Comparison of AI-Driven Method with Semi-Automated Segmentation for Total Kidney Volume (TKV) Estimation in ADPKD

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Background

Autosomal Dominant Polycystic Kidney Disease (ADPKD)

- Progressive cyst formation in the kidney tubules
- Distorts kidney shape
- Increases kidney size
- Decline in kidney function

Clinical Trials

- TKV established and accepted prognostic biomarker in ADPKD clinical trials by FDA

Kidney Segmentation

- Gold Standard: Manual or Semi-automated segmentation by expert radiologist
- AI-driven methods provide automated approach with high reproducibility

Objectives

- Compare AI-driven kidney segmentation to a semi-automated expert radiology reader for TKV measurement
- Assess the longitudinal TKV change between methods

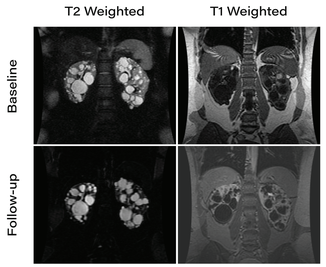
Method

Abdominal Magnetic Resonance Imaging

- Images from Consortium for Radiological Imaging Studies of Polycystic Kidney Disease (CRISP) and the HALT Progression of Polycystic Kidney Disease (HALT) datasets from NIDDK Central Repository

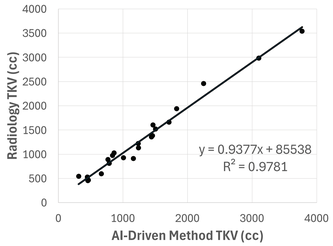
Image Segmentation and Data Analysis

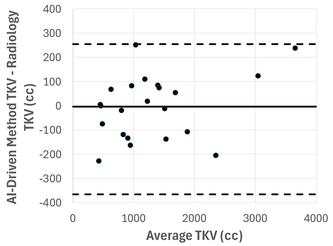
- **Radiology Read:** One expert radiologist assessed TKV on T2w sequence, while visually referencing T1w sequence
- **AI-Driven Method Read:** Deep learning 3D U-Net model developed and trained using radiologist-based kidney segmentations from 92 training image
- **Test cohort:** 12 subjects with two timepoints



Sample subject image demonstrating ADPKD and image quality

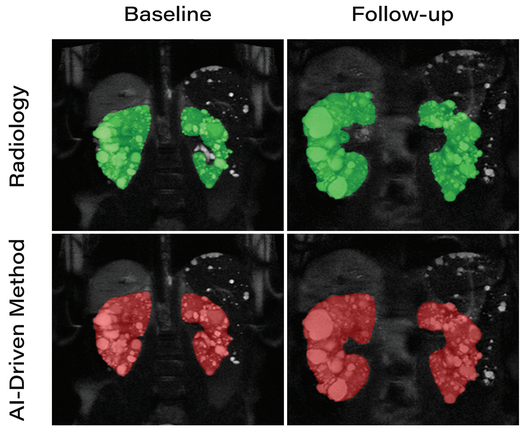
Results



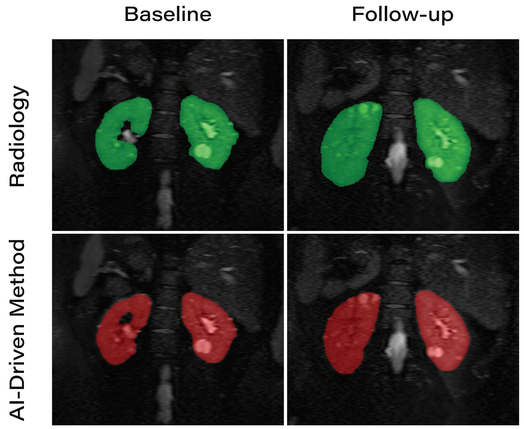


	Kidney Volume		
	Right	Left	Total
Mean Difference (cc)	4.69	-8.7	-4.01
Standard Deviation	53.4	91.2	131.6
Mean Difference (%)	-0.37	-1.62	-1.76
Linear Regression Slope			0.94
Linear Regression Intercept			85.6
R-Squared			0.98

Comparison of AI-Driven Method Read to the expert Radiology Read demonstrated by linear regression and Bland-Altman Analysis. There is strong correlation between the two methods and low mean difference in assessed TKV, as well as individual kidney assessment.



Difference in segmentations between timepoints. Case demonstrates AI-Driven Method results in case with numerous cysts present.



Difference in segmentations between timepoints. Case demonstrates AI-Driven Method results in case with fewer cysts present.

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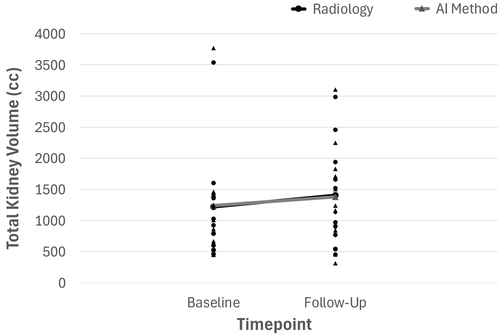

	Mean Absolute Change (cc)	St. Dev Absolute Change (cc)	Mean Percent Change (%)	St. Dev Percent Change (%)
Radiology	182.4	602.4	37.3	91.2
AI-Driven Method	142.9	545.9	32.3	69.1

Longitudinal TKV assessment between timepoints exhibits consistent performance between Radiology Read and AI-Driven Method Read.

Conclusions

- AI-Driven Method demonstrates consistent performance as compared to an expert radiologist in estimating total kidney volume from ADPKD subjects
- Longitudinal TKV monitoring and detection of physiological changes is reliable between segmentation methods
- AI-driven segmentation is suitable for initializing the kidney segmentation prior to a radiologist overread.
- Further model performance enhancement and refinement will result in improved renal pelvis segmentation.
- Integration of automated kidney segmentation into clinical trial operations will introduce efficiencies leading to improved accuracy, reproducibility, and reader performance.