Early Results in Novel Use of Contrast-Enhanced Susceptibility-Weighted Imaging in the Assessment of Response and Progression in Desmoid Fibromatosis: Pilot Study in a Specialized Cancer Institution

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Introduction

Desmoid tumors are rare mesenchymal neoplasms composed of a clonal proliferation of fibroblasts and myofibroblasts with intracellular collagen and poorly defined margins. Subjective routine-radiologic-reporting (RRR) often consider progressive Desmoid tumors to have a higher proportion of T2-hyperintense and T1-shortened-enhancing components, while responding or mature-collagenized tumors demonstrate a higher proportion of T2-hypointense-non-enhancing components.

- **Goal:** To determine the utility of the novel use of contrast-enhanced susceptibility-weighted imaging (CE-SWI) as a single sequence capable of simultaneously separating the T1-shortening-enhancing/T2-hyperintense-immature from the T2-hypointense-collagenized-mature components, using volumetric measurements, m-Choi, and first-order radiomic features.

Study Design

- This pilot study included 10 single-lesion extremity Desmoid fibromatosis patients undergoing standard-of-care-MRI, including CE-SWI, performed March 2021- May 2023.
- Three-dimensional tumor segmentation was performed using MIM-software in 48 VOI.
- Maximum-diameter, volume, and modified-Choi (mChoi) measurements were computed from CE-SWI and T2-WI.
- Five first-order radiomic features, including mean, skewness, kurtosis, and 10th and 90th percentiles, were computed using in-house developed software (CARPI-AF: Cancer-Radiomic-Perfusion-Imaging-Automated-Framework).

Results

- **Radiomics:**
  - CE-SWI detected 23% more 90th-percentile voxels relative to T2-WI.
  - T2-WI demonstrated 8.5% more 10th-percentile voxels than CE-SWI
  - Expected first-order response/progression-related-changes in 10th-percentile, 90th-percentile, mean, and skewness were present in 90% of cases.
- **RECIST Progression:**
  - Two patients displayed true-progression by T2-WI-based RECIST reference standard.
  - Same was detected by CE-SWI-based-volume and CE-SWI-based-mChoi 4.5 months earlier than T2-WI-based-RECIST.
  - RRR assessed both cases as progression.
- **RECIST Stability:**
  - Eight patients were classified as stable-disease by T2-WI-based-RECIST.
  - Four cases of discrepant progression were determined by an increase greater than 25% of T2-WI-based-volume (three patients) and CE-SWI-based-volume (two patients).
  - Four cases of discrepant positive responses were predicted by CE-SWI-based-mChoi (three patients) and T2-WI-based-mChoi (four patients).
  - RRR determined only one as progression.

Imaging Patterns of Response in Desmoid Tumors

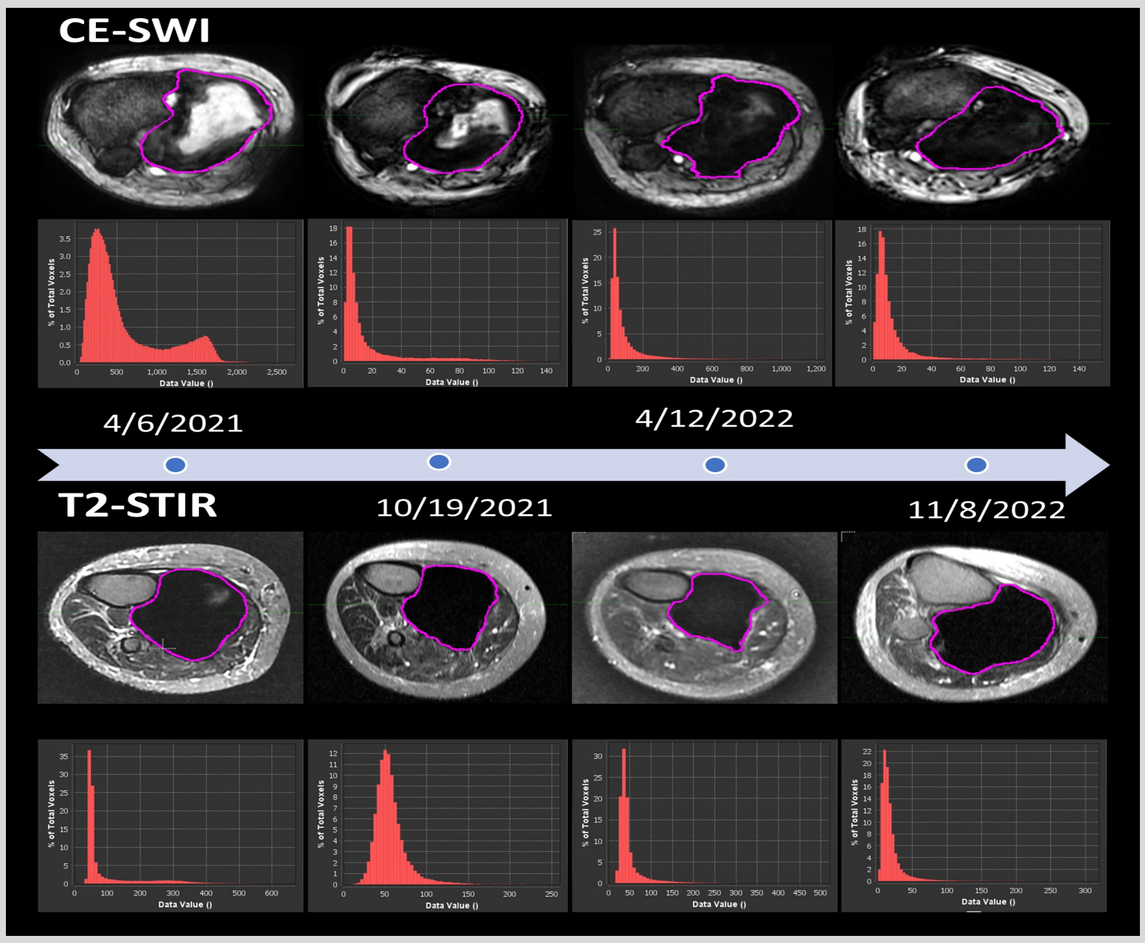

Fig 1. Representative responding desmoid tumor. Comparison between CE-SWI and T2-STIR images and their respective histograms of a desmoid fibromatosis tumor across 4 time points undergoing response to treatment from left to right demonstrating the process of reduced enhancement and increased T2 hypointensity during response. The increase of T2 hypointense elements is typically considered a sign of positive response irrespective of tumor size. In contrast, an increase in the T2 hyperintense and T1 shortened enhancing components is often seen as a sign of progression that can precede enlargement.

Expected Trends in Responding Desmoid Tumors

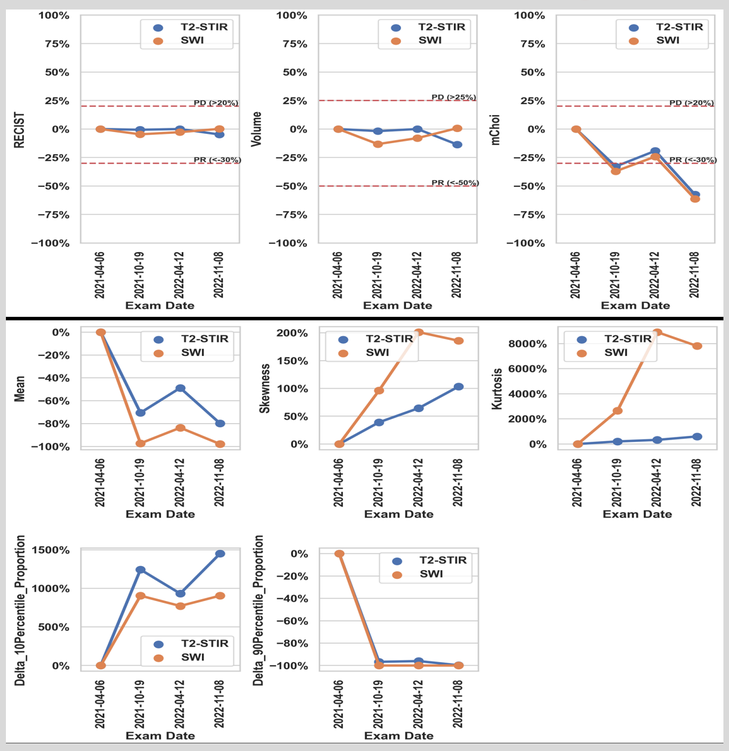

Fig 2. Expected radiomic trends in responding desmoid patients. Plots of RECIST, Volume, mChoi, and first-order radiomic features of a representative patient across treatment demonstrate expected response trends, including decreased mean, increased skewness, increased 10th percentile voxel proportion, and decreased 90th percentile voxel proportion. Thresholds for progression and response were set at 20% and 30% for RECIST and volumetric mChoi assessments. An increase of 25% and a decrease of 50% were considered thresholds for progression and response, respectively, for 3D volumetric assessment.

T2-Based RECIST Response Categorization

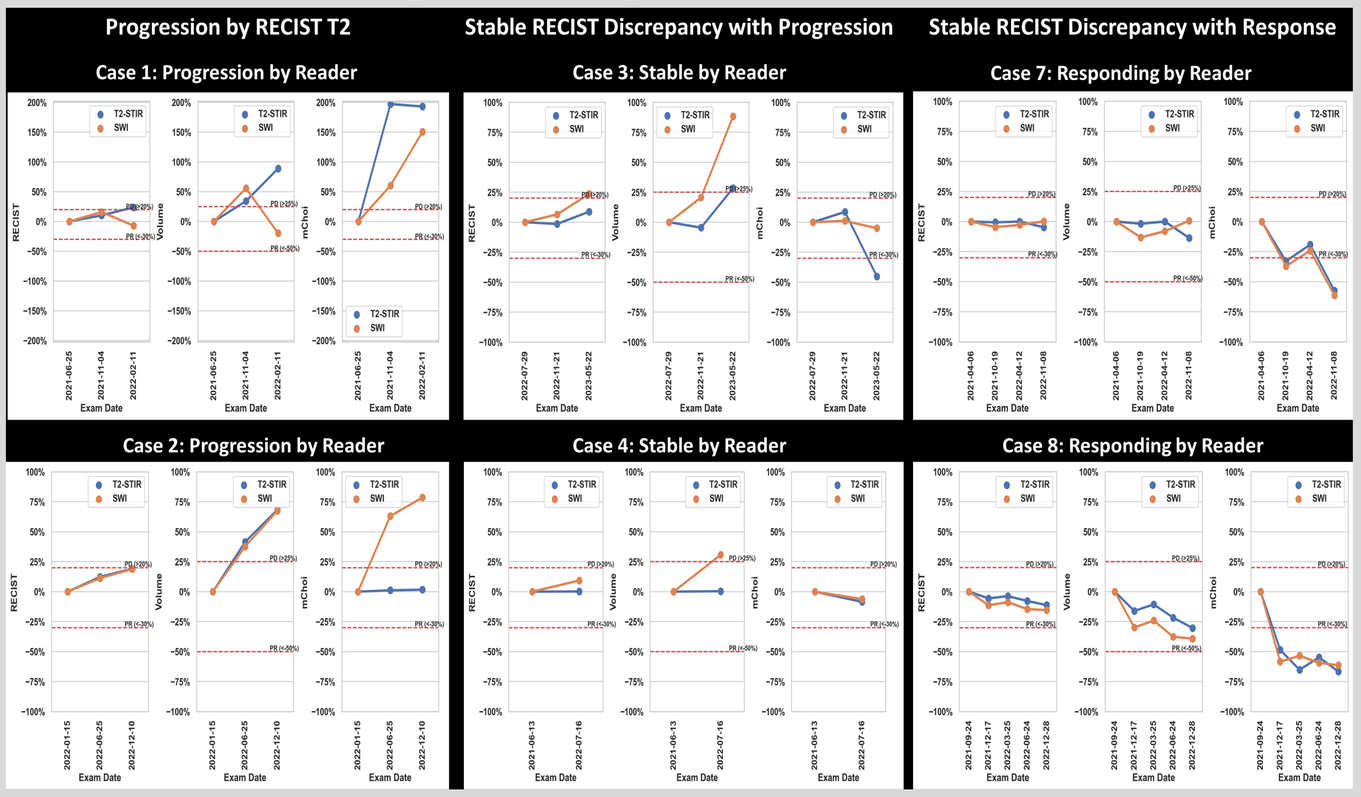

Fig 3. RECIST, volume, and mChoi plots from 6 representative desmoid fibromatosis patients and their corresponding response categorization. Left panels show true progression by T2-based RECIST, also detected by CE-SWI-based-volume and CE-SWI-based-mChoi with an average of 4.5 months earlier. Middle panels show stable T2-based RECIST with discrepancy assessment of progression by CE-SWI volume in 2 representative patients. Clinical radiologists are often insensitive to detect progression by volume change. Right panels show stable RECIST with discrepancy assessment of response detected by CE-SWI mChoi in 2 representative patients. Clinical radiologists are very sensitive to changes in T2 signal and enhancement in correlation with the variation of mChoi values.

CE-SWI Sensitivity for Detection of Hyperintense Voxels in Progression

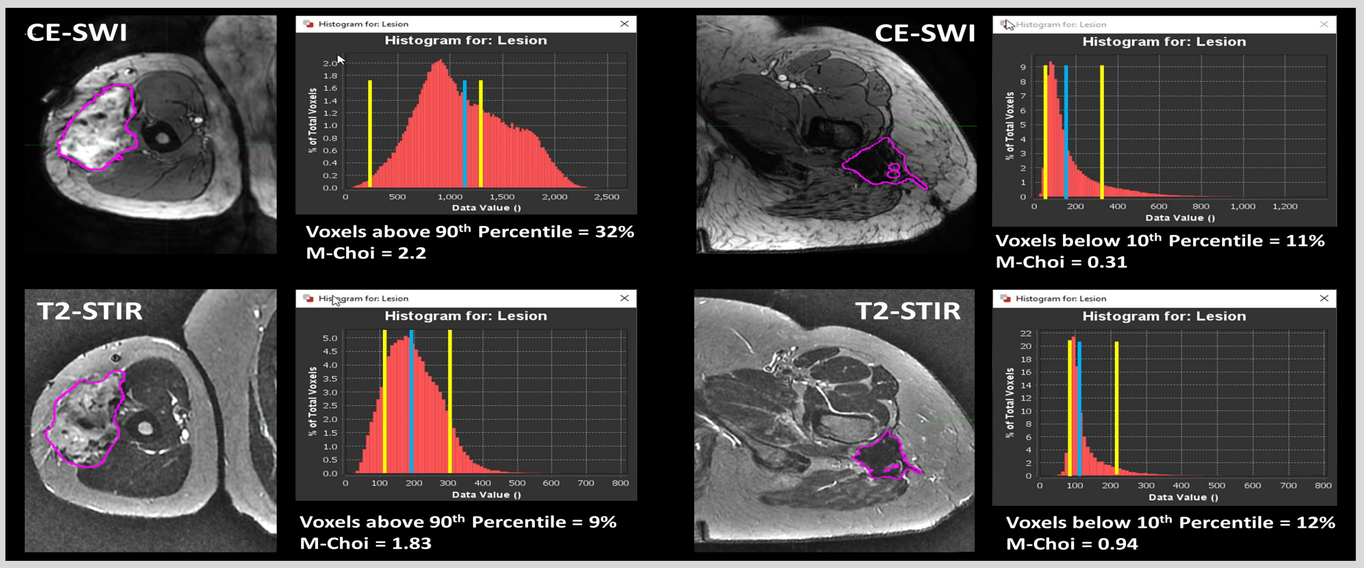

Fig 4. Representative progressive (left) and responding (right) desmoid tumors with their corresponding voxel intensity histograms. Left panels show a higher percentage of voxels above the 90th percentile in SWI-CE versus T2-STIR in an active progressing lesion. Right panels show a higher percentage of voxels below the 10th percentile in T2 versus SWI-CE in a highly collagenized responding tumor. On average, SWI-CE imaging captured 23% more 90th percentile voxels than T2.

First-Order Radiomic Trends in Desmoid Fibromatosis

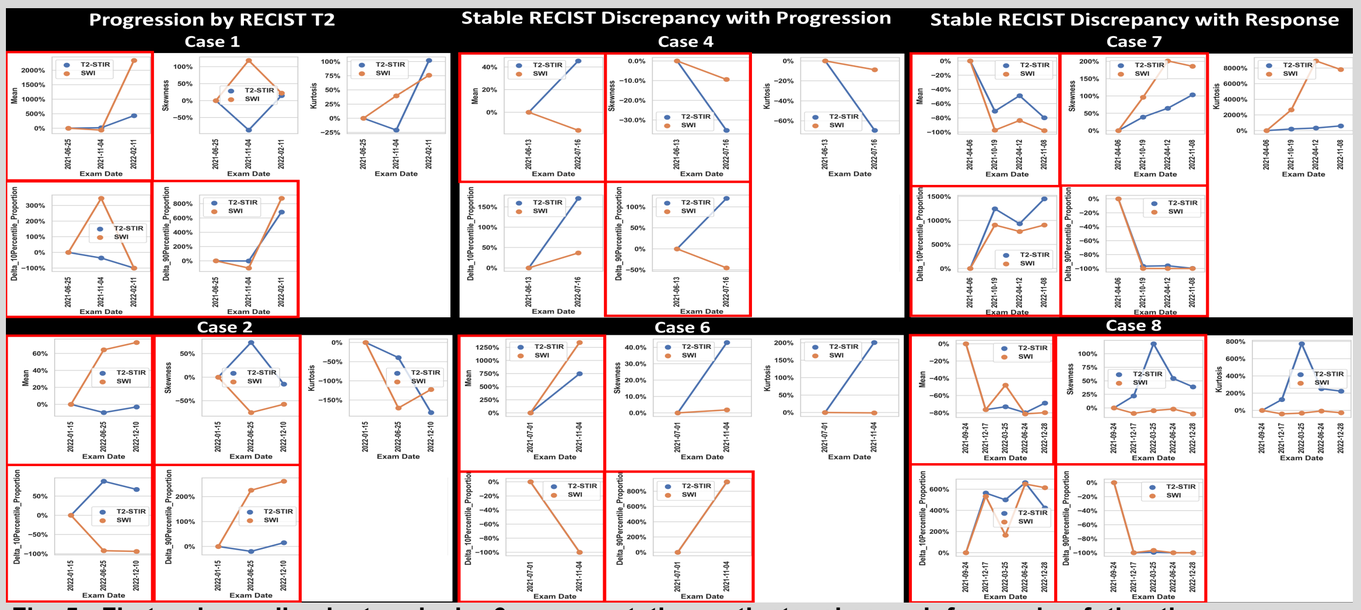

Fig 5. First-order radiomic trends in 6 representative patients observed for each of the three response categories. The red boxes highlight the trends of first-order radiomic features concordant with the expected response category trend. The expected trends associated to responding patients, including increasing 10th percentile hypointense voxel proportion, decreasing 90th percentile hyperintense voxel proportion, decreasing mean, and increasing skewness, and the opposite in progressive patients, were present in at least one of these features in 90% of patients; and all four combined 30% of them.

Conclusions

- CE-SWI-based-volumetric and CE-SWI-based-mChoi measurements could improve the prediction of response/progression in Desmoid tumors, increasing discrimination between T2*-hypointense-collagenized-mature and T1-shortened-enhancing-immature components, respectively, in predominant mature-responding and immature-progressive disease.
- RRR is relatively insensitive to volumetric-tumor-changes preceding RECIST-progression and tends to be better tuned with response-related-T2*-signal and enhancement changes.
- A larger population study should follow these encouraging early results, including multifocal and RECIST-response cases.

References

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