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# Diagnostic Accuracy of Unenhanced CT for Hepatic Fat Quantification in Prospective Liver Donors: A prospective Comparison with MRI PDFF

**Dr. Gowardhan S**

gowardhan.s@gmail.com

Amrita Institute of Medical Sciences and Research Centre

**Dr. Milind Karippaliyil**

Amrita Institute of Medical Sciences and Research Centre

**Dr. Sreekumar K P**

Amrita Institute of Medical Sciences and Research Centre

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# Title Page

## Title

Diagnostic Accuracy of Unenhanced CT for Hepatic Fat Quantification in Prospective Liver Donors: A prospective Comparison with MRI PDFF

## Authors

**Dr. Gowardhan S,**

Department of Radiology

Amrita Institute of Medical Sciences and research Centre

Kochi, Kerala, India

Email: gowardhan.s@gmail.com

## Co- Authors

**Dr. Milind Karippaliyil**

Department of Radiology

Amrita Institute of Medical Sciences and research Centre

Kochi, Kerala, India

Email: milind545@gmail.com

**Dr. Sreekumar K P**

Department of Radiology

Amrita Institute of Medical Sciences and research Centre

Kochi, Kerala, India

Email: sreekumarkp@aims.amrita.edu

## Affiliation

[1] Department of Radiodiagnosis and Imaging, Amrita Institute of Medical Sciences and Research Centre, Kochi, Kerala, India

## Corresponding Author

Dr. Gowardhan S

Department of Radiodiagnosis and Imaging

Amrita Institute of Medical Sciences and Research Centre

Kochi, Kerala, India

Email: gowardhan.s@gmail.com

## Running Title

CT versus MRI-PDFF in Liver Donor Steatosis

# Title

Hepatic Fat Quantification in Prospective Liver Donors: Diagnostic Accuracy of Unenhanced CT Compared with MRI-PDFF

# Abstract


## Background

Hepatic steatosis is a key factor in living liver donor assessment because even low-grade fat infiltration may impair graft function and hepatic regeneration. Although liver biopsy is the traditional reference standard, it is invasive and unsuitable for routine screening. Computed tomography (CT) is part of standard donor work-up, but its accuracy for low-grade steatosis remains uncertain. This study evaluated the diagnostic performance of unenhanced CT for hepatic fat quantification using magnetic resonance imaging-proton density fat fraction (MRI-PDFF) as the reference standard.

## Methods

This prospective single-centre comparative study included 76 clinically selected prospective living liver donors evaluated over a 20-month period from June 2024 to January 2026. All underwent unenhanced CT and MRI-PDFF. CT-based hepatic and splenic attenuation values were obtained and hepatic steatosis grading was derived using established liver–spleen indices. MRI-PDFF (Dixon-based, 1.5-T) served as the reference. Agreement was assessed using Cohen's kappa, and grade-wise sensitivity, specificity, predictive values, and accuracy were calculated.

## Results

The mean age was 41 years; 65.8% were female. CT classified 48 donors (63.2%) as normal, 24 (31.6%) as mild steatosis, three (3.9%) as moderate steatosis, and one (1.3%) as severe steatosis. MRI-PDFF classified 72 donors (94.7%) as mild steatosis, three (3.9%) as moderate steatosis, and one (1.3%) as severe steatosis; no donor met the MRI-PDFF normal category. For mild steatosis, CT sensitivity was 31.94%, specificity was 75.00%, and

accuracy was 34.21%, with slight agreement (kappa = 0.01). For moderate steatosis, sensitivity was 66.67%, specificity was 98.63%, accuracy was 97.37%, and agreement was substantial (kappa = 0.65). Findings were concordant in the single severe case of steatosis, Among CT-defined mild steatosis cases, the mean MRI-PDFF was 10.8% by inline ROI analysis and 11.6% by segmentation.

**Conclusions**

Unenhanced CT underestimates very early and mild hepatic steatosis in prospective living liver donors but performs well in moderate and severe disease. MRI-PDFF is preferred for accurate fat quantification in donor selection, while CT remains essential for anatomical assessment, vascular mapping, and volumetry.

**Keywords**

hepatic steatosis; living liver donor; computed tomography; MRI-PDFF; proton density fat fraction; donor imaging; radiology

# Background

Hepatic steatosis is increasingly encountered during evaluation of prospective living liver donors. In the transplant setting, even low to moderate fat infiltration may impair graft regeneration, increase susceptibility to ischemia-reperfusion injury, and adversely affect recipient outcomes [1-4]. Accurate preoperative quantification is therefore essential to avoid both unsafe donation and unnecessary donor exclusion.

Liver biopsy has historically served as the reference standard for steatosis grading, but it is invasive, subject to sampling error, and poorly suited to repeated screening in otherwise healthy donor candidates [5]. Imaging-based assessment is therefore central to modern donor work-up. Unenhanced CT is attractive because it is widely available, rapid, objective, and already used to evaluate donor anatomy, vascular structures, and volumetry [6-8]. However, CT estimates fat indirectly through attenuation changes and may be insensitive when hepatic fat content is low.

MRI-PDFF is currently regarded as the most accurate non-invasive imaging biomarker for hepatic fat quantification. By using chemical shift-encoded acquisition with correction for confounders such as T1 bias,

T2* decay, and fat spectral complexity, MRI-PDFF provides reproducible whole-liver quantification and strong correlation with histology and magnetic resonance spectroscopy [9-14]. These advantages have made MRI-PDFF a practical radiological reference standard for donor imaging studies.

The present study was designed to assess the diagnostic performance of unenhanced CT for hepatic steatosis grading in prospective living liver donors using MRI-PDFF as the reference standard, and to identify the MRI-PDFF range at which CT begins to detect fatty infiltration reliably.

# Methods

## Aim

To evaluate the diagnostic accuracy of unenhanced CT for hepatic fat quantification in prospective living liver donors using MRI-PDFF as the reference standard, and to identify the MRI-PDFF threshold at which CT begins to reliably detect hepatic steatosis.

## Study design and setting

This prospective comparative study was conducted in the Department of Radiodiagnosis and Imaging, Amrita Institute of Medical Sciences and Research Centre, Kochi, Kerala, India, over a 20-month period from June 2024 to January 2026. Written informed consent was obtained from all participants before inclusion. MRI-PDFF served as the reference standard for hepatic fat quantification.

## Study population

Seventy-six clinically selected prospective living liver donors were included. Inclusion criteria were defined as individuals selected as donors after routine clinical screening under institutional transplant protocols who underwent both unenhanced CT and MRI-PDFF as part of the donor imaging work-up, with complete imaging datasets of adequate quality for hepatic fat quantification. Exclusion criteria were defined as those patients with general contraindications to MRI (non-MRI compatible implants, severe claustrophobia), poor image quality due to motion or technical limitations and the cases with imaging findings that could confound hepatic fat quantification, including marked iron overload or diffuse parenchymal liver disease

## CT acquisition and attenuation analysis

Unenhanced CT of the upper abdomen was performed on a 256-slice multidetector scanner with the donor in the supine position during breath-hold. Hepatic attenuation values were obtained from multiple circular regions of interest placed in the right lobe while avoiding major vessels, bile ducts, focal lesions, and beam-hardening artefact. Splenic attenuation was measured in corresponding regions. CT-based steatosis grading was derived using liver-spleen attenuation difference, and liver-to-spleen attenuation ratio, as described in prior CT-based steatosis literature [7,8,16,25].

## MRI-PDFF acquisition

MRI was performed on a 1.5-T system using a Dixon-based sequence. Donors were scanned supine with breath-hold acquisition after localizer imaging. Imaging parameters included TR/TE of 9/1.2 ms, field of view of 332 mm, matrix size of 111 x 160, slice thickness of 3.5 mm, and acquisition time of 15 seconds. Fat fraction values were obtained from auto-calculated inline ROI-based measurements and segmentation-based whole-liver analysis.

## Steatosis grading

MRI-PDFF grading was based on validated PDFF thresholds described in prior literature [14,19]. CT grading was based on liver-spleen attenuation difference and liver/spleen attenuation ratio derived from established literature [7,8,16,25]. Donors were categorized as grade 0 (normal), grade I (mild), grade II (moderate), or grade III (severe) steatosis. Agreement between CT and MRI-PDFF grades was assessed using Cohen's kappa statistic.

## Statistical analysis

Statistical analysis was performed using SPSS version 20.0. Grade-wise sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were calculated using MRI-PDFF as the reference standard. Agreement between CT and MRI-PDFF was assessed with Cohen's kappa. Because

moderate and severe steatosis were uncommon in this screened donor cohort, inferential testing in these subgroups was limited, and these results were interpreted primarily descriptively.

# Results

## Cohort profile

The study included 76 donor candidates. The mean age was 41 years, with an age range of 21 to 61 years. Females constituted 65.8% of the cohort (50/76), and males constituted 34.2% (26/76) (Table 1, Figures 1 and 2).

**Table 1. Baseline cohort characteristics**

| Variable | Value |
|---|---|
| Sample size | 76 |
| Mean age | 41 years |
| Age range | 21-61 years |
| Male | 26 (34.2%) |
| Female | 50 (65.8%) |

## Distribution of steatosis on CT and MRI-PDFF

CT classified 48 donors (63.2%) as having no fatty liver, 24 (31.6%) as mild steatosis, three (3.9%) as moderate steatosis, and one (1.3%) as severe steatosis (Table 2, Figure 3). In contrast, MRI-PDFF classified 72 donors (94.7%) as mild steatosis, three (3.9%) as moderate steatosis, and one (1.3%) as severe steatosis; no donor met the MRI-PDFF normal category (Table 2, Figure 4). This marked discordance indicates that CT frequently labelled donors as normal despite measurable fat on MRI-PDFF (Figure 5).

**Table 2. Distribution of hepatic steatosis grades on CT and MRI-PDFF**

| Steatosis grade | CT, n (%) | MRI-PDFF, n (%) |
|---|---|---|
| Normal | 48 (63.2%) | 0 (0%) |
| Mild | 24 (31.6%) | 72 (94.7%) |
| Moderate | 3 (3.9%) | 3 (3.9%) |
| Severe | 1 (1.3%) | 1 (1.3%) |

*Note: MRI-PDFF did not identify any donor in the normal category, illustrating the greater sensitivity of MRI-PDFF for low-level fat deposition.*

## Exploratory comorbidity patterns

Descriptive plots suggested that higher MRI-PDFF grades clustered more often among donors with dyslipidaemia, diabetes or prediabetes, hypothyroidism, obesity, and polycystic ovarian syndrome. However, subgroup counts were small, and these observations were exploratory rather than inferential (Figure 6).

## Grade-wise diagnostic agreement

For mild steatosis, CT identified 23 true-positive and one false-positive case but missed 49 MRI-positive mild cases. Sensitivity was 31.94%, specificity was 75.00%, positive predictive value was 95.83%, negative predictive value was 5.77%, and overall accuracy was 34.21%. Agreement between CT and MRI-PDFF for mild steatosis was slight (kappa = 0.01).

For moderate steatosis, CT showed two true-positive, one false-positive, one false-negative, and 72 true-negative cases, yielding sensitivity of 66.67%, specificity of 98.63%, accuracy of 97.37%, and substantial agreement (kappa = 0.65). For severe steatosis, CT and MRI-PDFF were concordant in the single severe case, with perfect agreement and 100% diagnostic performance across all calculated parameters (Tables 3 and 4).

**Table 3. Grade-wise diagnostic performance of CT using MRI-PDFF as the reference standard**

| Steatosis grade | Sensitivity (%) | Specificity (%) | Accuracy (%) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Mild | 31.94 | 75.00 | 34.21 |
| Moderate | 66.67 | 98.63 | 97.37 |
| Severe | 100.00 | 100.00 | 100.00 |

**Table 4. Predictive values and agreement between CT and MRI-PDFF across steatosis grades**

| Steatosis grade | PPV (%) | NPV (%) | Cohen's kappa | Interpretation |
|---|---|---|---|---|
| Mild | 95.83 | 5.77 | 0.01 | Slight |
| Moderate | 66.67 | 98.63 | 0.65 | Substantial |
| Severe | 100.00 | 100.00 | 1.00 | Perfect |

*Note: PPV = positive predictive value; NPV = negative predictive value. Kappa interpretation was based on conventional agreement categories.*

### CT detection threshold relative to MRI-PDFF

Among donors classified as mild steatosis on CT, the mean MRI-PDFF was 10.8% using inline ROI measurements and 11.6% using segmentation-based analysis. This suggests that CT began to identify steatosis consistently only when MRI-PDFF values approached approximately 10-12%, rather than at the earliest MRI-PDFF threshold of abnormality (Figure 7).

### Representative imaging examples

Representative imaging examples demonstrated the practical basis of the observed discordance. A donor categorized as normal on CT could still show mild steatosis on MRI-PDFF, whereas concordance improved progressively for mild, moderate, and severe disease as hepatic fat content increased. Whole-liver segmentation and voxel-wise histograms provided an intuitive view of both fat fraction and R2* distribution within the liver (Figures 8-13).

## Discussion

This study demonstrates that unenhanced CT underestimates hepatic steatosis in prospective living liver donors when MRI-PDFF is used as the reference standard. The most important discrepancy occurred in the low-fat range: nearly two-thirds of donors were labelled normal on CT, whereas MRI-PDFF identified measurable steatosis in all donors and categorized most as having mild fatty infiltration. These findings are clinically relevant because donor cohorts are intentionally enriched with normal and near-normal livers, precisely the range in which inaccurate under-calling may matter most.

The weak performance of CT for mild steatosis is biologically and technically plausible. CT relies on attenuation reduction as an indirect surrogate of fat, and low-level steatosis may not lower hepatic attenuation enough to separate abnormal from normal parenchyma. Attenuation measurements are also vulnerable to confounding from ROI placement, beam hardening, body habitus, scanner factors, and coexisting parenchymal processes [6-8,16]. MRI-PDFF, by contrast, directly quantifies fat proton signal and is considerably more sensitive to early fat accumulation [9-14,19,20].

An additional practical observation from this study is that CT appeared to detect mild steatosis reliably only when MRI-PDFF approached approximately 10-12%. This threshold effect helps explain why CT classified many MRI-positive donors as normal and supports the concept that CT is most useful once fat burden becomes more substantial. The substantial agreement observed for moderate steatosis and perfect concordance in the single severe case are consistent with this behaviour and with prior imaging literature showing improved CT performance at higher fat fractions [7,8,23,24].

Despite these limitations, CT remains valuable in donor work-up. It is fast, widely available, and indispensable for anatomic evaluation, vascular mapping, and volumetry. The results of this study do not argue against CT in donor assessment; rather, they define its appropriate role. CT is useful for identifying advanced fatty infiltration and for comprehensive structural assessment, but it should not be the sole imaging test when precise quantification of early or borderline steatosis is important for donor selection decisions.

MRI-PDFF offers several advantages that are especially relevant in transplant imaging: whole-liver coverage, excellent reproducibility, absence of ionizing radiation, and improved sensitivity for mild disease. Incorporating MRI-PDFF into donor algorithms may reduce uncertainty in borderline cases and decrease dependence on

biopsy while preserving donor safety. In resource-constrained settings where universal MRI may not be feasible, CT can still serve as an initial screen, but equivocal or clinically important low-grade cases should undergo MRI-PDFF correlation.

The exploratory association between metabolic comorbidities and higher MRI-PDFF grades also deserves mention. Although subgroup counts were small, the descriptive plots were directionally consistent with current understanding of fatty liver biology. Even so, the screened donor population in this study remained largely clustered within the mild range, emphasizing how subtle steatosis can persist despite donor candidacy and apparently favourable clinical selection.

## Limitations

This study has several limitations. First, histopathologic correlation was not available because liver biopsy is not routinely justified in healthy donor candidates; MRI-PDFF was therefore used as the non-invasive reference standard. Second, the cohort was intentionally selective, producing very few moderate and severe cases and limiting subgroup inference. Third, this was a single-centre study using scanner-specific acquisition parameters, which may limit generalizability. Finally, grade-wise mild-steatosis analysis was affected by marked class imbalance because MRI-PDFF identified only four non-mild cases.

## Conclusions

Unenhanced CT significantly underestimates hepatic steatosis in prospective living liver donors, particularly in very early and mild disease. MRI-PDFF is more sensitive and should be favoured when accurate fat quantification is required for donor selection or when CT findings are borderline or discordant with clinical suspicion. CT remains an important component of donor imaging for structural assessment and performs well in moderate and severe steatosis, but it should not be relied upon as a standalone tool for precise grading of low-level hepatic fat.

# Abbreviations

CT: Computed tomography; MRI: Magnetic resonance imaging; MRI-PDFF: Magnetic resonance imaging-proton density fat fraction; NPV: Negative predictive value; PDFF: Proton density fat fraction; PPV: Positive predictive value; ROI: Region of interest; SPSS: Statistical Package for the Social Sciences.

# Declarations

The manuscript does not contain identifiable patient information, and all imaging data were anonymized prior to analysis and figure preparation.

## Ethics approval and consent to participate

This study was approved by the Thesis Dissertation Review Committee (scientific, ethical and financial), Amrita Institute of Medical Sciences and Research Centre, Kochi, Kerala, India. Written informed consent was obtained from all participants before inclusion in this prospective study. All procedures were performed in accordance with institutional ethical standards and the Declaration of Helsinki. Approval/reference number: ECASM-AIMS-2024-431

## Consent for publication

Not applicable.

## Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request, subject to institutional and ethical regulations.

## Competing interests

The authors declare that they have no competing interests.

## Funding

No funding was received for this study.

## Authors' contributions

GS contributed to study conception and design, data collection, image analysis, data interpretation, and drafting of the manuscript.

MK contributed to data interpretation and critical revision of the manuscript for important intellectual content.

SKP contributed to study supervision, data interpretation, and critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript.

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# Figure legends

Figure 1. Distribution of the study cohort by sex.

Figure 2. Age distribution of prospective living liver donors.

Figure 3. CT-based grading distribution of hepatic steatosis.

Figure 4. MRI-PDFF-based grading distribution of hepatic steatosis.

Figure 5. Comparison of CT and MRI-PDFF steatosis grade counts.

Figure 6. Exploratory distribution of MRI-PDFF grades across donor comorbidities.

Figure 7. Relationship between MRI-PDFF values and CT detection threshold.

Figure 8. Representative donor categorized as CT grade 0 but MRI-PDFF mild steatosis.

Figure 9. Representative donor with CT grade I and MRI-PDFF mild steatosis.

Figure 10. Representative donor with CT grade II and MRI-PDFF moderate steatosis.

Figure 11. Representative donor with CT grade III and MRI-PDFF severe steatosis.

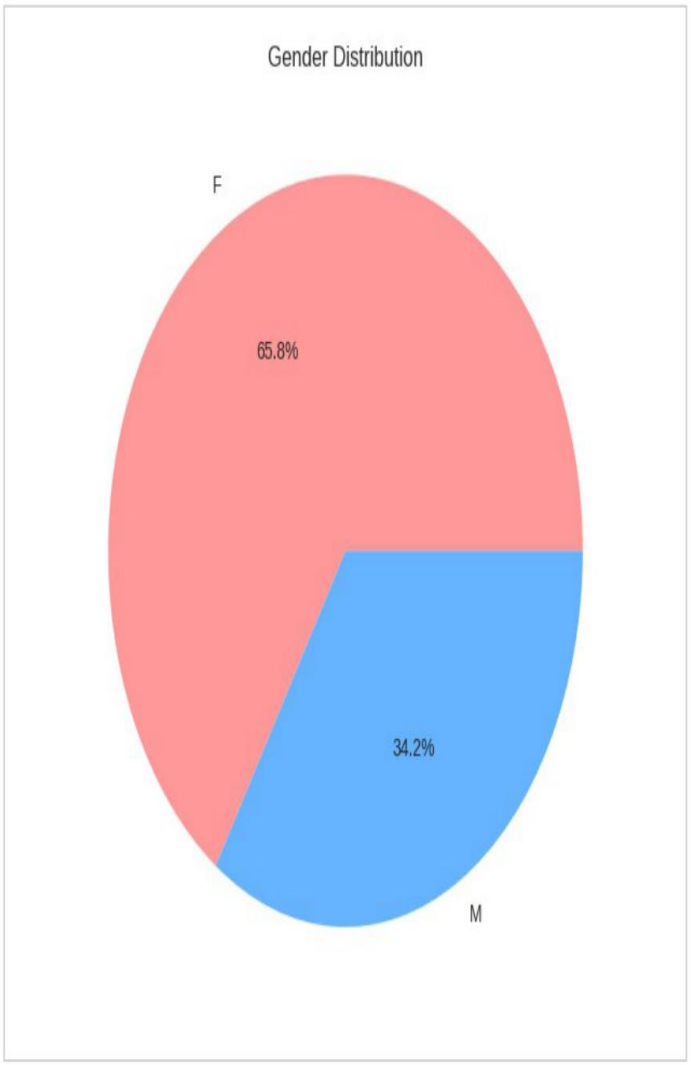
Figure 12. Whole-liver MRI segmentation used for MRI-PDFF assessment.

Figure 13. Voxel-wise histogram of MRI-PDFF and R2* values.

# FIGURES AND TABLES

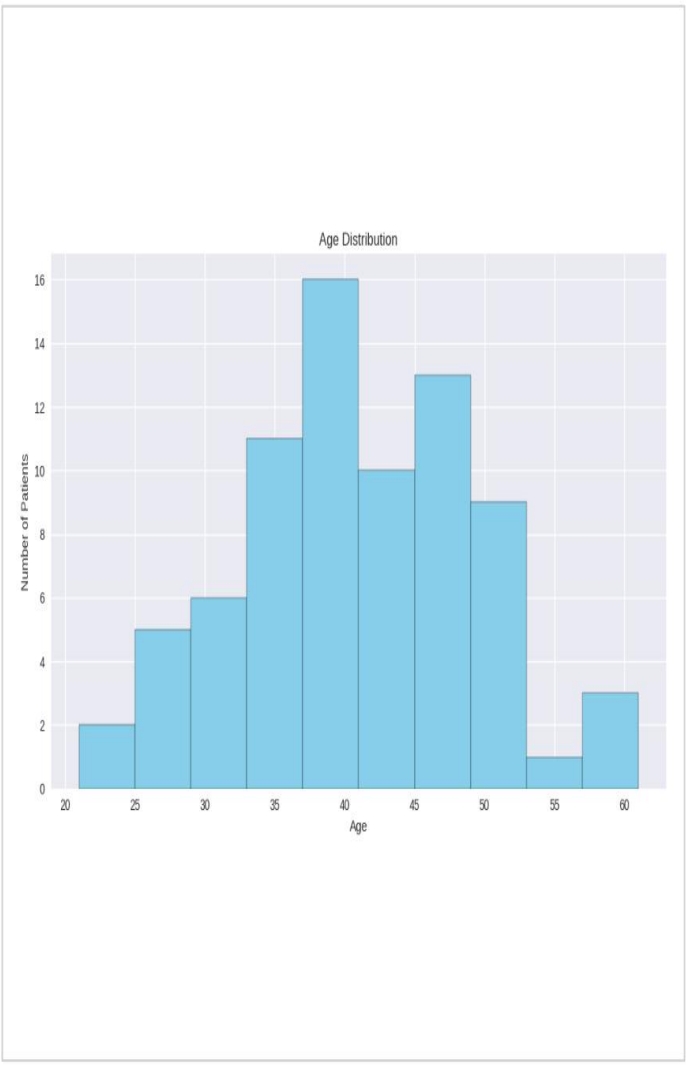
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**FIGURE 1**




Distribution of the study cohort by sex.

**FIGURE 2**

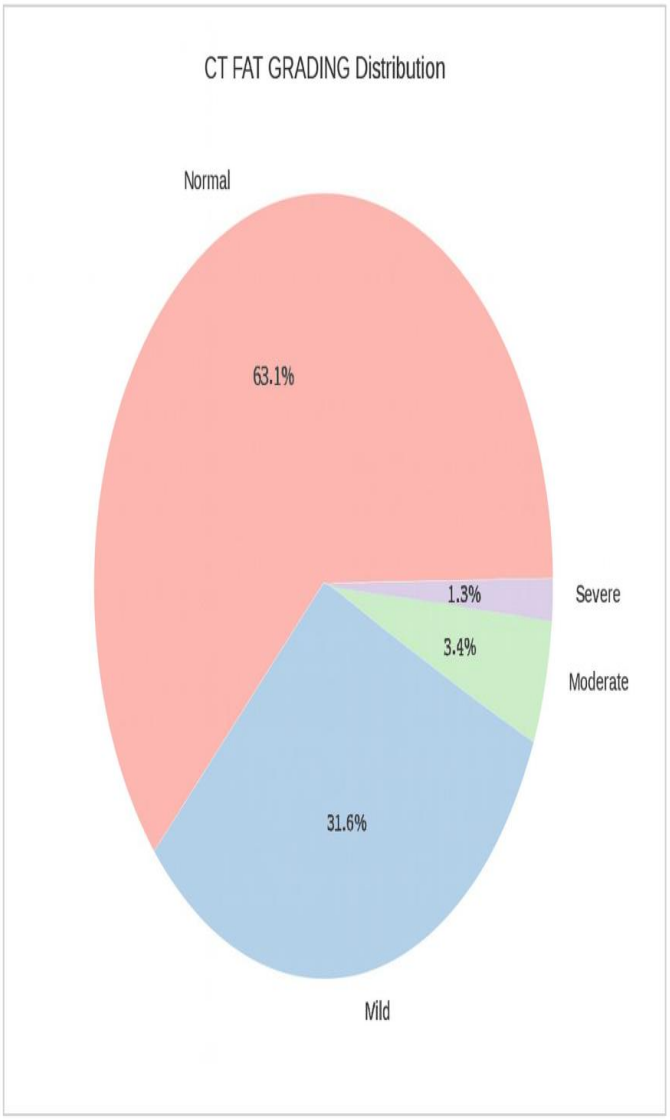



Age distribution of prospective liver donors.

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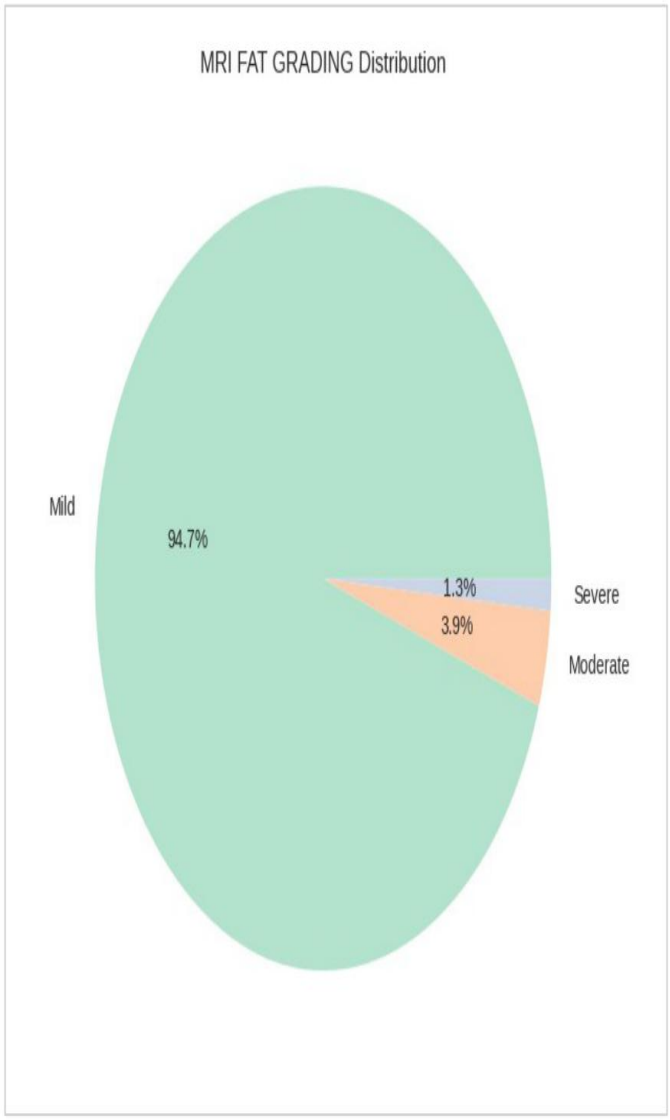
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**FIGURE 3**




CT-based grading distribution of hepatic steatosis.

**FIGURE 4**



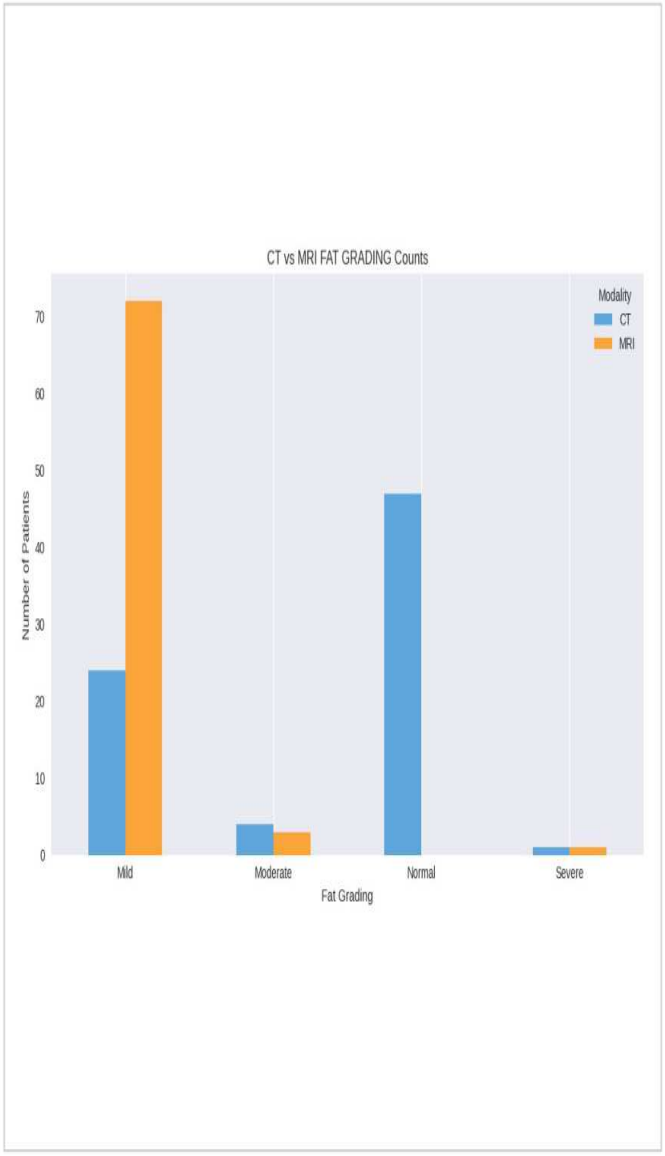

MRI-PDFF-based grading distribution of hepatic steatosis.

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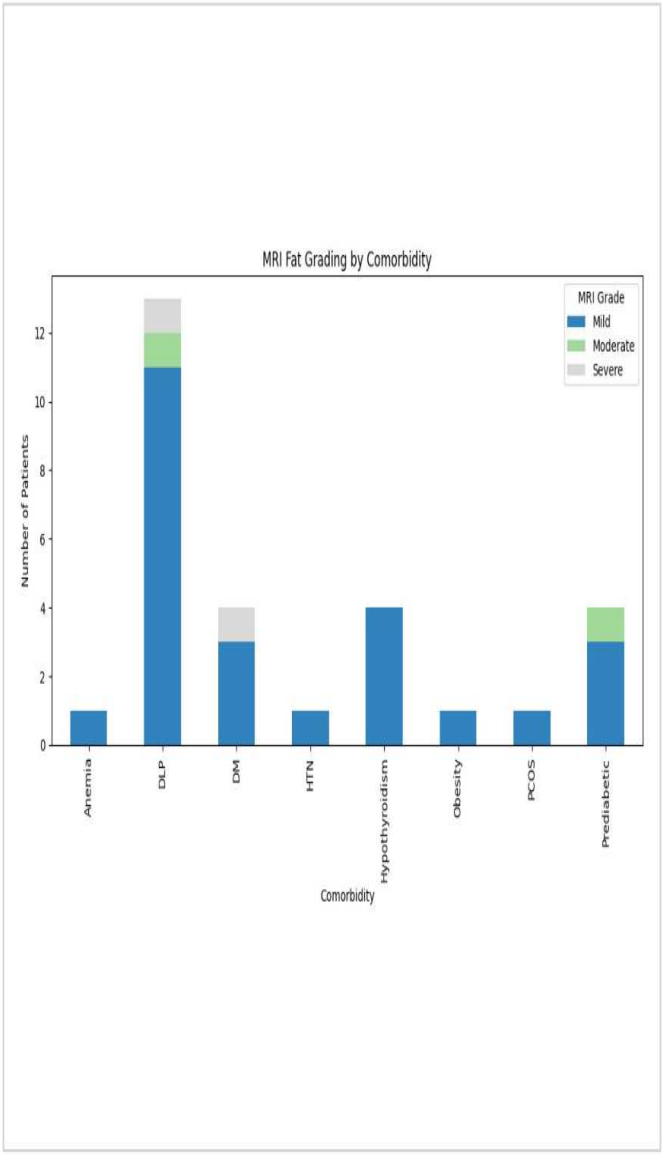
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FIGURE 5




Comparison of CT and MRI-PDFF steatosis grade counts.

FIGURE 6

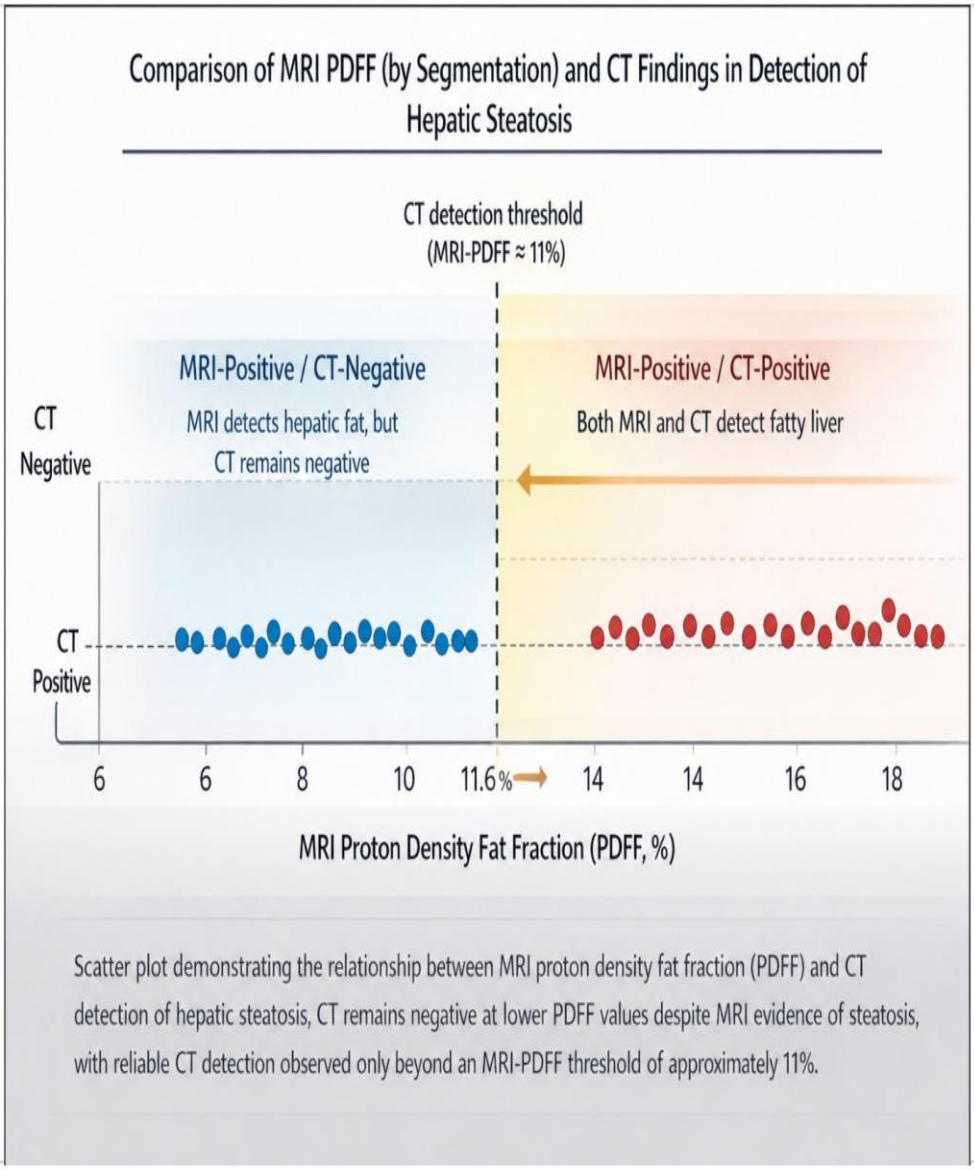



Exploratory distribution of MRI-PDFF grades across comorbidities.

3

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**FIGURE 7**




CT remained negative at lower MRI-PDFF values and began to detect steatosis more consistently once MRI-PDFF approached approximately 10-12%.

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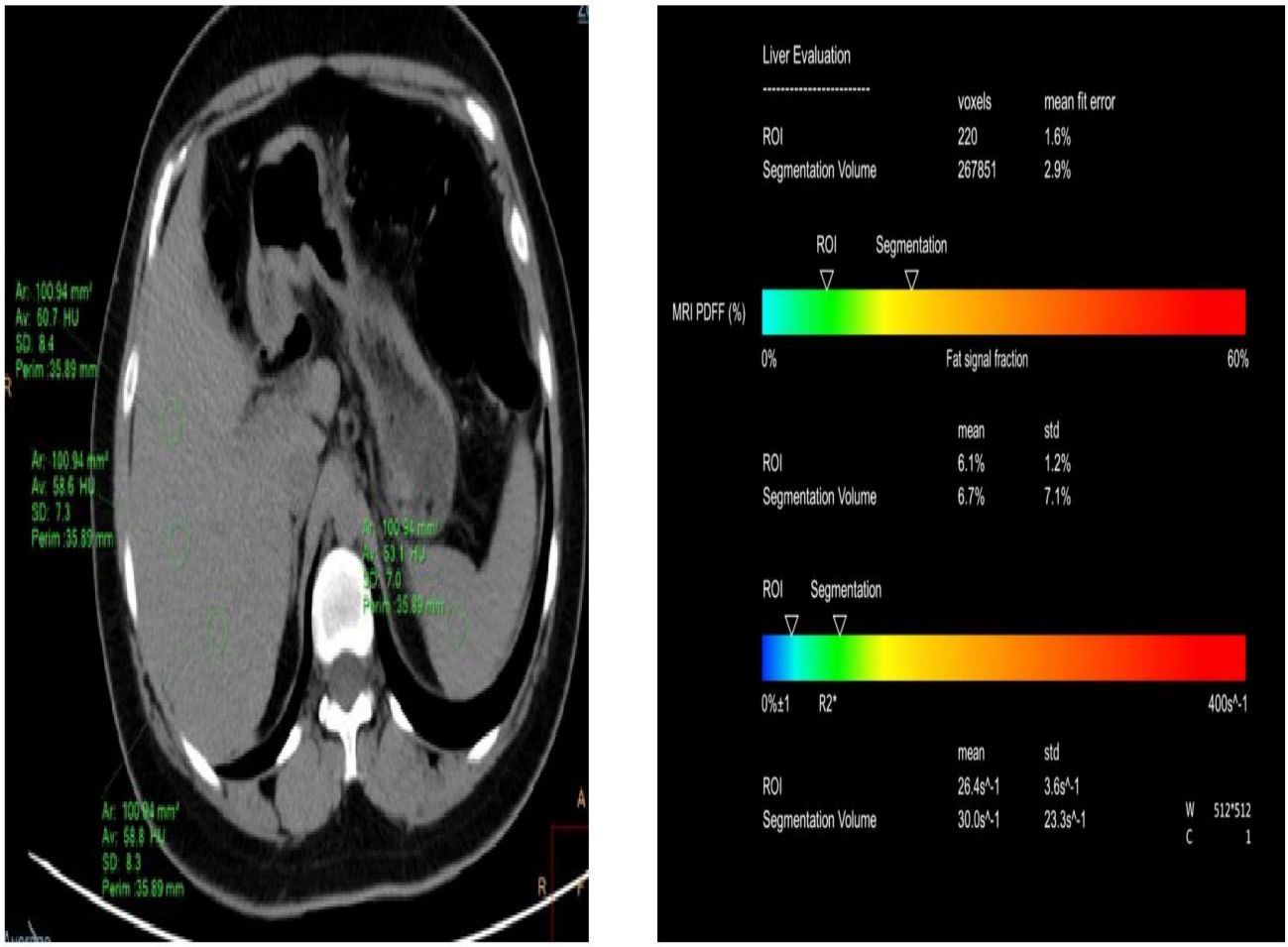
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# FIGURE 8

## CT grade 0 with MRI-PDFF mild steatosis



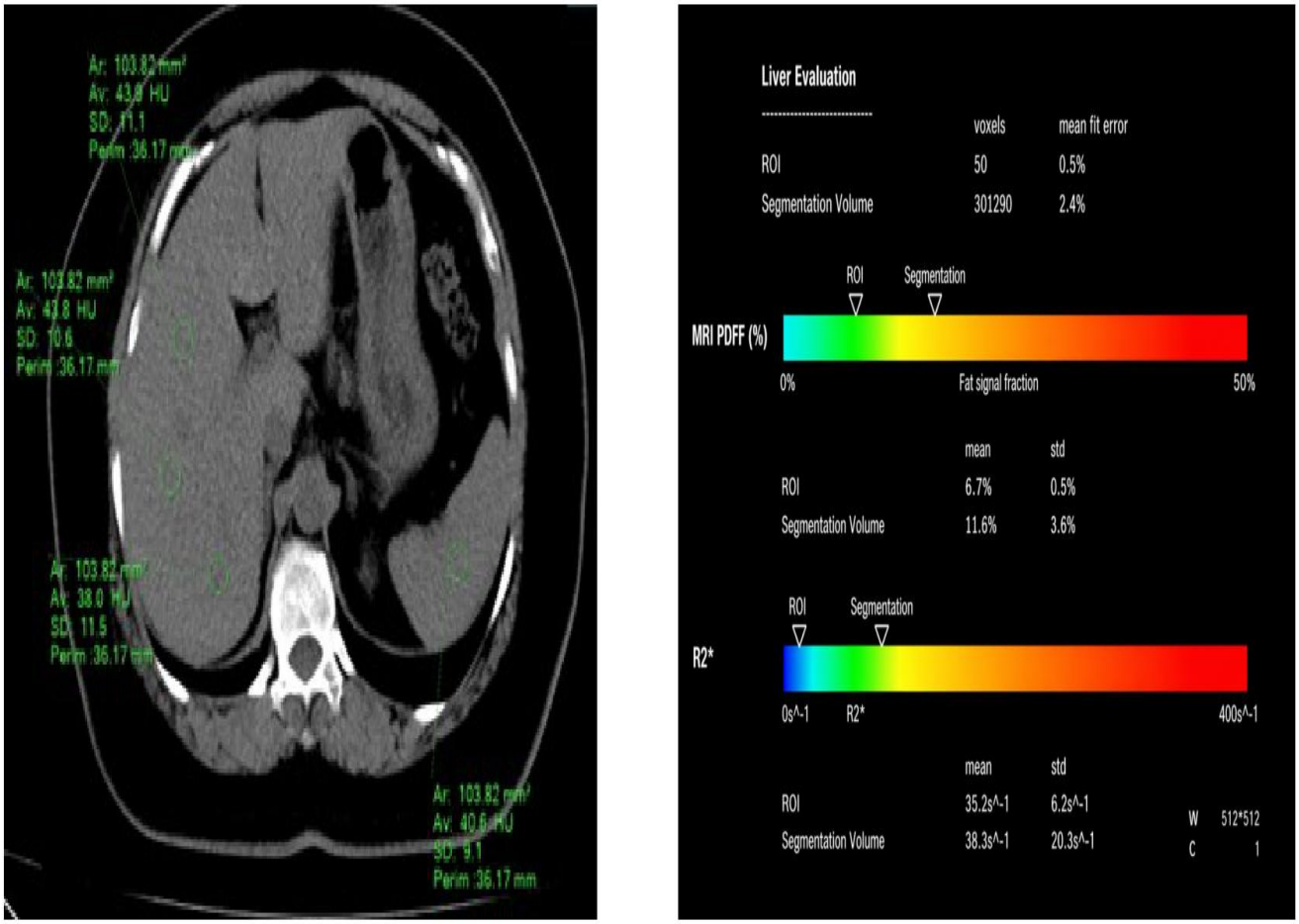

Unenhanced CT with ROI sampling (left) and corresponding MRI-PDFF summary (right).

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## FIGURE 9

CT grade I with MRI-PDFF mild steatosis



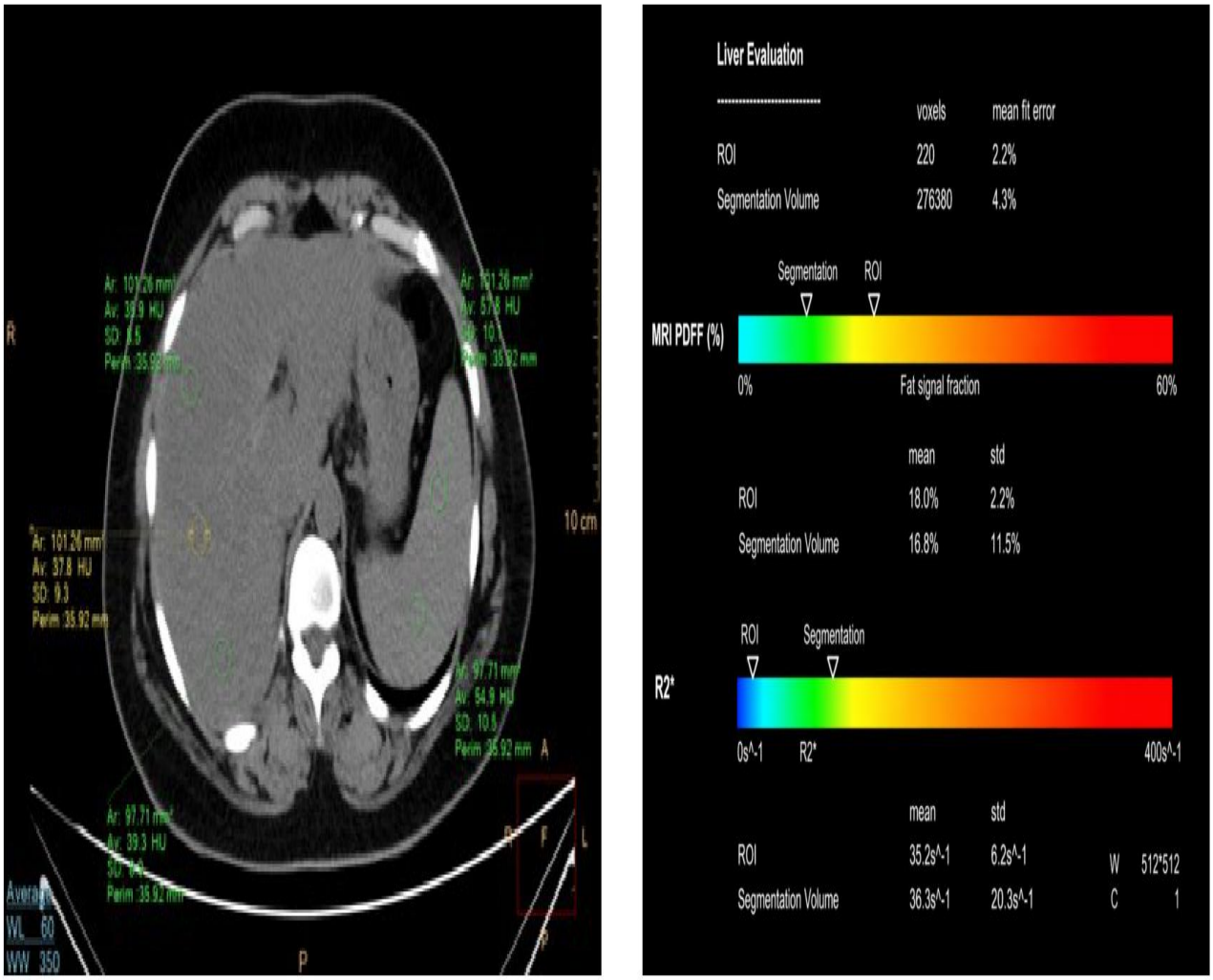

CT and MRI-PDFF findings in a donor with low-grade fatty infiltration.

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# FIGURE 10

CT grade II with MRI-PDFF moderate steatosis



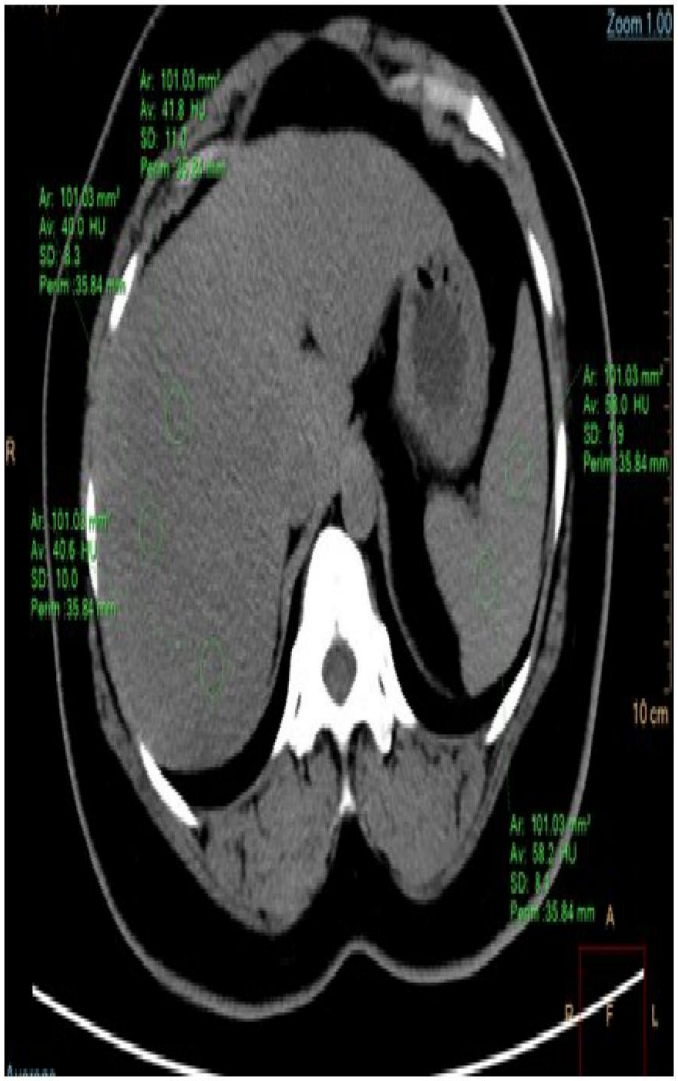

Representative concordant moderate steatosis case on CT and MRI-PDFF.

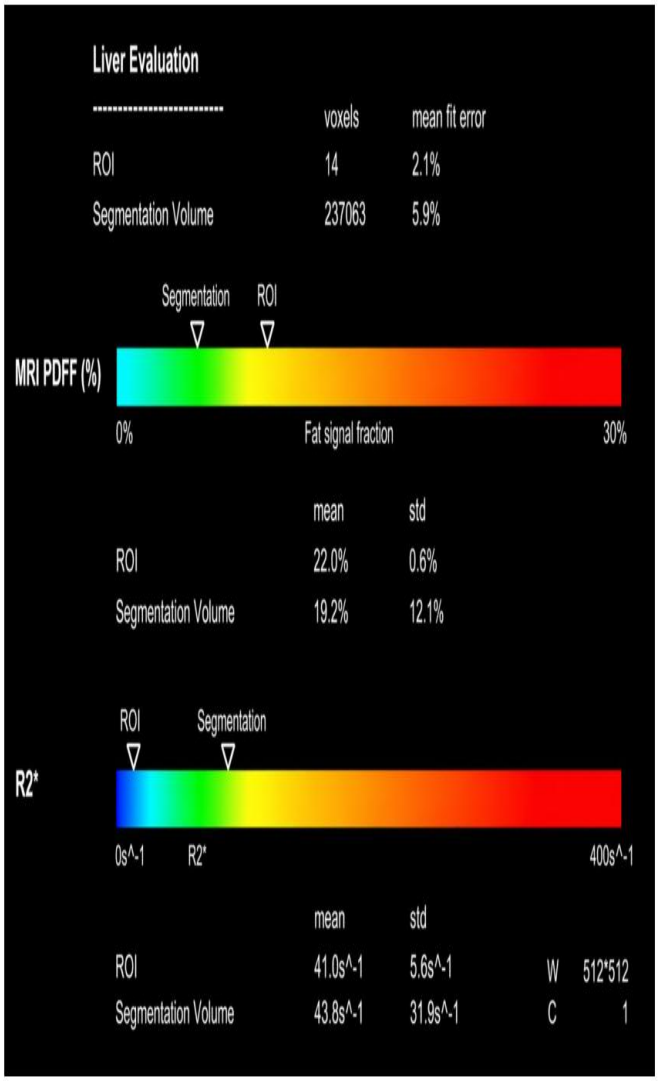


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# FIGURE 11

CT grade III with MRI-PDFF severe steatosis



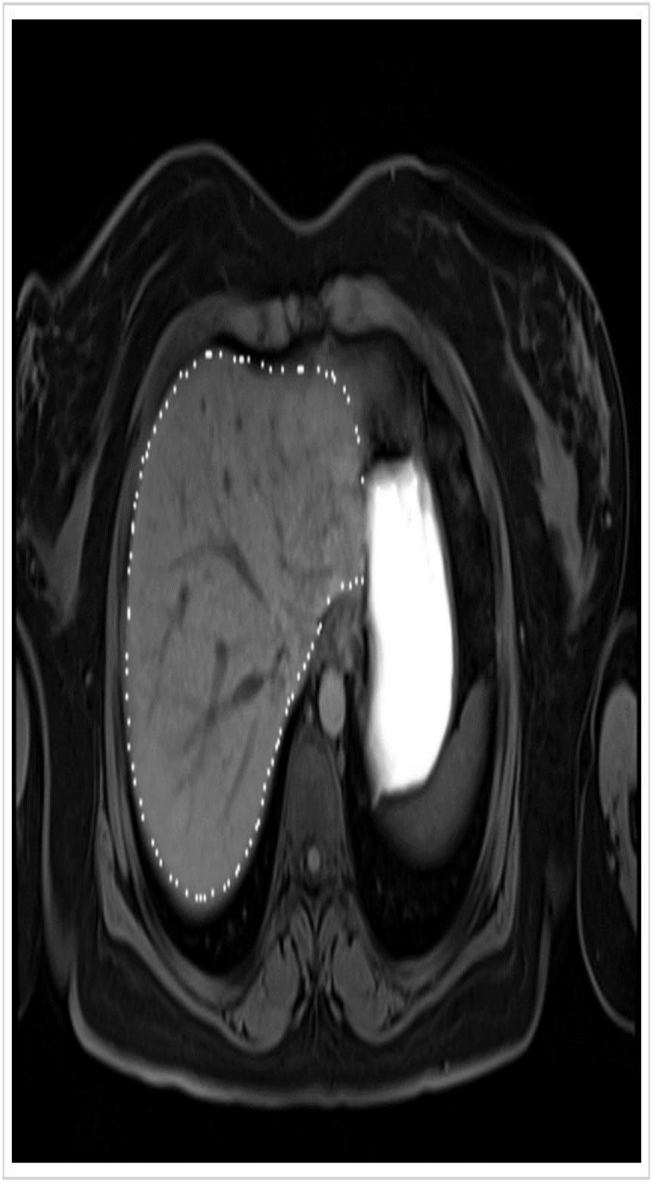




Representative severe steatosis case with concordant CT and MRI-PDFF findings.

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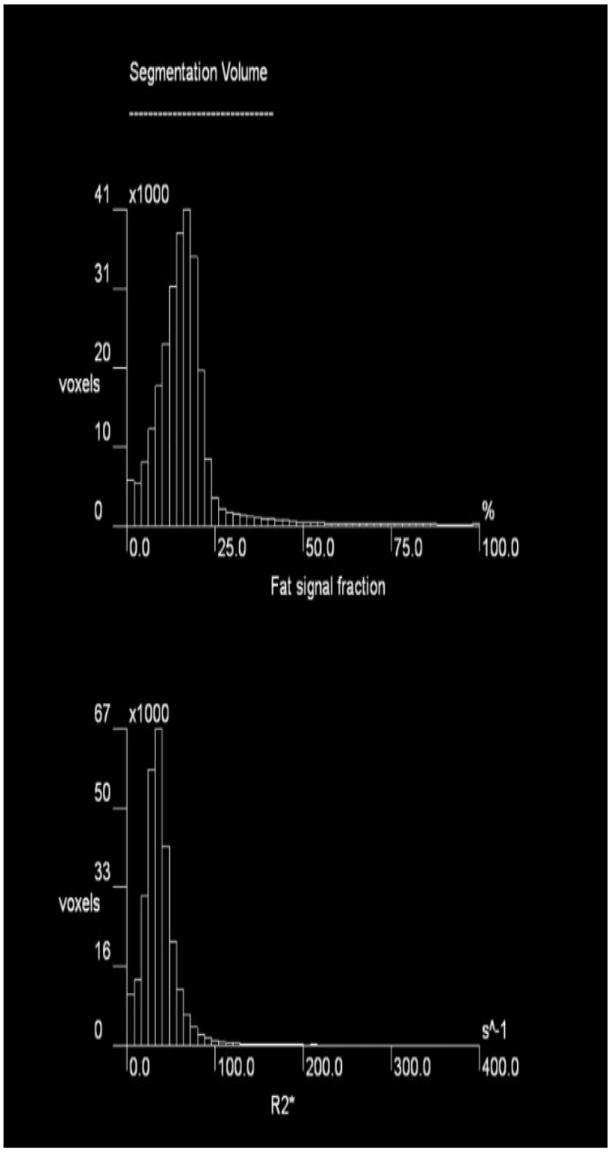
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FIGURE 12



Whole-liver segmentation used for MRI-PDFF assessment.

FIGURE 13




Voxel-wise histogram of fat signal fraction and R2* values.



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# FIGURE LEGENDS


• • Figure 1. Distribution of the study cohort by sex.
• Figure 2. Age distribution of prospective liver donors.
• Figure 3. CT-based grading distribution of hepatic steatosis.
• Figure 4. MRI-PDFF-based grading distribution of hepatic steatosis.
• Figure 5. Comparison of CT and MRI-PDFF steatosis grade counts.
• Figure 6. Exploratory distribution of MRI-PDFF grades across donor comorbidities.
• Figure 7. Relationship between MRI-PDFF values and CT detection threshold.
• Figure 8. Representative donor categorized as CT grade 0 but MRI-PDFF mild steatosis.
• Figure 9. Representative donor with CT grade I and MRI-PDFF mild steatosis.
• Figure 10. Representative donor with CT grade II and MRI-PDFF moderate steatosis.
• Figure 11. Representative donor with CT grade III and MRI-PDFF severe steatosis.
• Figure 12. Whole-liver MRI segmentation for PDFF assessment.
• Figure 13. Voxel-wise histogram of MRI-PDFF and R2* values.




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