

## Supplementary Material

### Standardized T1 quantification

Effect of T1 standardization on the COVERSCAN dataset using the scanner-referenced T1 (srT1) methodology is shown in figure S5.

### MRI Protocol

The volumetric scan provides sufficient contrast and spatial resolution for organ delineation. The 2D acquisitions were oriented axially or obliquely during imaging depending on the pancreas positioning. Details are shown in supplementary table S2.

|                                     | 3D Dixon VIBE                      |                                    | 2D MOLLI srT1                               |   |
|-------------------------------------|------------------------------------|------------------------------------|---|---|
|                                     | 1.5T                               | 3T                                 | 1.5T  | 3T  |
| FOV (mm)                            | 380 x 309                          | 440 x 440                          | 440 x 330                                   | 440 x 330                                   |
| Matrix Size                         | 320 x 195 x 40<br>(320 x 260 x 80) | 224 x 224 x 36<br>(224 x 224 x 72) | 192 x 144<br>(384 x 288)                    | 192 x 144<br>(384 x 288)                    |
| In-Plane Resolution (mm)            | 1.19 x 1.58<br>(1.19 x 1.19)       | 1.96 x 1.96                        | 2.29 x 2.29<br>(1.15 x 1.15)                | 2.29 x 2.29<br>(1.15 x 1.15)                |
| Slice Thickness (mm)                | 8 (4)                              | 8 (4)                              | 8<br>1 slice                                | 8<br>1 slice                                |
| Flip Angle (°)                      | 10                                 | 9                                  | 35  | 35  |
| TE/ $\Delta$ TE/TR (ms)             | 2.39/2.38/6.54<br>2 echoes         | 1.23/1.23/3.8<br>2 echoes          | 1.97/–/4.76                                 | 1.05/–/2.43                                 |
| Parallel Imaging                    | CAIPIRINHA 2 x 2                   | CAIPIRINHA 2 x 2                   | GRAPPA 2                                    | GRAPPA 2                                    |
| Partial Fourier Factor              | Phase: 7/8<br>Slice: 7/8           | –                                  | 6/8   | 6/8   |
| MOLLI TI (ms) for 60 bpm heart rate | –                                  | –                                  | 146, 226, 306,<br>1146, 2146,<br>3146, 4146 | 100, 180, 260,<br>1100, 2100,<br>3100, 4100 |
| MOLLI readout duration (ms)         | –                                  | –                                  | 516.96                                      | 373.10                                      |
| MOLLI Acquisition Scheme            | –                                  | –                                  | 5(1)1(1)1                                   | 5(1)1(1)1                                   |

Table S2. Typical acquisition parameters for pancreas MRI scans. Values in parentheses represent reconstructed parameters (if different from the acquisition parameters).

## Description of manual method

All analyses were reviewed by one of two senior analysts with 3+ years' experience, and a quality assurance team with radiography background was available for image quality queries.

The ROIs were placed avoiding the pancreatic duct, imaging artefacts or any partial volume effects. The volumetric scan was used when needed to check for partial volume effects from surrounding organs and structures (e.g. stomach, bowel, or visceral adipose tissue).

Upon further inspection, 4% of the total 708 scans had one ROI placed on the srT1 map; 6% had two ROIs, and 90% had three ROIs.

For inter-operator agreement, two readers independently analyzed all datasets. One reader processed all datasets twice to obtain intra-operator agreement. Scan-rescan agreement was obtained by comparing the analyses of one reader on the two repeat scans.

## Description of semi-automated method: 2D mask refinement

Pixels with poor T1 numerical fits were excluded from the 2D mask. An R-Squared map had been derived as part of the T1 mapping step. Only pixels with R-Squared  $\geq 0.99$  were kept for subsequent processing and quantification.

Additional thresholding was applied to minimise the inclusion of non-parenchymal tissues such as pancreatic ducts and visceral fat intrusions, with pixels of srT1 values of  $< 400$  ms or  $> 1200$  ms being excluded from the 2D mask, similarly to (1). The package scikit-image version 0.19.3 was then used to perform morphological image opening (erosion following by dilation). A cross-shaped structuring element of 3-by-3 pixels (morphology.disk with radius=1) was used in the morphological image opening operation (morphology.binary\_opening). An illustration of this process is shown in supplementary figure S6.

## Comparison of manual ROIs, manual delineations, and automated segmentations

A subset of 100 datasets from the COVERSCAN cohort were selected to explore whether the systematic difference between manual ROIs and automated segmentations could be attributable to ROI sampling effects. For this exploration, the manual delineations generated

using the first step of the manual method (see **Description of manual method** in main text) were used. The extracted median srT1 from manual delineations was compared to (a) median srT1 from manual ROIs and to (b) median srT1 from automated segmentations. Results are shown in **Figure 3** of main text.

## Development of automated quality control: Linear regression model

Seven manually selected QC features were computed using the 2D mask:  $x$  and  $y$  coordinates of the centroid of the 2D mask, number of connected components in the 2D mask, area in number of pixels of the 2D mask, standard deviation of srT1 values within the 2D mask, inter-quartile range (IQR) of srT1 values within the 2D mask, and median srT1 value within the 2D mask. These features were designed to capture segmentation failures (e.g. centroid coordinates, area, number of connected components) as well as highly heterogeneous srT1 presentations (e.g. standard deviation, IQR) that would be more susceptible to ROI sampling effects, and therefore potentially lead to higher disagreement with a segmentation-based approach.

The linear regression model was trained using MATLAB R2022b (The MathWorks, Inc., Natick, MA). The target variable to predict for the regression model was the absolute srT1 difference between the manual and semi-automatic methods, where the semi-automatic results were generated *without* the automated QC step (manual\_vs\_auto\_diff\_abs). Model building was performed on the training set using 10-fold cross-validation, the default hyperparameters and principal component analysis (PCA) disabled.

The linear regression model is represented by the equation of the form:

$$\text{manual\_vs\_auto\_diff\_abs} = \beta_0 + \beta_1 \cdot x_1 + \beta_2 \cdot x_2 + \beta_3 \cdot x_3 + \beta_4 \cdot x_4 + \beta_5 \cdot x_5 + \beta_6 \cdot x_6 + \beta_7 \cdot x_7$$

where  $\beta_i$  are the estimated coefficients and  $x_i$  are the predictor variables.

The obtained coefficients for the given predictors were:

- $\beta_0$  (Intercept) = -13.477
- $\beta_1$  for  $x_1 = \text{qc\_st1\_mask2d\_centroid\_x}$  = 0.082554
- $\beta_2$  for  $x_2 = \text{qc\_st1\_mask2d\_centroid\_y}$  = -0.13
- $\beta_3$  for  $x_3 = \text{qc\_st1\_num\_connected\_components}$  = -0.28113

- $\beta_4$  for  $x_4 = \text{qc\_st1\_std2} = -0.031709$
- $\beta_5$  for  $x_5 = \text{qc\_st1\_area\_pixels} = -0.00021907$
- $\beta_6$  for  $x_6 = \text{qc\_st1\_iqr} = 0.047315$
- $\beta_7$  for  $x_7 = \text{qc\_st1\_median} = 0.035855$

This equation was used to predict the value of `manual_vs_auto_diff_abs` based on the given predictors.

## References

1. Al-Mrabeh A, Hollingsworth KG, Steven S, Tiniakos D, Taylor R: Quantification of intrapancreatic fat in type 2 diabetes by MRI. PLoS One 2017; 12:1–19.