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The early impact of bariatric surgery on metabolic dysfunction-associated steatotic liver disease (MASLD) as assessed by fibroscan at 6 months postoperatively

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MASLD is very common in patients with severe obesity. Fibroscan offers a non-invasive method of detecting and monitoring MASLD. This study aimed to assess the impact of bariatric surgery on MASLD using Fibroscan. Between November 2022 and December 2024, 165 patients undergoing bariatric surgical intervention were prospectively offered Fibroscan preoperatively and at six months postoperatively (mean 7 ± 1 months) if they had sonographic evidence of MASLD. Patient demographics, total weight loss percentage (TWL%), pre and postoperative BMI, Liver Stiffness Measurement (LSM), Controlled Attenuation Parameter (CAP) and associated medical problems were assessed. Based on validated studies and EASL clinical practice guidelines, a CAP score greater than 240 dB/m was defined as hepatic steatosis and LSM of greater than 7 kPa was defined as hepatic fibrosis for this study. Resolution of MASLD and hepatic fibrosis refers to the normalisation of CAP and LSM scores respectively and does not imply histological resolution. A total of 111 patients underwent pre- and postoperative Fibroscan. Preoperatively, the mean weight ± SD was 141 ± 25 kg and BMI was 49 ± 7 kg/m^2. By 7 ± 1 months postoperatively, the mean weight loss was 43 ± 26 kg and TWL% was 27.6 ± 7% ($p < 0.001$). Preoperatively, MASLD decreased from 100%(111) to 61%(68) by 7 ± 1 months postoperatively ($p < 0.001$). Hepatic fibrosis decreased from 41%(45) to 8%(9) ($p < 0.001$). The mean reduction in CAP was 26% ($p < 0.001$) and the mean reduction in LSM was 33% ($p < 0.001$). Of eighteen patients with severe fibrosis (LSM > 12 kPa) 72% (13) demonstrated resolution by 7 ± 1 months postoperatively ($p = 0.002$). Bariatric surgery was associated with an improvement and, in many cases, total regression of MASLD by seven months postoperatively. Fibroscan may help identify nonresponders with persistently elevated CAP and LSM, who may benefit from additional weight loss measures including pharmacotherapy when weight loss has plateaued between 12 and 18 months postoperatively.

Metabolic dysfunction-associated steatotic liver disease (MASLD), previously termed non-alcoholic fatty liver disease, has emerged as a significant global health concern, paralleling the rising rates of obesity and metabolic disorders. It is defined as hepatic steatosis confirmed by imaging or biopsy, in the presence of at least one cardiometabolic risk factor, including obesity[1]. It is the most common cause of chronic liver disease worldwide, with a global prevalence of 30%, rising to 80–90% among adults with obesity[2,3]. Risk factors include type 2 diabetes mellitus (T2DM), obesity, hypertension (HTN) and obstructive sleep apnoea (OSA). MASLD encompasses a wide spectrum of conditions including hepatic steatosis, hepatic fibrosis, metabolic dysfunction-associated steatohepatitis (MASH) and hepatocellular carcinoma. It is also associated with an increased risk of cardiovascular disease, chronic kidney disease and extrahepatic cancers, particularly gastrointestinal cancer[4,5]. This highlights the significant economic and health burden of this multisystem disease.

Weight loss is the cornerstone of MASLD treatment. Current EASL guidelines recommend aiming for a sustained weight loss of ≥ 5% to reduce liver fat and ≥ 10% to improve fibrosis[6]. Recently, pharmacological and surgical options have emerged as effective treatments for MASLD.

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In 2024, resmetirom became the first medication approved by the Food and Drug Administration for treating noncirrhotic MASH and moderate to advanced hepatic fibrosis[7]. It is an oral thyroid hormone receptor beta-selective agonist which was shown to result in 25–30% steatosis resolution and approximately 25% reduction in liver fibrosis after 1 year[8]. More recently, interim analysis of a phase 3 trial assessing the GLP-1 receptor agonist semaglutide in the treatment of MASH has shown approximately 63% resolution of steatosis and 37% reduction in fibrosis following weekly administration of semaglutide for 72 weeks[9].

In adults with non-cirrhotic MASLD who meet the accepted criteria, bariatric surgery should be considered[9]. According to current practice guidelines, metabolic and bariatric surgery is recommended for individuals with a body mass index (BMI) > 35 kg/ m^2 and should be considered for individuals with Class I obesity (BMI 30–34.9 kg/m2) and T2DM[10]. Total weight loss percentage (TWL%) of at least 10% has been associated with the regression of liver fibrosis in 45% of patients[11]. Thus, bariatric surgery has emerged as a potential therapy not only for obesity but also for MASLD. It leads to significant and sustained weight loss, reducing the risk of obesity-related medical problems and complications, such as MASH and cardiovascular disease. While the EASL do not recommend one type of bariatric surgical intervention over another, Roux-en-Y gastric bypass resulted in the highest proportion of MASLD improvement compared to sleeve gastrectomy and gastric banding[12].

The EASL recommends the use of non-invasive methods in the screening, evaluation, and prognostication of MASLD[6]. Fibroscan is an accurate, non-invasive tool which uses Controlled Attenuation Parameter (CAP) and Liver Stiffness Measurement (LSM) to quantify hepatic steatosis and hepatic fibrosis respectively.

The reliability of Fibroscan has been extensively validated against liver biopsy. A CAP value of > 240 decibels per meter (dB/m) value corresponds to the presence of steatosis in > 5% of hepatocytes[13]. Several studies have demonstrated that an LSM value between 7 and 12 kPa is associated with liver fibrosis, and LSM > 12 kPa is associated with a high likelihood of advanced fibrosis with a positive predictive value of 0.71 and possible cirrhosis with a positive predictive value of 0.41[14,15]. Based on these studies and in conjunction with EASL clinical practice guidelines, a CAP score greater than 240dB/m was defined as hepatic steatosis and LSM of greater than 7 kPa was defined as hepatic fibrosis for this study. Similarly, an LSM of greater than 12 kPa was considered to be advanced hepatic fibrosis with possible cirrhosis.

The objective of this study was to prospectively evaluate the impact of bariatric surgery on MASLD as defined by Fibroscan, assessing the early changes in hepatic steatosis (CAP) and fibrosis (LSM). Patients were followed up 6 months postoperatively (mean 7 ± 1 months) as they lose most of their TWL% during this postoperative period[16]. We also sought to explore factors associated with persistence of MASLD (poor responders) who may benefit from additional Fibroscan monitoring or even liver biopsy.

Methods

This is a prospective cohort study on 111 adult patients with MASLD who underwent bariatric surgery between November 2022 to December 2024. This study was approved by the Clinical Research Ethic Committee (CREC) of Cork Teaching Hospitals, Ireland, and the Bon Secours Hospital Clinical Ethics Committee Research Sub-Committee. It was performed in accordance with the ethical standards of the 1964 Helsinki Declaration. Informed consent was obtained from all individual participants included in the study.

245 Patients underwent bariatric surgery within this timeframe. 165 of these had a preoperative Fibroscan 6 months before surgery. Patients were included based on the EASL criteria for MASLD, defined as the presence of hepatic steatosis and at least one cardiometabolic risk factor, which include obesity, T2DM and hypertension[1]. 2 patients were excluded as they had a CAP < 240 dB/m. A further 52 patients with MASLD on preoperative Fibroscan declined a postoperative Fibroscan. To assess potential selection bias, baseline characteristics were compared between patients who did and did not undergo postoperative Fibroscan assessment. Of the 163 patients with confirmed MASLD preoperatively, 111 had a postoperative Fibroscan, performed at 7 ± 1 months postoperatively (Fig. 1).

Data were stored on a Microsoft Excel™ (Microsoft Corporation, Washington, USA) spreadsheet. Variables included age, sex, BMI, type 2 diabetes mellitus, obstructive sleep apnoea, hypertension, LSM, CAP and TWL%.

A Fibroscan device (Echosens, Paris, France) was utilised to evaluate hepatic steatosis and fibrosis using CAP and LSM respectively. Fibroscan was selected over Ultrasound (US) as it provides better standardised steatosis assessment than US alone[17] Additionally, US is less sensitive than Fibroscan in detecting mild steatosis[18]. Measurements were acquired following the manufacturer's guidelines and the European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) Guidelines and Recommendations on the Clinical Use of Liver Ultrasound Elastography[19]. Two operators performed all measurements. To maximise the reliability of each patient's CAP and LSM readings, ≥ 10 valid measurements were obtained by achieving a success rate ≥ 60% and an interquartile range/median ≤ 30%[20].

Resolution of hepatic steatosis was defined as CAP < 240 dB/m, based on thresholds for absence of clinically significant steatosis in prior non-invasive studies[17]. Similarly, the resolution of fibrosis was defined as LSM < 7 kPa, consistent with the absence of significant fibrosis (≥ F2) reported in meta-analyses[21,22].

For demographic measures, descriptive statistics were determined. Continuous variables were expressed as mean ± standard deviation (SD). Categorical variables were reported as the number and proportion (%) of patients. Statistical analyses were performed using SPSS v24.0 software (SPPS Inc., Chicago IL). A p value of < 0.05 was considered statistically significant.

Results

All 111 patients (100%) had MASLD preoperatively. Seventy-nine patients (71%) were female and thirty-two (29%) were male. All patients (100%) underwent Roux-en-Y gastric bypass (RYGB). The average (mean ± SD) age was 48 ± 11 years and the age range was 23–70 years. The prevalence of associated medical problems among

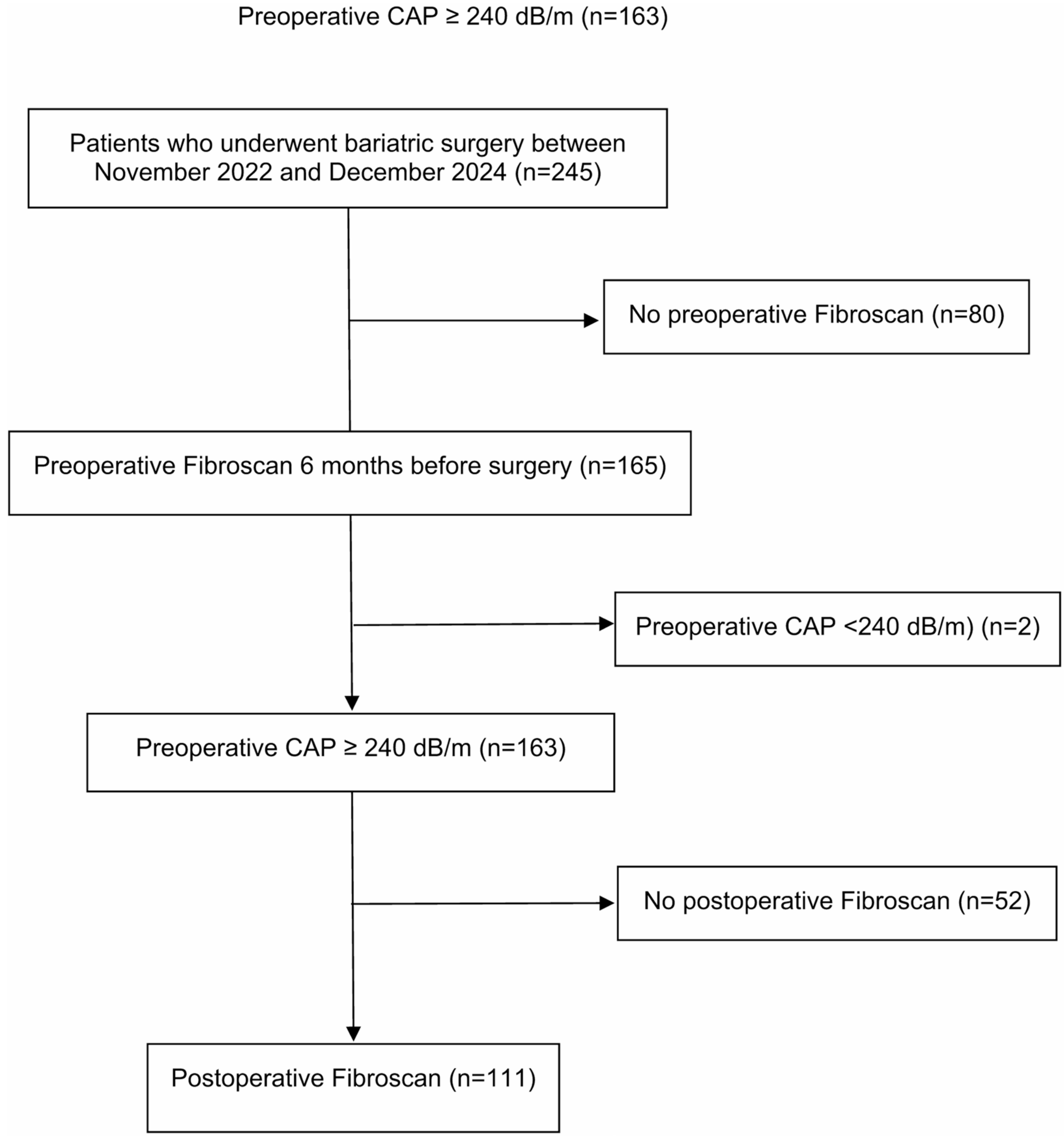

Fig. 1. Flowchart of the sample selection.

this cohort were also noted. Forty-eight (43%) patients had hypertension, twenty-three (21%) had type 2 diabetes mellitus (T2DM), and sixty-two (56%) had obstructive sleep apnoea (OSA). Spearman's rank correlation showed a statistically significant positive association between preoperative BMI and CAP score ($\rho = 0.23$, $p = 0.032$). There was a stronger positive correlation between preoperative BMI and LSM score ($\rho = 0.32$, $p = 0.0019$).

The mean preoperative weight was 142 ± 25 kg. The average weight loss was 43 ± 26 kg and the average total weight loss percentage (TWL%) was 27.6 ± 7% ($p < 0.001$). The mean BMI decreased from 49 ± 7 kg/m^2 preoperatively to 35 ± 6 kg/m^2 7 ± 1 months postoperatively ($p < 0.001$). There was a significant departure from normal data distribution of weight change, W(112) = 0.82, $p < 0$ 0.001). Bariatric surgery elicited a statistically significant weight reduction at 7 ± 1 months (Z = −6.80, $p < 0.001$). There were no statistically significant differences in age, sex, BMI or preoperative LSM or CAP between patients who completed postoperative Fibroscan assessment ($n = 111$) and those who declined follow-up ($n = 52$) ($p > 0.05$).

The difference in Fibroscan scores is displayed in Table 1. Patients underwent postoperative Fibroscan at 7 ± 1 months postoperatively. There was a statistically significant improvement between mean pre- and post-op CAP, LSM and BMI results. The mean preoperative CAP score was 355 ± 41 dB/m and the mean preoperative LSM was 8.3 ± 6 kPa. Eighteen patients (16%) had an LSM of 12 kPa or greater and thus were deemed to have advanced liver fibrosis with possible cirrhosis. The mean postoperative CAP score was 262 ± 52 dB/m, giving a mean reduction of 26% ($p < 0.001$). The mean postoperative LSM was 5.6 ± 3.7 kPa, giving a mean reduction of 33% ($p < 0.001$).

	Before Bariatric Surgery	After Bariatric Surgery	Mean Reduction	*p* value*
CAP (dB/m)	**355 ± 41**	**262 ± 52**	**26%**	**< 0.001**
LSM (kPa)	8.3 ± 6	5.6 ± 3.7	33%	< 0.001
BMI (kg/m²)	49 ± 7	35 ± 6	28%	< 0.001
	Total (%)	Total (%)	Normalisation rate	p value**
CAP > 240	111 (100%)	68 (61%)	39%	< 0.001
LSM > 7	45 (41%)	9 (8%)	80%	< 0.001
LSM > 12	18 (16%)	5 (4.5%)	72%	0.002

Table 1. Preoperative and postoperative fibroscan scores of 111 bariatric surgery patients with MASLD. Data are presented as frequency (%) or mean (SD) CAP Controlled Attenuation Parameter; LSM Liver Stiffness Measurement; BMI Body Mass Index *Paired *t*-test or Wilcoxon signed-rank test **McNemar's test

	Persistence of MASLD	Regression of MASLD	*p* value
Number (%)	**68 (61)**	**43 (39)**	-
Female (%)	46 (67)	33 (77)	0.475**
Age ± SD	47.6 ± 10.8	48.3 ± 13.3	0.810***
TWL% ± SD	26 ± 5.3	30 ± 8.3	0.031****
HTN (%)	30 (44)	18 (42)	0.826**
T2DM (%)	15 (22)	9 (21)	1.000*
OSA (%)	33 (49)	29 (67)	0.076**

Table 2. Baseline demographic and clinical characteristics of 111 bariatric surgery patients with MASLD according to postoperative MASLD status. Data are presented as frequency (%) or mean (SD) TWL% Total weight loss percentage; HTN hypertension; T2DM type 2 diabetes mellitus; OSA obstructive sleep apnoea *Fisher's exact test. ** Chi-square test ***Independent t-test **** Mann-Whitney U test

After bariatric surgery, 59 (53%) patients demonstrated a > 25% improvement in CAP, while 51 (46%) patients demonstrated a > 25% improvement in LSM. McNemar's test found no significant difference between the two Fibroscan parameters ($p = 0.32$), suggesting that bariatric surgery was associated with broadly consistent improvements across both CAP and LSM. Using Pearson's correlation coefficient TWL% was positively correlated with reduction in CAP score ($r = 0.30$, $p = 0.004$), indicating greater weight loss was associated with greater improvement in hepatic steatosis.

As determined by abdominal ultrasound and Fibroscan, all patients (100%) had MASLD preoperatively. Postoperatively, sixty-eight (61%) had it. MASLD resolution, defined as CAP < 240 dB/m, occurred in 39% of patients by 7 ± 1 months postoperatively ($p < 0.001$). Preoperatively, forty-five (41%) had hepatic fibrosis, postoperatively only nine (8%) had hepatic fibrosis. Resolution of hepatic fibrosis, defined as LSM < 7 kPa, occurred in 80% of patients ($p < 0.001$). Advanced hepatic fibrosis (LSM > 12 kPa) resolution occurred in 72% of patients ($p = 0.002$).

Table 2 demonstrates the demographic characteristics of the study population based on the regression (excellent responders) and persistence (poor responders) of MASLD postoperatively. There were no significant differences in sex, age or prevalence of associated medical problems between those with and without postoperative MASLD ($p > 0.05$).

There was a statistically significant difference in TWL% between excellent responders and poor responders. Excellent responders achieved a markedly higher TWL% of 30 ± 8.3, compared to poor responders who achieved a TWL% of 26 ± 5.3. An independent t-test confirms the significance of this difference ($p = 0.031$).

An exploratory multivariate linear regression analysis was performed to assess whether TWL% remained independently predictive of CAP and LSM reduction, adjusting for age, sex, T2DM, OSA and hypertension (Tables 3 and 4). TWL% remained independently associated with CAP reduction.

Discussion

Bariatric surgery was observed as an extremely effective treatment for MASLD. After seven months, this cohort exceeded the expected TWL% and CAP and LSM improvement. The mean TWL% 6 months post RYGB is reported to be approximately 25%, whereas our cohort achieved a slightly higher TWL% of 27.6%[23,24]. Similarly, other studies report mean reductions of approximately 17% in CAP and 21–28% decrease in LSM 6 months following bariatric surgery[25,26]. In contrast, our cohort exhibited more pronounced improvements in these parameters with mean reductions of 26% in CAP and 33% in LSM.

We compared demographic and preoperative clinical characteristics between patients who underwent postoperative Fibroscan and those who declined. No statistically significant differences were observed in key baseline variables, including age, sex, BMI, and preoperative LSM and CAP values. Thus, limiting selection bias.

Predictor	β value	95% Confidence Interval	*p* value
TWL%	2.973	1.167–4.780	0.002
Age	0.281	-0.824–1.386	0.614
Sex (male)	14.775	-14.542–44.092	0.319
HTN (%)	1.903	-23.256–27.063	0.881
T2DM (%)	17.674	-14.687–50.035	0.280
OSA (%)	9.996	-14.810–34.802	0.425

Table 3. Exploratory multivariate linear regression assessing independent predictors of CAP reduction. $R^2 = 0.184$, overall model $p = 0.0107$. TWL% Total weight loss percentage; HTN hypertension; T2DM type 2 diabetes mellitus; OSA obstructive sleep apnoea

Predictor	β value	95% Confidence Interval	*p* value
TWL%	0.034	-0.102–0.170	0.619
Age	-0.008	-0.091–0.075	0.844
Sex (male)	1.313	-0.889–3.514	0.239
HTN (%)	-1.361	-3.251–0.528	0.155
T2DM (%)	0.160	-2.270–2.590	0.896
OSA (%)	0.020	-1.843–1.883	0.983

Table 4. Exploratory multivariate linear regression assessing independent predictors of LSM reduction. $R^2 = 0.047$, overall model $p = 0.684$. TWL% Total weight loss percentage; HTN hypertension; T2DM type 2 diabetes mellitus; OSA obstructive sleep apnoea

Exploratory multivariate analysis demonstrated that TWL% remained independently associated with improvement in hepatic steatosis as assessed by CAP. This could suggest that the magnitude of weight loss may play a key role in early MASLD improvement following bariatric surgery, independent of baseline demographic and metabolic factors. However, given the exploratory nature of this analysis and the use of non-invasive measures, these findings should be interpreted cautiously. In contrast, no independent association was observed between TWL% and reduction in LSM.

Throughout this manuscript, the term "resolution" refers to normalisation of non-invasive Fibroscan scores and does not imply histological resolution. After just 7 months, we observed a hepatic steatosis resolution rate of 39% and fibrosis resolution rate of 80%. These results are novel because of the strict application of resolution as an endpoint. Whereas existing studies report only on improvement rather than resolution at similar timepoints, reserving assessment of resolution for later stages of the follow up.

In our study, an advanced fibrosis resolution rate of 72% was observed 7 months after bariatric surgery. There is evidence to indicate that this is sustained with other studies reporting an advanced hepatic fibrosis resolution rate of 84% after 5 years[27]. These findings suggest that hepatic recovery, particularly fibrosis resolution, may be achievable at a more rapid rate than previously recognised.

Fibroscan is significantly more cost effective than routine liver biopsy for the evaluation of MASLD. In a UK model, Fibroscan-based pathways cost £1,272 per patient versus £1,679 for liver biopsy[28]. Furthermore, hospital admission following liver biopsy occurs in 1–3% of cases, with a mortality rate of around 0.2%[29,30]. Given its proven diagnostic accuracy, reproducibility and cost effectiveness as a noninvasive test, the authors chose Fibroscan over liver biopsy as the primary assessment tool.

There is currently no consensus on the performance of intraoperative and postoperative liver biopsies for MASLD in patients undergoing bariatric surgery. Fibroscan has been validated in several studies for evaluation of both MASLD and fibrosis in patients with obesity[6,31,32]. We suggest that these patients no longer require intraoperative or early postoperative liver biopsies. Indeed, our Fibroscan data are consistent with similar biopsy-based studies demonstrating statistically significant dramatic improvement in both MASLD and fibrosis in the early postoperative period.

The early postoperative period provides a meaningful opportunity to assess each patients response to bariatric surgery. A new baseline Fibroscan at 7 ± 1 months after bariatric surgery would help to identify a small sub-group of poor responders. Adjunctive GLP-1 receptor agonist therapy in patients with suboptimal weight loss has been shown to contribute to additional TWL% as well as improve biochemical markers[33]. Thus, these patients may benefit from a combination of pharmacological and surgical intervention.

A higher TWL% was observed to be a significant predictor of regression of MASLD in the early months after bariatric surgery. The absence of significant associations between other variables seems to illustrate the dominant influence of weight loss on MASLD status following bariatric surgery. While associated medical problems such as T2DM, HTN and OSA contribute to the development of MASLD, they have far less independent impact than TWL%.

Since MASLD is a progressive disease and the findings of this study reflect short-term postoperative outcomes only, longer-term longitudinal follow-up is required to determine the durability of improvements in MASLD, as well as the potential for disease relapse over time. Future studies with extended follow-up at 18–36 months and beyond will be essential to fully characterise the sustained impact of bariatric surgery on MASLD.

Limitations

There are some limitations of this study. Firstly, we acknowledge the absence of histological confirmation. Improvements observed in Fibroscan parameters reflect changes in steatosis and liver stiffness identified by a non-invasive test and should not be interpreted as histological remission. Secondly, the sample size is relatively small, hindering the generalisability of the findings. Thirdly, there is limited follow up data. However, as this is an ongoing prospective study, additional data will be collected to strengthen future analyses at 18 months and 3 years. This will include quality of life outcomes as well as serial Fibroscan measurements, particularly in the poor responders. A formal alcohol questionnaire was not completed at baseline by patients. Nonetheless, all patients included in this study did not have an alcohol consumption of > 30 g/day in men and > 20 g/day in women.

Conclusion

- In this cohort, significant improvements in MASLD and hepatic fibrosis were observed as early as 7 ± 1 months following bariatric surgery.
- Fibroscan is an invaluable tool that enables non-invasive assessment of MASLD and hepatic fibrosis, which may help in identifying excellent and poor responders.
- Liver biopsy may be considered in selected patients, especially those with persistently high CAP and LSM scores after at 7 ± 1 months postoperatively.

Data availability

The Data used and analysed during this study are available upon reasonable request to the corresponding author.

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Author contributions

WyS wrote the main manuscript text. RC, CT and CO'S collected the data allowing for it to be analysed.DO'C helped with ethical approval and statistical analysis of the data.HS, DH, WiS and CO'B revised it critically and approved the version to be published.All authors reviewed the manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Ethical approval

Ethical approval for this study was granted by the Cork Research Ethics Committee (CREC), Cork Teaching Hospitals, approved by the committee chairperson Professor Brendan Buckley. Ethical approval was also granted by the Bon Secours Hospital Clinical Ethics Committee Research Sub-Committee Sciences, approved by ethics consultant Professor David Smith and chairperson Ms. Mary Dunne. Informed consent was obtained from all individual participants included in the study.

Additional information

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