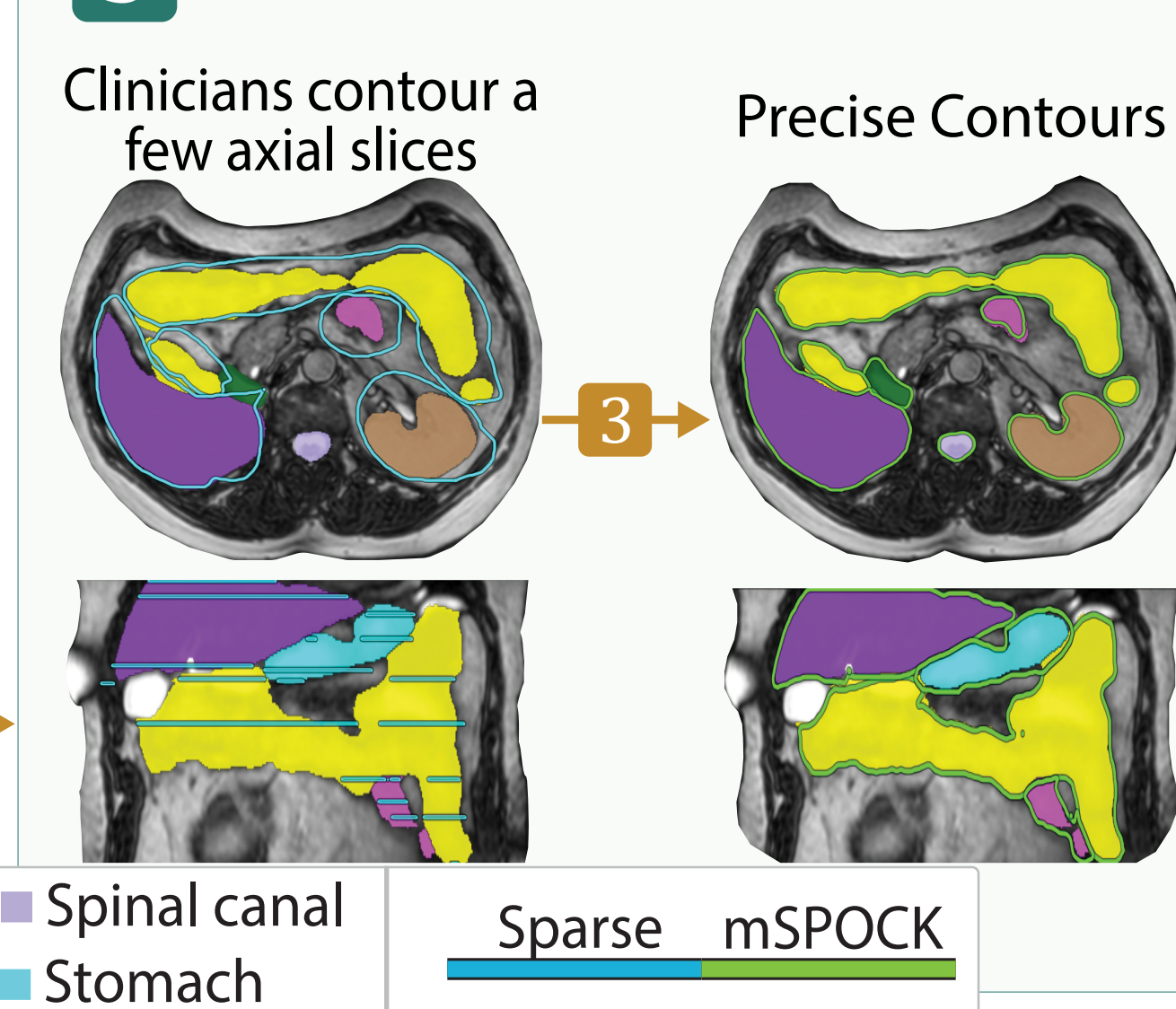
4 Slice-count & Contour Quality Analysis



- Erosion: up to 12 mm
- Dilation: up to 16 mm

Info for sparse contouring

5 Inference



THE NEED!

Can fast, accurate, and clinically acceptable OAR contours be generated from minimal user input while preserving clinician control and dose-relevant accuracy?

- We propose mSPOCK, a human-guided conditional segmentation framework that transforms rough, sparse user-drawn slices into precise full-volume OAR masks, turning auto-contouring into a clinically practical contour completion task.
- We used structure-guided deformation augmentation [1] to simulate sparse contours and conditional nnU-Net [2–4] training to enable learning in limited-data settings.
- mSPOCK was assessed geometrically, dosimetrically, and through clinician editing time to demonstrate both accuracy and workflow efficiency.

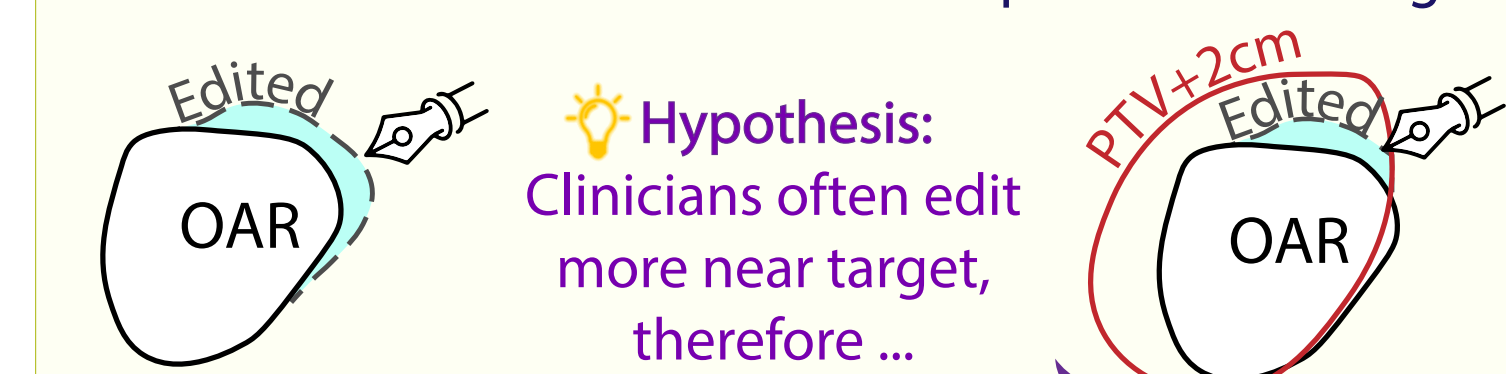
6 Evaluation

Geometric Analysis

- Dice score (DSC)
- Average Surface Distance (ASD)

Time-based Analysis

- (0) Recorded sparse contouring and editing times:
- (1) Editing across whole volume
- (2) Targeted editing within a predefined margin



Dosimetric Analysis

- Separate plans from contour sets (1) and (2)
- Dose discrepancies vs ground truth, normalised to the prescribed dose (40 Gy to the PTV):
 - $D_{0.1\text{cm}^3}$: near-maximum dose
 - $D_{50\%}$: median dose

Comparators

- TotalSegmentator MRI [5]
- Dedicated non-conditional model trained on the same data (nonCond)

Fig. 1. Overview of the mSPOCK workflow, including sparse-input simulation, conditional segmentation, and geometric, dosimetric, and time-based evaluation.

Results

Sparse contouring quality and quantity analysis

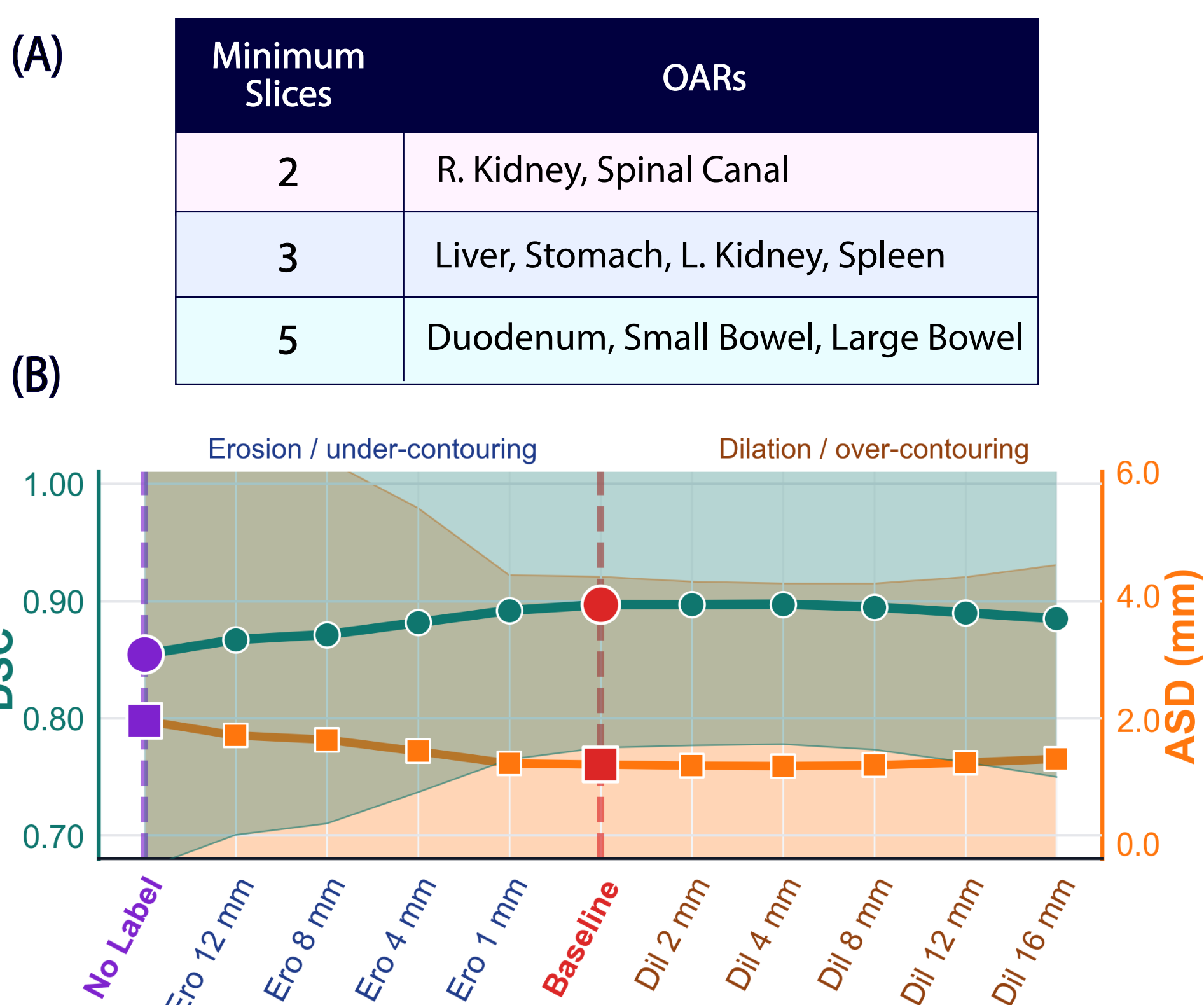


Fig 2. Analysis of sparse-input requirements: minimum slices required (A) and robustness to contour quality (B).

- Only 2–5 sparse slices per OAR required.
- Robust to variable sparse contour quality.
- Users can err on the side of inclusiveness (over-contouring).
- Therefore, sparse contours may be drawn by a trained user with basic anatomical knowledge, followed by clinician review.

Geometric accuracy and method comparison

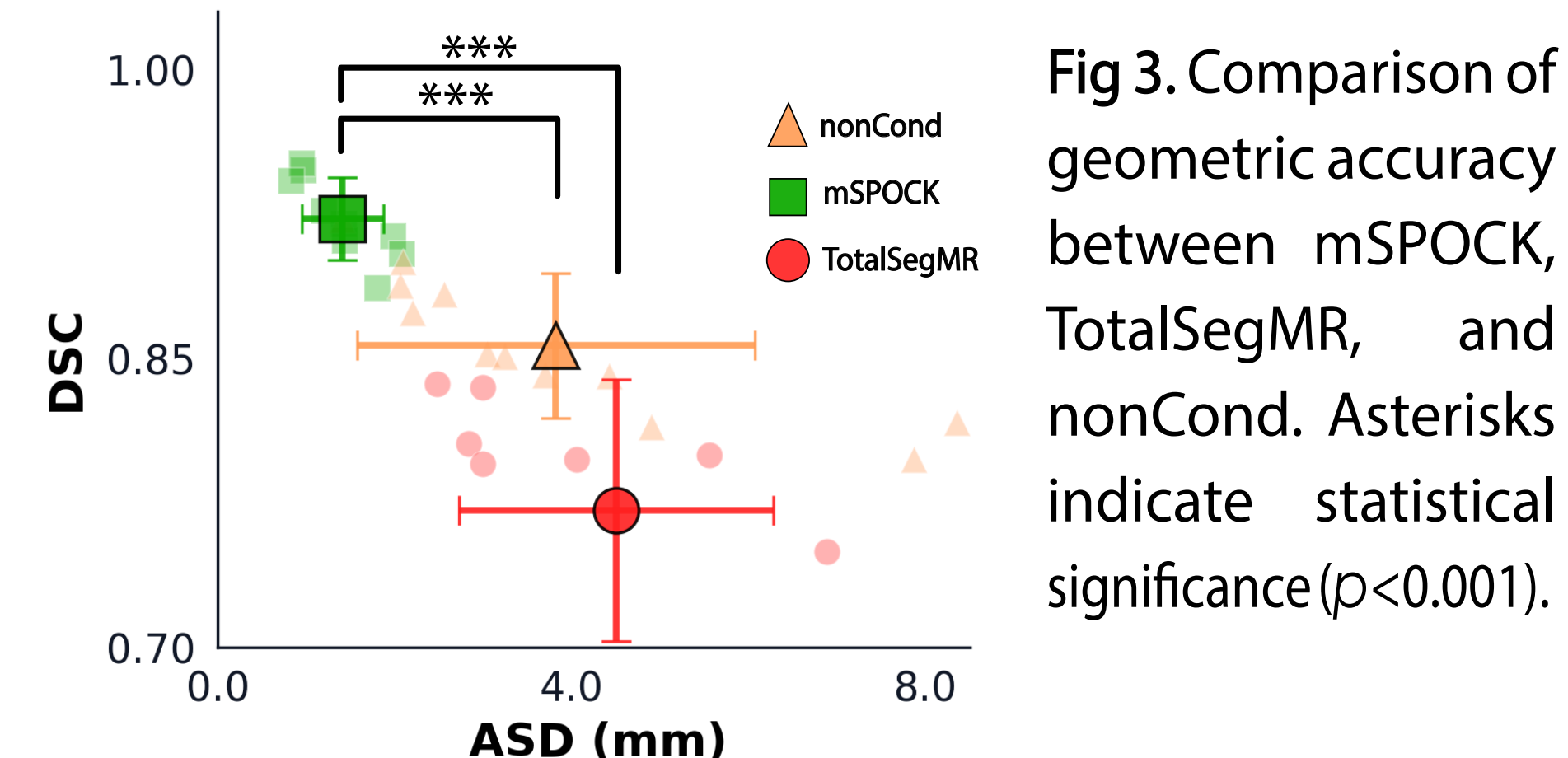


Fig 3. Comparison of geometric accuracy between mSPOCK, TotalSegMR, and nonCond. Asterisks indicate statistical significance ($p < 0.001$).

- DSC: 0.93 ± 0.02
- ASD: 1.48 ± 0.94 mm
- Best: Kidneys (DSC: 0.98, ASD: 0.50 mm)
- Worst: Duodenum (DSC: 0.78, ASD: 3.88 mm)

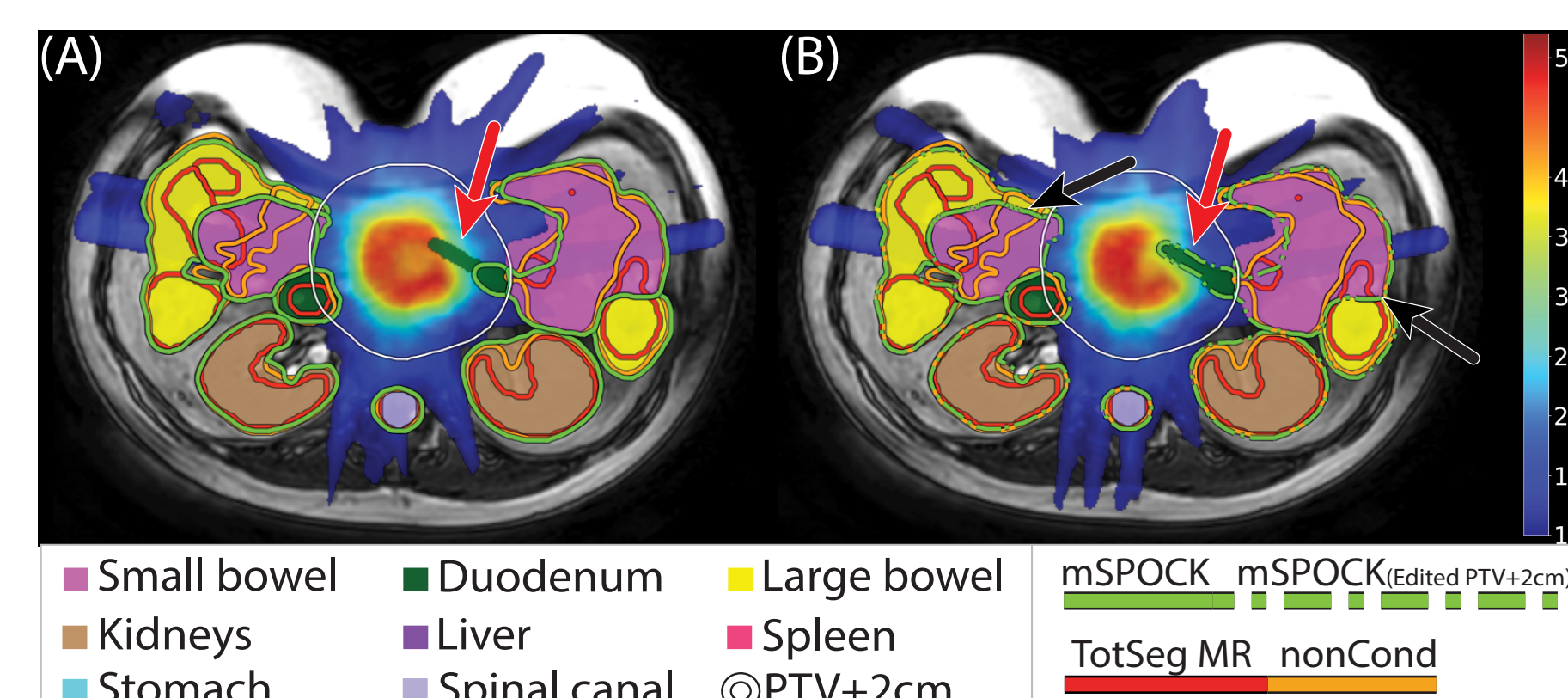


Fig 4. Contour comparison with dose overlays from plans using (A) unedited and (B) PTV+2cm targeted-edited mSPOCK contours. Red arrows show mSPOCK editing changes; black arrows show comparator errors.

- Target-adjacent edits can strongly influence dose.
- mSPOCK matches best with ground truth than other methods.

Time and dosimetric analysis

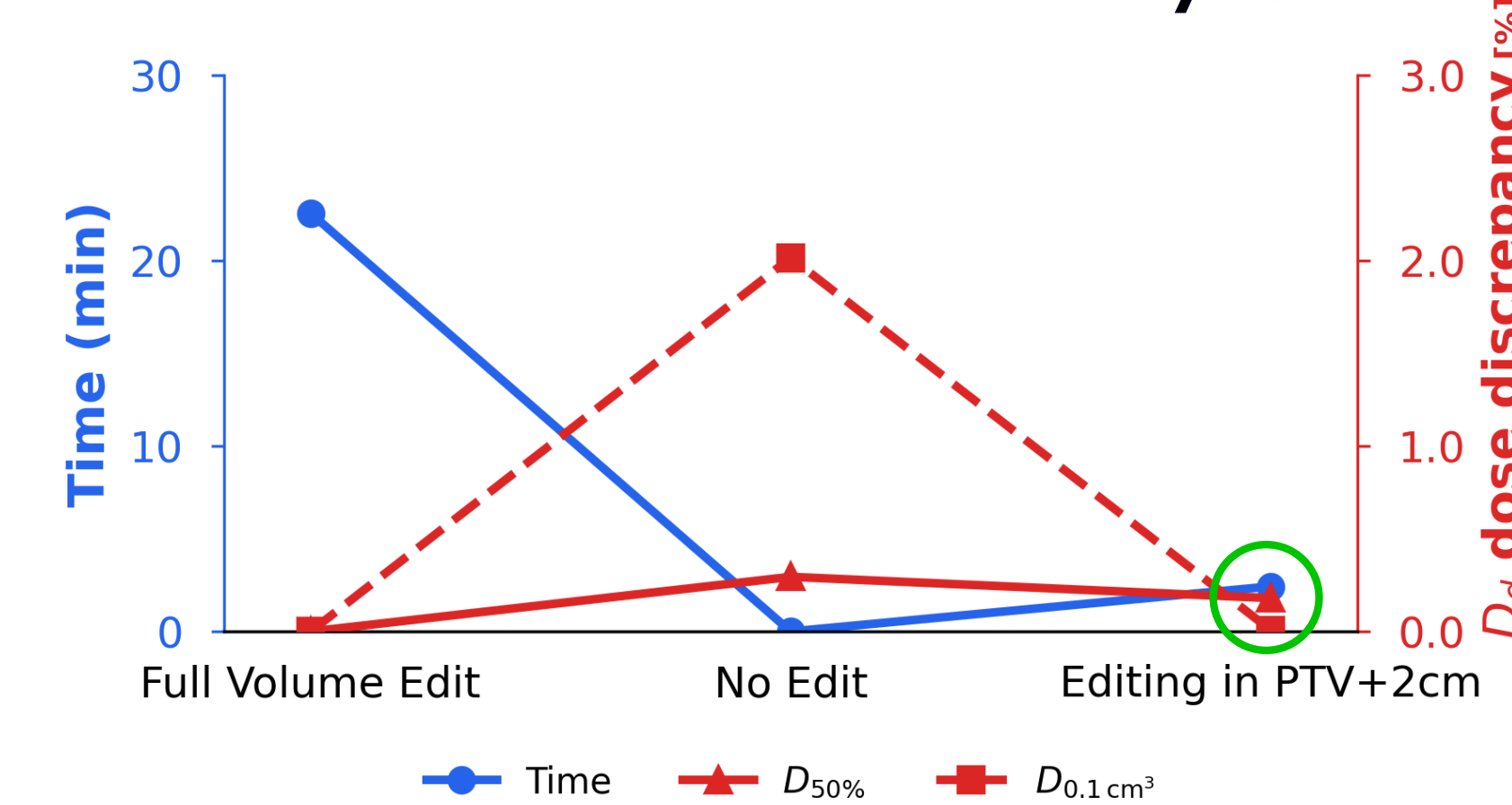


Fig 5. Editing time versus normalised dose discrepancy relative to ground truth.

Organs	Sparse Contouring Time [s]	Full Editing Time [s]	Editing within PTV+2cm		No Editing	
			Time [s]	$D_{0.1\text{cm}^3}$ [%]	$D_{50\%}$ [%]	$D_{0.1\text{cm}^3}$ [%]
Duodenum	126 ± 9	192 ± 89	95 ± 63	0 ± 0	0.9 ± 1.6	11.6 ± 11
Small Bowel	102 ± 11	547 ± 288	20 ± 20	0 ± 0	0.2 ± 0.3	0.1 ± 0.5
Large Bowel	146 ± 11	331 ± 208	28 ± 34	0 ± 0	0.3 ± 0.3	0 ± 0
Stomach	88 ± 13	55 ± 55	0 ± 0	0 ± 0	0 ± 0	5 ± 8.7
Other OARs*	<78	<150	<5	<0.1	<0.1	<0.4
(S)um/(M)ean	661 ± 42	1354 ± 173	146 ± 38	0 ± 0	0.2 ± 0.6	2 ± 6.1

Tab 1. Time and dose-discrepancy summary for clinically relevant OARs. *Other OARs: both kidneys, liver, spinal canal, and spleen.

- Clinicians spent ~11 min providing sparse contours and ~23 min editing full-volume contours; a total workflow time of ~34 min/case.
- PTV+2cm editing, reduced correction time to <2.5 min (overall ~13 min).
- Even without editing, mSPOCK contours showed close agreement with ground truth.
- Targeted editing achieved near-zero dose discrepancies.

Conclusions

- mSPOCK is accurate, fast, and clinically usable.
- Only minimal user guidance is required, making contour generation faster while preserving clinician oversight.
- Robustness to contour quality supports practical use despite user variability and non-perfect sparse inputs.
- Targeted editing produces near-zero dose discrepancies with only ~2.5 min of correction.
- mSPOCK offers a practical route to accelerate both offline planning and online adaptive MRgRT workflows.
- mSPOCK is not limited to pancreatic MRgRT; it offers a general solution for contour generation in limited-data settings.

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