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ASSESSMENT OF THE PREDICTIVE ROLE OF NON-ALCOHOLIC FATTY LIVER DISEASE (NAFLD) GRADES IN THE DIAGNOSIS OF DIABETES MELLITUS USING ULTRASONOGRAPHY

Original Research

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ABSTRACT

Background: Non-alcoholic fatty liver disease (NAFLD) is a common hepatic condition marked by excessive fat accumulation in hepatocytes, frequently seen in individuals with metabolic disorders. It is strongly associated with insulin resistance and type 2 diabetes mellitus (T2DM), both of which are increasing globally. Ultrasonography (USG) has emerged as a non-invasive, cost-effective, and sensitive tool for identifying and grading fatty liver disease, helping predict metabolic risk. Understanding the relationship between NAFLD severity and diabetes is critical for timely clinical intervention.

Objective: To investigate the correlation between ultrasonographically graded NAFLD and the presence of diabetes mellitus.

Methods: This cross-sectional study was conducted over a 7-month period from September 2020 to April 2021 at the Radiology Departments of Aga Khan Health Services and District Headquarters Hospital Gilgit. A total of 120 patients aged above 35 years, of both sexes, presenting with fatty liver changes on USG were included. Patients were categorized into four NAFLD grades (0–III) based on echogenicity, parenchymal texture, and liver-to-kidney contrast. Random blood glucose levels were assessed to determine diabetic status. Patients with alcohol consumption, hepatotoxic medication use, hypertension, or pregnancy were excluded.

Results: Of the 120 participants, 58 were male and 62 were female, with a mean age of 59.6 years. A total of 90 patients (75%) were diagnosed with diabetes mellitus. The prevalence of diabetes increased progressively with fatty liver grade: 3 out of 19 (15.8%) in grade 0, 25 out of 31 (80.6%) in grade I, 32 out of 37 (86.5%) in grade II, and 30 out of 33 (90.9%) in grade III. Chi-square analysis showed a statistically significant association ($p < 0.001$) between NAFLD grade and diabetes prevalence.

Conclusion: There is a significant linear association between NAFLD severity and the presence of diabetes mellitus. Ultrasonographic grading of fatty liver can serve as a predictive indicator for early metabolic risk screening and blood glucose monitoring in at-risk populations.

Keywords: Diabetes Mellitus, Fatty Liver, Hepatic Steatosis, Insulin Resistance, Non-alcoholic Fatty Liver Disease, Ultrasonography, USG.

INTRODUCTION

Fatty liver disease, characterized by the accumulation of fat in hepatocytes, has emerged as a significant global health concern, particularly in individuals who do not consume alcohol, where the condition is classified as non-alcoholic fatty liver disease (NAFLD) (1,2). NAFLD is now recognized not only as the most prevalent chronic liver disorder but also as a potential precursor to systemic metabolic dysfunction, particularly type 2 diabetes mellitus (T2DM) (3). Mounting evidence suggests that metabolic disturbances associated with sedentary behavior, such as insulin resistance and abnormal fat distribution, play a critical role in both the development and progression of NAFLD and T2DM (4). Despite increasing awareness of these associations, gaps remain in understanding the mechanisms and predictive value of NAFLD in diabetes onset, especially when relying on varying diagnostic tools such as alanine transaminase (ALT) levels or clinical scoring systems, which may limit diagnostic accuracy in retrospective study designs (5,6). Ultrasound imaging has long been considered the gold standard for the non-invasive detection of hepatic steatosis, given its accessibility, affordability, and capacity to differentiate between focal and diffuse liver disease (6,7). Notably, parenchymal liver conditions like steatosis and fibrosis manifest distinct echogenic patterns on ultrasound, providing a visual marker of disease severity (8). Yet, despite its widespread use, the diagnostic utility of ultrasonography in monitoring disease progression and response to treatment remains contested (9). NAFLD has been linked to a variety of risk factors including obesity, diabetes, alcohol use, certain medications, hepatitis C, and nutritional imbalances, all of which highlight its multifactorial nature (10). Among biochemical indicators, γ-glutamyltransferase (γ-GTP) levels have emerged as a significant predictor of non-insulin-dependent diabetes mellitus (11), reinforcing the metabolic dimension of fatty liver disease.

Diagnostic interpretation of ultrasonographic images in NAFLD relies heavily on the assessment of liver echogenicity, often relative to the renal cortex, along with other sonographic features such as posterior beam attenuation and vascular blurring (12). These imaging parameters have become increasingly critical in both clinical and research settings, where reliable non-invasive diagnostics are essential. A growing body of literature underscores the association between NAFLD and diabetes, with several longitudinal and population-based studies offering compelling insights. For example, a study demonstrated a notably higher prevalence of fatty liver in individuals with T2DM compared to non-diabetics, emphasizing the need for enhanced public awareness and early screening in diabetic populations (13). In contrast, a study reported an association between NAFLD and hyperglycemia over a decade-long follow-up, found in multivariate analysis that fatty liver was not an independent predictor of diabetes, suggesting that baseline glucose levels and age held greater predictive value (14). Conversely, a study reported that individuals with NAFLD had nearly double the risk of developing diabetes over three years, underscoring its potential role as a modifiable risk factor (15). Their findings advocate for lifestyle interventions in at-risk populations as a preventive strategy against diabetes onset.

Earlier histopathological-ultrasonographic correlation studies confirmed that, bright liver echoes on ultrasound strongly correlate with the degree of fatty infiltration, lending credibility to ultrasound as a reliable screening modality (16). More recently, a study evaluated the interplay of fatty liver and insulin sensitivity in over 11,000 Korean individuals, ultimately concluding that fatty liver itself—independent of insulin levels—conferred a heightened risk of T2DM, further solidifying the disease's clinical relevance (17). Despite these advances, inconsistencies persist in defining whether NAFLD acts as a bystander or a driving force in diabetes pathogenesis. As diabetes prevalence continues to rise globally, particularly in developing countries, clarifying this association is critical to formulating effective screening, prevention, and management strategies. Therefore, the objective of this study is to determine the diagnostic correlation between ultrasound-detected fatty liver and the development of type 2 diabetes mellitus, and to evaluate the reliability of ultrasonographic markers as potential predictors of diabetic risk.

METHODS

This cross-sectional study was conducted over a span of seven months, from September 2020 to April 2021, at the Department of Radiology, Aga Khan Health Services and District Headquarter Hospital, Gilgit. The study aimed to evaluate the association between non-alcoholic fatty liver disease (NAFLD) and type 2 diabetes mellitus (T2DM) using ultrasonographic findings as a diagnostic modality. A convenient sampling technique was employed to recruit participants, and a total of 120 patients were enrolled. These

individuals presented with varying grades of fatty liver, ranging from Grade 0 to Grade III, as assessed on ultrasonography. Patients of both sexes aged above 35 years were included, given that insulin resistance and T2DM are more prevalent in this age group and are recognized risk factors for NAFLD. Only those patients with random blood glucose levels exceeding 140 mg/dL, consistent with the diagnostic threshold for T2DM, were included. Exclusion criteria comprised patients with a history of alcohol intake, use of hepatotoxic medications known to cause fatty liver, pregnant women, and individuals with a documented history of hypertension. The rationale for excluding hypertensive patients is unclear, as hypertension is itself a metabolic risk factor often associated with NAFLD and T2DM.

Patients were referred to the radiology department for abdominal ultrasonography due to complaints such as right upper quadrant abdominal pain or a sense of fullness. All enrolled participants underwent real-time abdominal ultrasonography using Toshiba Apolio 300 CV Colour Doppler and Canon Xario 100 ultrasound machines. Scans were conducted by an experienced radiologist to minimize interobserver variability and eliminate equipment-related artifacts. Ultrasound assessment focused on standardized parameters for grading fatty liver, which included parenchymal texture, liver-to-kidney contrast, and echogenicity of the portal vein. Grade 0 denoted normal liver echotexture with clear visualization of the portal vein. Grade I represented a mild diffuse increase in echogenicity with preserved visualization of the diaphragm and portal vein. Grade II indicated a moderate increase in liver echogenicity with slightly impaired visualization of the portal vein and diaphragm. Grade III was characterized by marked echogenicity and poor visualization of both the portal vein and diaphragm. These grading criteria are widely accepted and clinically validated for the non-invasive detection of hepatic steatosis (16–21). Ethical approval for this study was obtained from the relevant institutional review board, and all participants provided written informed consent prior to enrollment.

RESULTS

A total of 120 patients with diagnosed fatty liver disease were enrolled in the study, comprising 58 males and 62 females. The mean age of participants was 59.6 years. The most represented age group was 51–60 years, accounting for 25% of the study population, followed by 41–50 years (20.83%) and 61–70 years (20%). The age distribution ranged from 31 to 90 years, with the lowest frequency seen in the 81–90 years group (8.3%). Based on ultrasonographic grading, 19 patients were categorized as Grade 0, 31 as Grade I, 37 as Grade II, and 33 as Grade III fatty liver disease. In Grade 0, 16 patients (53.33%) were non-diabetic and only 3 (3.33%) were diabetic. In Grade I, 6 patients (20%) were non-diabetic while 25 (27.78%) were diabetic. Among those in Grade II, 5 patients (16.67%) were non-diabetic and 32 (35.56%) were diabetic. Grade III included 3 non-diabetic (10%) and 30 diabetic patients (33.33%). Overall, 90 of the 120 patients (75%) had type 2 diabetes mellitus. A clear linear trend was observed between increasing grades of fatty liver and the frequency of diabetes mellitus. Ultrasound findings revealed progressive changes in liver architecture with increasing fatty liver grade. Among the 19 patients with Grade 0 disease, liver parenchymal texture, liver-to-kidney contrast, and portal vein echogenicity were normal. All 31 patients with Grade I fatty liver showed slight and diffuse parenchymal texture changes, hyperechoic liver-to-kidney contrast, and echogenic portal veins. In Grade II patients, liver parenchymal texture was increased, liver-to-kidney contrast remained hyperechoic, but portal vein echogenicity was reduced. Among Grade III patients, parenchymal texture was markedly increased, liver-to-kidney contrast was poor, and portal vein echogenicity was absent.

The study confirmed a clear association between the progression of fatty liver grades and the corresponding deterioration in ultrasound imaging features, as well as a marked rise in the prevalence of type 2 diabetes mellitus. Each higher grade demonstrated worsening echogenic and textural characteristics, further correlating with metabolic impairment. A chi-square test was conducted to assess the association between the grades of fatty liver and the presence of diabetes mellitus. The test yielded a chi-square value of 48.45 with 3 degrees of freedom, and the associated p-value was < 0.0001, indicating a statistically significant relationship between increasing fatty liver grade and the prevalence of diabetes. This finding supports the observed trend where higher grades of fatty liver correlated with a greater proportion of diabetic patients. To further evaluate the linear association, a regression analysis was performed using the numeric grade of fatty liver as the independent variable and the number of diabetic patients in each grade as the dependent variable. The linear regression model yielded an R-squared value of 0.726, suggesting that approximately 73% of the variability in diabetes frequency could be explained by fatty liver grade. However, the p-value for the regression slope was 0.148, which did not reach statistical significance, possibly due to the limited number of data points (n=4) and small sample sizes per group. Despite this, the upward trend aligns with clinical expectations and supports the hypothesis of a strong correlation.

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Table 1: Ratio of Male: Female

Count Male and Female	
Male	58
Female	62
TOTAL	120

Table 2: Age Distribution Frequency

Age Limit	Frequency	Relative Freq.	Percentage Freq.
31-40 Yrs.	12	0.1000	10.00%
41-50 Yrs.	25	0.2083	20.83%
51-60 Yrs.	30	0.2500	25.00%
61-70 Yrs.	24	0.2000	20.00%
71-80 Yrs.	19	0.1583	15.83%
81-90 Yrs.	10	0.0833	8.33%
Total	120	1.0000	100.00%

Table 3: Frequency Table of Diabetic and Non-Diabetic Patients

Grades Of Fatty Liver	Freq. of Non-Diabetic Patients	% Freq. of Non-Diabetic Patients	Freq. of Diabetic Patients	% Freq. of Diabetic Patients	Frequency of Grand Total	% Frequency of Grand Total
Grade 0	16	53.33%	3	3.33%	19	15.83%
Grade I	6	20.00%	25	27.78%	31	25.83%
Grade II	5	16.67%	32	35.56%	37	30.83%
Grade III	3	10.00%	30	33.33%	33	27.50%
Grand Total	30	100.00%	90	100.00%	120	100.00%

Table 4: Frequency Distribution Table of Liver Parenchymal Changes

Fatty Liver Grade0/ I/II/III	Liver Parenchymal Changes				
	Increased	Markedly Increased	Normal	Slight and Diffuse	Frequency
Grade 0	0	0	19	0	19
Grade I	0	0	0	31	31
Grade II	37	0	0	0	37
Grade III	0	33	0	0	33
Grand Total	37	33	19	31	120

Table 5: Frequency Distribution Table of Liver to Kidney Contrast Changes

Fatty Liver Grade0/ I/II/III	LIVER to Kidney Contrast			
	Hyperechoic	Normal	poor	Grand Total
Grade 0	0	19	0	19
Grade I	31	0	0	31
Grade II	37	0	0	37
Grade III	0	0	33	33
Grand Total	68	19	33	120

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Table 6: Frequency Distribution Table of Changes in Portal Vein Echogenicity

Fatty Liver Grade0/ I/II/III	Portal Vein Echogenicity				
	Absence	Decreased	Echogenic	Normal	Grand Total
Grade 0	0	0	0	19	19
Grade I	0	0	31	0	31
Grade II	0	37	0	0	37
Grade III	33	0	0	0	33
Grand Total	33	37	31	19	120

Table 7: Chi-Square Analysis

Test	Chi2 Value	p-value	Degrees of Freedom	Significance
Chi-Square	48.450	<0.0001	3	Significant

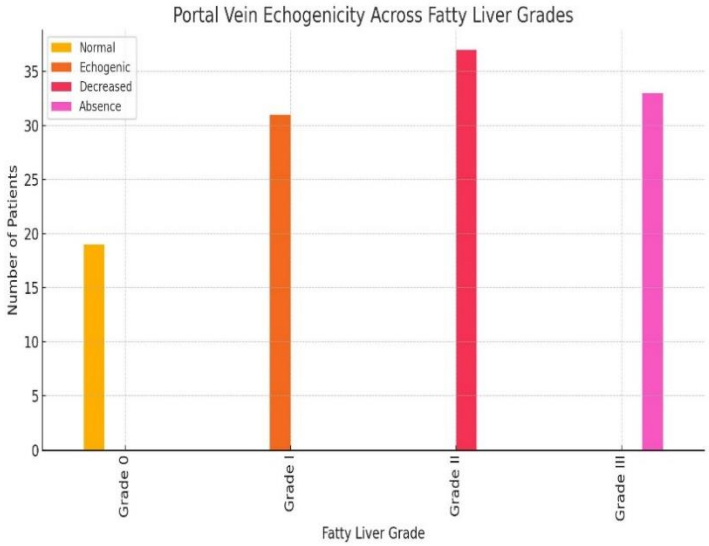


Figure 1 Portal Vein Echogenicity Across Fatty Liver Grades

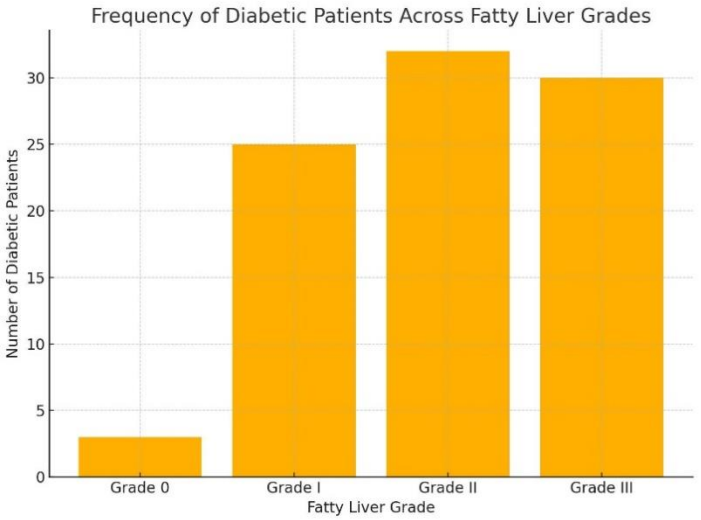
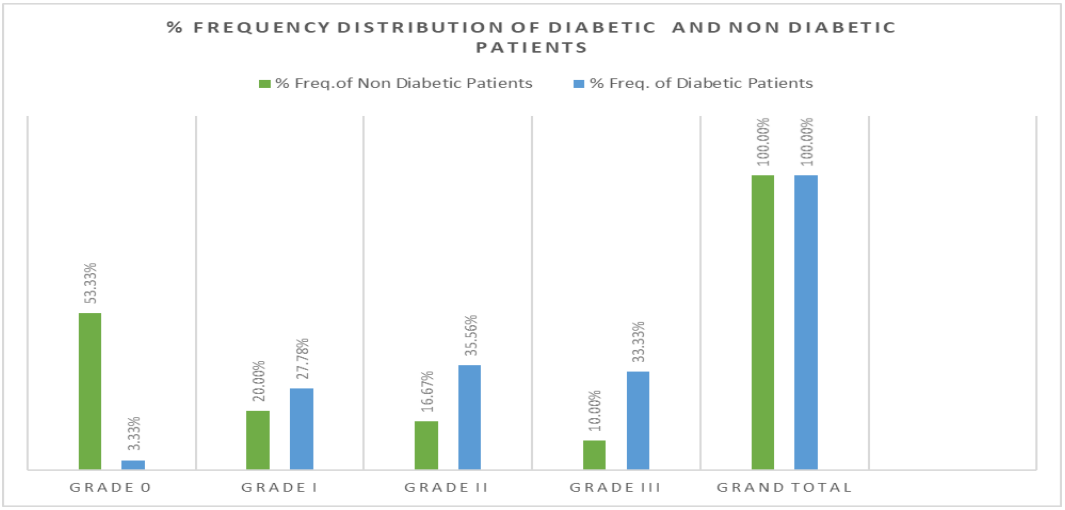


Figure 2 Frequency of Diabetic Patients Across Fatty Liver Grades



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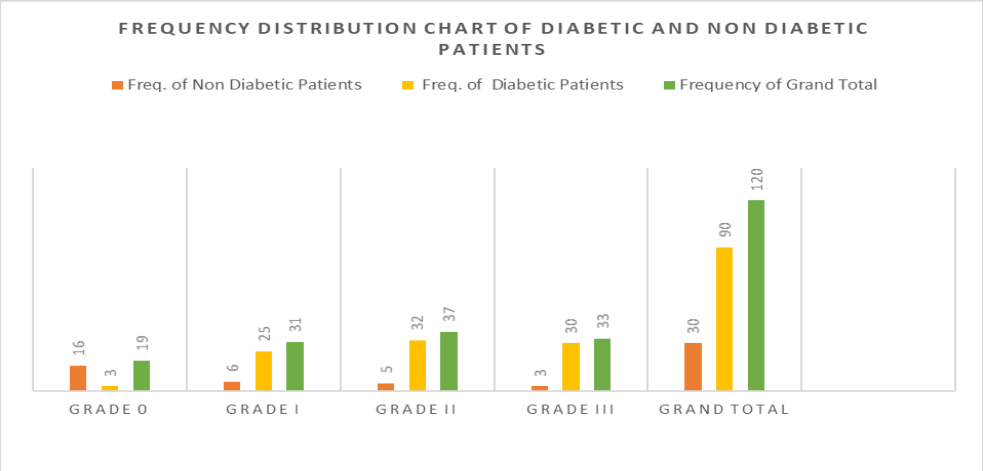

DISCUSSION

The present study reinforced the growing body of evidence linking non-alcoholic fatty liver disease (NAFLD) with type 2 diabetes mellitus (T2DM). A high proportion of patients (75%) with NAFLD in this cohort were found to be diabetic, suggesting a notable correlation between increasing hepatic steatosis and glycemic abnormalities. This finding is consistent with prior studies which reported that approximately 50% to 70% of individuals with ultrasonographically diagnosed fatty liver were also affected by T2DM (16). The association became even more apparent as the grading of fatty liver increased, paralleled by a rise in random blood glucose levels, confirming a statistically significant relationship between the severity of hepatic fat accumulation and the presence of diabetes mellitus (17). The findings of this study align with the consensus that NAFLD is a hepatic manifestation of metabolic syndrome and occurs commonly in insulin-resistant states such as obesity, dyslipidemia, and T2DM (18). The observed 75% prevalence rate of NAFLD in diabetics closely matches prior regional findings that reported prevalence rates ranging between 60% to 76% (19). It was also demonstrated that higher grades of fatty liver are associated with increased blood glucose levels, supporting previous clinical data that proposed a direct relationship between hepatic steatosis severity and poor glycemic control (20). This strengthens the clinical value of ultrasound as a diagnostic and monitoring tool in metabolic disease assessments.

The study benefited from the use of ultrasonography, which is recognized for its high sensitivity and specificity in detecting fatty liver and liver fibrosis, with reported diagnostic accuracies up to 94% sensitivity and 100% specificity in non-obese patients (21). The accessibility, affordability, and safety of ultrasonography make it a practical modality for early detection and grading of NAFLD in both clinical and community settings (22). The strength of this study also lies in its detailed correlation of sonographic features—including liver parenchymal texture, liver-to-kidney contrast, and portal vein echogenicity—with diabetic status, which added a pathophysiological perspective to the imaging findings. However, several limitations were acknowledged. The use of a cross-sectional design precluded the ability to establish temporal or causal relationships between fatty liver and the development of diabetes. Furthermore, the reliance on convenience sampling and a limited sample size may introduce selection bias and restrict the generalizability of findings. The exclusion of hypertensive individuals, despite hypertension being a component of metabolic syndrome, may have excluded a critical subgroup relevant to the overall metabolic profile. Additionally, important variables such as body mass index (BMI), lipid profile, HbA1c levels, liver enzymes, and medication history were not included, all of which could act as confounders or mediators in the association between NAFLD and diabetes.

The lack of longitudinal follow-up also limited the study's ability to assess the progression of NAFLD and its long-term impact on glycemic control or complications. Despite showing a significant correlation between fatty liver grades and diabetes prevalence, statistical modeling such as regression analysis revealed non-significant linearity, likely due to limited sample size. This underscores the need for future studies to adopt larger sample sizes, prospective designs, and multivariable adjustments to yield more robust and generalizable conclusions. There is a need to integrate NAFLD surveillance into diabetes screening protocols, particularly in populations with high rates of obesity and sedentary lifestyle. Large-scale, multicenter studies using standardized ultrasound grading, biochemical indices, and longitudinal follow-up should be prioritized to clarify the bidirectional relationship between hepatic steatosis and glucose

metabolism. Clinicians should be encouraged to use liver ultrasound not only to detect NAFLD but also to predict metabolic deterioration in at-risk patients. Regular monitoring of blood glucose levels in individuals with fatty liver disease can aid in early diagnosis and mitigation of diabetes-related complications.

CONCLUSION

This study concluded that there is a strong association between non-alcoholic fatty liver disease and diabetes mellitus. The findings highlighted that as the severity of fatty liver increased, the likelihood of diabetes also rose, underscoring the importance of early identification and grading of fatty liver through ultrasonography. As a reliable and accessible imaging tool, ultrasound played a vital role in detecting hepatic changes linked to metabolic disturbances. These results emphasize the need for routine metabolic evaluation in patients diagnosed with fatty liver disease, offering a valuable opportunity for timely intervention and prevention of diabetes-related complications.

AUTHOR CONTRIBUTION

Author	**Contribution**
Farzeen Zehra*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Sidra Rasheed	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Syed Zaigham Ali Shah	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Muhammad Kaleem Akhter	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Ahmad Raza	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Anum Ifthikhar	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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