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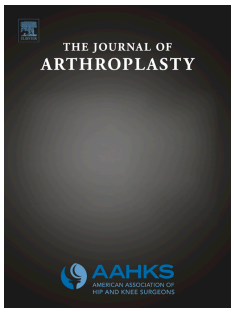

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Does the Presence of Metabolic Syndrome or Its Components Influence Patient-Reported Outcomes After Total Hip Arthroplasty?

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Does the Presence of Metabolic Syndrome or Its Components Influence Patient-Reported Outcomes After Total Hip Arthroplasty?

Abstract

Background

An increasing number of individuals who suffer from hip osteoarthritis (OA) undergoing total hip arthroplasty (THA) have metabolic comorbidities. Among these, metabolic syndrome (MetS) has been identified as a potential key contributor to OA pathogenesis. While MetS is also known to increase perioperative risks, its impact on treatment outcomes, such as function, quality of life, and mental health, remains poorly understood. We conducted a prospective cohort study aimed at evaluating whether the presence of MetS and its individual components influences postoperative hip function, health-related quality of life, and mental health outcomes following THA.

Methods

This prospective cohort study included 514 patients who underwent primary THA for hip OA at our university hospital. Patients were stratified into two groups based on the absence (n = 455) or presence (n = 59) of MetS. Patient-reported outcome measures were assessed preoperatively and at one month and one year postoperatively, including hip function (Hip Disability and Osteoarthritis Outcome Score (HOOS), and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)), pain (Visual Analogue Scale), quality of life (SF-12), and mental health (PHQ-4).

Results

At one year postoperatively, patients who were diagnosed with MetS exhibited worse scores regarding hip function in several subcategories, for instance, in WOMAC pain (MetS: 3.3 ± 4.1

versus No MetS: 1.5 ± 2.5, mean difference = -1.8 [95% confidence interval (CI): -3.6 to 0], *P* = 0.017). Differential effects of the individual MetS components regarding hip function were observed. Dyslipidemia was associated with poorer outcomes, whereas the effects of obesity, T2DM, and hypertension were relatively limited. Importantly, while the proportion of patients reporting yellow flags for depression and anxiety did not differ preoperatively between patients who did and did not have MetS, a higher prevalence was observed in the MetS group at one year postoperatively (MetS: 13.6% versus No MetS: 4.0%, *P* = 0.006).

Conclusion

We demonstrated that MetS is associated with impaired functional and psychological outcomes after THA, with dyslipidemia as a particularly relevant contributing component. Our findings highlight the importance of an integrated preoperative assessment that combines metabolic risk profiling with mental health screening and optimization to enhance patient outcomes.

Keywords*:* PROM, Metabolic syndrome, Dyslipidemia, Arthroplasty, Hip

Introduction

Total hip arthroplasty (THA) is one of the most effective surgical interventions, offering substantial improvements in pain relief and quality of life for patients who suffer from advanced hip osteoarthritis (OA) [1, 2]. As the global burden of OA continues to rise, the demand for THA will inevitably increase accordingly. Simultaneously, an increasing number of patients undergoing THA have lifestyle-related cardiovascular risk factors and complex metabolic profiles. Among these conditions, metabolic syndrome (MetS), which represents a constellation of central obesity in combination with at least two of the following comorbidities (hypertension, type 2 diabetes mellitus (T2DM), and dyslipidemia), has gained increasing attention. MetS has specifically been discussed as a critical contributor to OA pathophysiology and has even led to the proposal of a refined clinical phenotype, termed “MetS-OA” [3-5].

Although MetS is increasingly recognized in OA pathophysiology, it remains unclear whether MetS as a whole or its individual components worsen postoperative outcomes in individuals undergoing THA. Particularly, the effect of MetS on physical capacity and mental health outcomes is unexplored in this context. For both patients and surgeons, the main goal of THA is to restore function and improve quality of life. While THA is highly successful in achieving these outcomes, patients who are diagnosed with MetS may experience a more complicated postoperative course [6-9]. Understanding these relationships is crucial in an aging, comorbidity-rich patient population, where personalized care and realistic outcome expectations are becoming increasingly important. Despite growing recognition of MetS as a systemic risk factor, its impact on patients' treatment outcome, including physical function, quality of life, and specifically mental health after THA, remains inadequately explored, leaving both patients and surgeons with uncertainty.

To address this, we conducted a prospective cohort study aimed at evaluating whether the presence of MetS and its individual components influences postoperative hip function, health-related quality of life, and mental health outcomes following THA.

Methods

Study design and patient cohort

In this prospective cohort study, we screened 995 adult patients who presented with hip OA scheduled for THA between November 1, 2021, and January 31, 2024, at our tertiary center. A total of 195 patients refused to participate, and 799 patients were subsequently examined for eligibility. Of those, 38 patients (4.8%) were excluded based on the presence of secondary OA due to rheumatic diseases. A further 57 patients (7.1%) were primary scheduled for revision surgery and were therefore excluded. Thus, 704 patients who underwent primary unilateral THA were initially enrolled in the study and followed prospectively over a period of one year after surgery. A total of 190 patients (age: mean 69 years (range, 47 to 89), 55% (n = 104)

women, 45% (n = 86) men) did not participate in the one-year follow-up, resulting in a final cohort of 514 patients for analysis (age: mean 69 years (range, 26 to 90), 57% (n = 293) women, 43% (n = 221) men). There were no differences in demographic and clinical data between the loss to follow-up subgroup and the study cohort. In particular, the proportion of patients affected by MetS was comparable (MetS: Study cohort 11.5% (n = 59), loss to follow-up subgroup 12.6% (n = 24), $P = 0.674$) (Supplemental Table 1). A total of 59 patients fulfilled the criteria for MetS, whereas the No MetS group consisted of 455 patients (Table 1). THA was performed in all patients via the posterior approach. The groups did not differ regarding age ($P = 0.860$). As expected, there were differences in body mass index (BMI) evident, with a higher mean BMI in the MetS group (MetS: mean 34.1 (range, 30.0 to 48.1) versus No MetS: mean 27.9 (range, 16.9 to 46.4); mean difference = -6.1 [95% confidence interval (CI): -7.5 to -4.9], $P < 0.001$). There were no significant differences between patients who did and did not have MetS found regarding reported mental health disorders, tobacco use disorder, or alcohol use disorder (Table 1). Demographic data, preoperative clinical parameters, and prior diagnoses and medical treatments concerning hypertension, T2DM, and dyslipidemia were assessed. For the main analysis, patients were divided into two groups: those who did not meet the MetS criteria and those who did. In a subgroup analysis, patients were further stratified based on the presence of individual MetS components (obesity (BMI $\geq$ 30), hypertension, T2DM, and dyslipidemia) (obesity: MetS: 100% (n = 59) versus No MetS: 27.0% (n = 123), $P < 0.001$; hypertension: MetS: 100% (n = 59) versus No MetS: 64.8% (n = 295), $P < 0.001$; T2DM: MetS: 47.5% (n = 28) versus No MetS: 5.7% (n = 26), $P < 0.001$; dyslipidemia: MetS: 76.3% (n = 45) versus No MetS: 23.7% (n = 108), $P < 0.001$). Ethical approval for this study was obtained from the local ethics committee (PV7275), and all procedures complied with the ethical standards outlined in the Declaration of Helsinki.

Data collection

Patient-reported outcome measures (PROMs) were collected using standardized self-reported questionnaires preoperatively (t_0), one month (t_1), and one year after THA (t_2). As part of an established internal patient registry, these assessments were conducted to systematically document the functional and symptomatic status of patients undergoing THA. Hip functionality was assessed using the Hip disability and Osteoarthritis Outcome Score (HOOS, scale: zero to 100), with higher scores indicating better function and less pain [10], and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC, scale: zero to 100), where higher scores represent greater pain and disability, i.e., worse outcomes [11]. Pain at rest was further assessed by using the Visual Analog Scale (VAS, scale: zero to 10), with higher scores representing more pain [12]. Patient satisfaction was assessed by applying the German version of the Client Satisfaction Questionnaire (ZUF-8, scale: eight to 32), with higher scores indicating greater satisfaction. Health-related quality of life was measured by the 12-Item Short-Form Health Survey (SF-12) with the subscales physical and mental component scores (SF-12-PCS/MCS, scale: zero to 100), respectively, with higher scores reflecting better health status [13, 14]. Symptoms of depression and anxiety were screened using the four-item Patient Health Questionnaire (PHQ-4, scale: zero to 12), with scores of six to eight indicating yellow flags (moderate psychological distress) and scores of nine to 12 representing red flags (severe psychological distress) [15]. Complications and adverse events were assessed using the one-year follow-up questionnaire and by reviewing medical records (primary hospitalization or readmission), in accordance with the proposed standardized list of the Hip Society THA Complications Workgroup [10], supplemented by acute renal failure.

Sample size calculation and data analyses

A comprehensive description of the sample size calculation and statistical analysis can be found in the Supplemental Materials and Methods.

Results

One year after THA, patients who suffer from MetS experience poorer hip function than those who are not diagnosed with MetS

The comparison of patients who did and did not have MetS revealed several differences with respect to patient-reported hip functionality. Namely, patients who had MetS had lower HOOS scores for pain, activity of daily living (AdL), and sports and recreation, indicating poorer outcomes and greater pain (No MetS versus MetS (averaged over time) HOOS pain: mean difference = 5.7, [95% CI: 1.3 to 10.1], P = 0.011, Cohen's d = 0.371; HOOS AdL: mean difference = 8.2, [95% CI: 3.6 to 12.9], P < 0.001, Cohen's d = 0.502; HOOS sports/recreation: mean difference = 10.9, [95% CI: 4.0 to 17.7], P = 0.002, Cohen's d = 0.463). When considering the individual timepoints, lower scores were observed for AdL and sports and recreation, both at baseline and throughout the follow-up (HOOS AdL: t_0: mean difference = 7.6, [95% CI: -1.2 to 16.3], P = 0.032, Cohen's d = 0.462; t_1: mean difference = 7.8, [95% CI: -1.3 to 17.0], P = 0.032, Cohen's d = 0.477; t_2: mean difference = 9.3, [95% CI: 0.4 to 18.2], P = 0.009, Cohen's d = 0.567) (HOOS sports/recreation: t_0: mean difference = 8.3, [95% CI: -1.4 to 18.0], P = 0.047, Cohen's d = 0.353; t_1: mean difference = 10.8, [95% CI: -3.7 to 25.4], P = 0.047, Cohen's d = 0.463; t_2: mean difference = 13.5, [95% CI: -2.3 to 29.2], P = 0.047, Cohen's d = 0.574) (Figure 1A). There were no differences between patients who did and did not have MetS observed in the symptoms and quality of life subcategories (Supplemental Figure 1A, 1B). Importantly, no baseline differences were observed for either subcategory of the WOMAC (Figure 1B). However, for the WOMAC subcategories pain, function, and the WOMAC sum score, higher scores were observed in the MetS group, indicating poorer outcomes (No MetS versus MetS (averaged over time) WOMAC pain: mean difference = -1.5, [95% CI: -2.5 to -0.5], P = 0.004, Cohen's d = -0.495; WOMAC function: mean difference = -4.9, [95% CI: -7.9 to -1.8], P = 0.002, Cohen's d = -0.433; WOMAC sum: mean difference = -6.3, [95% CI: -10.3 to -2.3], P = 0.002, Cohen's d = 0.-417). These differences were not only apparent at the one-

year mark (WOMAC pain: t_2: mean difference = -1.8, [95% CI: -3.6 to 0], P = 0.017, Cohen's d = -0.603), (WOMAC function: t_2: mean difference = -6.7, [95% CI: -12.5 to -0.9], P = 0.003, Cohen's d = -0.597), (WOMAC sum: t_2: mean difference = -10.2, [95% CI: -18.1 to -2.4], P < 0.001, Cohen's d = -0.681), but were also evident as early as one month postoperatively, particularly for the pain subcategory and the WOMAC sum score (WOMAC pain: t_1: mean difference = -1.7, [95% CI: -3.6 to 0.3], P = 0.046, Cohen's d = -0.557) (WOMAC sum: t_1: mean difference = -6.2, [95% CI: -13.7 to 1.3], P = 0.047, Cohen's d = -0.411) (Figure 1B). Additionally, there were no differences evident between the groups regarding the WOMAC subcategory stiffness (Supplemental Figure 1C). The evaluation of pain at rest and satisfaction did not show differences (Figure 1C and Supplemental Figure 1D). The assessment of health-related quality of life using the SF-12 questionnaire showed lower physical and mental component scores in patients who had MetS across all three time points, reflecting poorer health status (No MetS versus MetS (averaged over time) PCS: mean difference = 2.8 [95% CI: 0.7 to 4.9], P = 0.009, Cohen's d = 0.344; MCS: mean difference = 4.8 [95% CI: 1.6 to 7.9], P = 0.003, Cohen's d = 0.436) (Figure 1D). Strikingly, when evaluating the mental component of the SF-12, no differences were observed at baseline or one month postoperatively. However, patients who were diagnosed with MetS showed lower scores at the one-year follow-up (MCS: t_2: mean difference = 5.1 [95% CI: -0.2 to 10.4], P = 0.037, Cohen's d = 0.464) (Figure 1D).

The presence of dyslipidemia is associated with worse functional and mental health-related outcomes after THA

Next, we examined whether the observed effects in patients who had MetS were primarily driven by individual components of the syndrome. We found that patients who were diagnosed with dyslipidemia displayed similar changes in the HOOS subcategories pain, AdL, and sports and recreation, i.e., lower HOOS scores indicating poorer outcomes and greater pain (No dyslipidemia versus dyslipidemia (averaged over time) HOOS pain: mean difference = 5.6,

[95% CI: 2.6 to 8.6], $P < 0.001$, Cohen's $d = 0.368$; HOOS AdL: mean difference = 5.5, [95% CI: 2.3 to 8.7], $P < 0.001$, Cohen's $d = 0.335$; HOOS sports/recreation: mean difference = 5.7, [95% CI: 1.1 to 10.3], $P = 0.015$, Cohen's $d = 0.242$) (Figure 2A). While no baseline differences were evident, patients who had dyslipidemia reported lower scores at both one month and one year postoperatively in the HOOS subcategories pain and AdL (HOOS pain: t_1: mean difference = 8.2, [95% CI: 2.4 to 14.0], $P < 0.001$, Cohen's $d = 0.539$; t_2: mean difference = 5.3, [95% CI: -0.8 to 11.4], $P = 0.033$, Cohen's $d = 0.346$) (HOOS AdL: t_1: mean difference = 9.3, [95% CI: 3.1 to 15.5], $P < 0.001$, Cohen's $d = 0.568$; t_2: mean difference = 5.7, [95% CI: -0.4 to 11.8], $P = 0.013$, Cohen's $d = 0.348$). In contrast, differences in the sports and recreation subcategory emerged only at the one-year follow-up (HOOS sports/recreation: t_2: mean difference = 9.5, [95% CI: -0.9 to 20.0], $P = 0.022$, Cohen's $d = 0.407$). No differences were observed in the symptoms and quality of life subcategories (Supplemental Figure 2A, 2B). Patients who had dyslipidemia also exhibited worse outcomes regarding WOMAC pain, function, and sum score, i.e., reported higher scores (No dyslipidemia versus dyslipidemia (averaged over time) WOMAC pain: mean difference = -1.3, [95% CI: -1.9 to -0.7], $P < 0.001$, Cohen's $d = -0.441$; WOMAC function: mean difference = -3.4, [95% CI: -5.5 to -1.3], $P = 0.002$, Cohen's $d = -0.301$; WOMAC sum: mean difference = -4.7, [95% CI: -7.5 to -2.0], $P < 0.001$, Cohen's $d = -0.315$), no difference was noted regarding the WOMAC subcategory stiffness (Figure 2B, Supplemental Figure 2C). Specifically, for the WOMAC function and the sum score, no differences were observed at baseline, while, however, patients who had dyslipidemia reported higher score values at both one month and one year postoperatively, indicating worse outcome (WOMAC function: t_1: mean difference = -5.7, [95% CI: -9.7 to -1.7], $P < 0.001$, Cohen's $d = -0.508$; t_2: mean difference -4.2, [95% CI: -8.2 to -0.2], $P = 0.006$, Cohen's $d = -0.376$), (WOMAC sum: t_1: mean difference = -7.9, [95% CI: -13.0 to -2.8], $P < 0.001$, Cohen's $d = -0.526$; t_2: mean difference = -6.4, [95% CI: -11.8 to -0.9], $P = 0.002$, Cohen's $d = -0.425$). Patients who were diagnosed with dyslipidemia also reported lower satisfaction scores

compared to those who did not have dyslipidemia (No dyslipidemia versus Dyslipidemia (averaged over time) ZUF-8: mean difference = 1.4, [95% CI: 0.3 to 2.5], *P* = 0.011, Cohen's *d* = 0.263) (Figure 2C). Regarding health-related quality of life, no difference was present at baseline (Figure 2D). However, patients who had dyslipidemia reported lower SF-12 PCS at both one month and one year postoperatively, reflecting poorer health status (PCS: t_1: mean difference = 2.9, [95% CI: 0.1 to 5.6], *P* = 0.006, Cohen's *d* = 0.355; t_2: mean difference = 3.3, [95% CI: -0.4 to 7.0], *P* = 0.016, Cohen's *d* = 0.407) (Figure 2D). No difference was observed in the MCS (Figure 2D). Interestingly, patients who had dyslipidemia reported higher pain values on the VAS scale after THA compared to patients who did not have dyslipidemia (VAS: t_2: mean difference = -1.1, [95% CI: -2.2 to 0], *P* = 0.032, Cohen's *d* = -0.648), indicating that the presence of dyslipidemia might contribute to pain perception after arthroplasty (Supplemental Figure 2D).

Differential effects of other MetS components on functional and mental health outcomes

Subgroup analyses further revealed that patients who suffered from obesity had lower scores in HOOS subcategories sports and recreation and AdL, i.e., worse outcomes (No Obesity versus Obesity (averaged over time) HOOS sports/recreation: mean difference = 6.9 [95% CI: 2.6 to 11.2], *P* = 0.002, Cohen's *d* = 0.298; HOOS AdL: mean difference = 3.8 [95% CI: 0.7 to 6.8], *P* = 0.015, Cohen's *d* = 0.230), as well as higher scores for the subcategories WOMAC function and sum, indicating a worse outcome (No Obesity versus Obesity (averaged over time) WOMAC function: mean difference = -2.5 [95% CI: -4.5 to -0.5], *P* = 0.016, Cohen's *d* = -0.221; WOMAC sum: mean difference = -2.8, [95% CI: -5.4 to -0.2], *P* = 0.037, Cohen's *d* = -0.186) (Supplemental Table 2 and Supplemental Table 3). Health-related quality of life scores, measured via the SF-12, were also lower in this group (No Obesity versus Obesity (averaged over time) PCS: mean difference = 2.2 [95% CI: 0.9 to 3.6], *P* = 0.001, Cohen's *d* = 0.277; MCS: mean difference = 2.1, [95% CI: 0 to 4.2], *P* = 0.046, Cohen's *d* = 0.192), while pain at

rest did not differ (Supplemental Table 4 and Supplemental Table 5). In patients who had T2DM, outcomes were largely similar to those who did not T2DM across all dimensions of the HOOS and WOMAC (Supplemental Table 6 and Supplemental Table 7). No relevant differences were observed in SF-12 component scores as well as pain at rest (Supplemental Table 8 and Supplemental Table 9). Patients who had hypertension (HTN) reported lower scores in HOOS AdL (No HTN versus HTN (averaged over time) HOOS AdL: mean difference = 3.3, [95% CI: 0.2 to 6.4], $P = 0.038$, Cohen's $d = 0.199$), as well as higher scores for WOMAC pain (WOMAC pain: mean difference = -0.7, [95% CI: -1.3 to -0.1], $P = 0.033$, Cohen's $d = -0.230$), and WOMAC function (WOMAC function: mean difference = -2.2, [95% CI: -4.2 to -0.1], $P = 0.038$, Cohen's $d = -0.194$), indicating worse functional outcome. (Supplemental Table 10 and Supplemental Table 11). Additionally, the SF-12 PCS was lower in patients who had hypertension, reflecting lower physical health status (No HTN versus HTN (averaged over time) PCS: mean difference = 1.9, [95% CI: 0.5 to 3.3], $P = 0.007$, Cohen's $d = 0.236$) (Supplemental Table 12 and Supplemental Table 13).

Patients who are diagnosed with MetS are more likely to experience persistent depression and anxiety symptoms after THA

We further assessed the prevalence of depressive and anxiety symptoms at baseline and throughout the one-year follow-up period. The proportion of patients reporting yellow flags for depression and anxiety (PHQ-4 score: six to eight points) was similar both preoperatively and at one month postoperatively (Figure 3A). However, one year after THA, patients who had MetS exhibited a higher prevalence of yellow flags for depression and anxiety compared to those who did not have MetS (t_2: MetS: 13.6% (n = six) versus No MetS: 4.0% (n = 13), $P = 0.006$) (Figure 3A). For severe psychological distress (red flags; PHQ-4 score: nine to 12 points), both groups showed a continuous decline in symptom prevalence over time. While patients who had MetS reported a higher prevalence of severe symptoms preoperatively (t_0:

MetS: 13.8% (n = eight) versus No MetS: 5.9% (n = 26), $P = 0.026$) and after one month (t_1: MetS: 8.0% (n = four) versus No MetS: 2.1% (n = eight), $P = 0.017$), no differences were observed between the groups one year after THA, suggesting that severe psychological distress in the MetS group aligned with that of the No MetS group (Figure 3A).

When examining the individual components of MetS and their association with depressive and anxiety symptoms, it became evident that patients who had dyslipidemia had a higher prevalence of yellow flags preoperatively (t_0: dyslipidemia: 24.0% (n = 35) versus No dyslipidemia: 14.3% (n = 50), $P = 0.009$). Although no group differences were observed at one month postoperatively, the prevalence of yellow flags was again higher in the dyslipidemia group one year after surgery (t_2: dyslipidemia: 8.5% (n = 10) versus No dyslipidemia: 3.5% (n = nine), $P = 0.044$) (Figure 3B). Furthermore, none of the other components of the MetS definition were associated with differing prevalence of depression or anxiety at any time point (Figures 3C to E). Of note, the evaluation of postoperative complications revealed no differences between groups in the incidence of surgical or non-surgical complications occurring within one year after THA (Supplemental Table 14). To further support the findings described above, we conducted a series of multivariable regression analyses adjusting for all MetS components. These models demonstrated that the association between MetS and worse postoperative outcomes is predominantly explained by the cumulative burden of its individual components. Notably, dyslipidemia emerged as the strongest independent predictor of impaired function and increased pain (Supplemental Tables 15 to 20).

Discussion

Due to ongoing demographic changes, the number of patients requiring THA is expected to increase in the future [16]. While THA remains one of the most effective and successful surgical interventions for restoring mobility and improving quality of life, outcomes can vary considerably among patient subgroups [17, 18]. Metabolic syndrome is increasingly prevalent

in this patient population, but its specific impact on THA outcomes measured by PROMs appears understudied. Most prior studies have focused on early postoperative complications or isolated MetS components, leaving a critical gap in understanding how MetS, as a systemic condition, affects physical function and mental well-being following surgery [19]. Therefore, we conducted this prospective cohort study, where we compared PROMs between individuals who did and did not have MetS, as well as between patients who were and were not diagnosed with individual MetS components. As previously outlined, the findings of this study suggest an association between MetS and poorer physical and mental outcomes after THA, with dyslipidemia emerging as a major contributing factor.

We observed that patients who had MetS exhibited worse functional outcomes compared to patients who did not have MetS regarding hip function, one year following THA, indicated by significant differences in HOOS and WOMAC subcategories. This finding is consistent with previous research, where worse function in the context of WOMAC scores was present in patients who had MetS undergoing hip and knee arthroplasty, both preoperatively and postoperatively [20], supporting the hypothesis of MetS being an independent risk factor for poorer functional outcomes.

Dyslipidemia was, in our analysis, the strongest factor of all components of the MetS definition associated with worse functional and mental health-related outcomes. Our results align with previous research linking dyslipidemia to increased OA prevalence and severity, as well as chronic pain after THA [21-23]. Dyslipidemia is often overlooked in preoperative assessment, but may, based on our results, serve as a potential identifier of patients at risk for suboptimal functional recovery. Therefore, identifying and managing dyslipidemia in the perioperative period could improve outcomes after THA and should be investigated. Overall, our subgroup analysis findings align with existing literature, suggesting that MetS is not merely the additive effect of its individual components [24]. There may rather be a distinct underlying

pathophysiological process associated with the syndrome itself that may influence postoperative outcomes [25].

Although the assessment of clinical relevance beyond statistical significance is essential, the available literature on minimal clinically important differences (MCIDs) remains heterogeneous. Reported MCID values vary considerably across studies, reflecting the evolving interpretation of clinically meaningful change [26-28]. In the context of hip arthroplasty, the following anchor-based MCID values have been recommended: 33 for HOOS pain, 25 for HOOS quality of life, 29 for WOMAC pain, 26 for WOMAC function, and 30 for WOMAC stiffness. In contrast, substantially lower median distribution-based MCID values of 10 for HOOS pain and 13 for HOOS quality of life were reported, highlighting the wide range and heterogeneity of these thresholds. Median MCID values for the HOOS symptoms, sports/recreation, and activities of daily living subscales were 17, 17, and 11, respectively, while the median distribution-based MCID for the WOMAC sum score was 11.8 [27]. For the SF-12, previously reported MCID values were 4.6 for the PCS and 6.0 for the MCS score [29]. As no established MCID values are available for the ZUF-8, a distribution-based approach was applied by calculating one-half of the baseline standard deviation, resulting in an MCID of 2.6 points for the ZUF-8 score [26, 30]. Comparison of these reference values with the present study results demonstrated statistically significant differences; however, these changes did not reach the reported MCID thresholds for functional outcomes, health-related quality of life, or patient satisfaction. In light of the relatively modest cohort size of our study and the substantial variability in reported MCID values resulting from differing calculation methods, our findings may nevertheless provide a foundational framework for future research in this domain.

Interestingly, the results of this study indicate that patients suffering from dyslipidemia exhibit higher levels of pain after THA (VAS: t_2: mean difference = -1.1, [95% CI: -2.2 to 0], P = 0.032, Cohen's d = -0.648), a finding that holds clinical relevance as the reported MCID

for VAS in the context of THA is -0.9 [31]. These findings underscore the potentially crucial role of dyslipidemia in pain perception following hip arthroplasty.

Additionally, patients who had MetS, as well as those who had dyslipidemia, were more likely to experience persistent symptoms of depression and anxiety throughout the one-year follow-up period after THA. This is especially concerning because patients expect THA to restore mobility, autonomy, and overall well-being. While mental health in the context of arthroplasty has become a topic of increasing interest in recent years, it remains under-addressed in clinical practice [32, 33]. Notably, symptoms of depression have been reported in more than 30% of patients before THA, underscoring the importance of incorporating mental health screening into both preoperative assessment and postoperative follow-up [34]. This issue becomes even more relevant in light of emerging evidence linking MetS to an increased presence of depression and anxiety, underlining the relationship between physical and psychological health [35, 36].

Our findings emphasize the need for a multidisciplinary approach that includes early identification of psychological distress, patient counseling regarding potential recovery trajectories, and accessible referral pathways for mental health support. A specialized pain psychology approach has the capacity to address psychological and functional impairments before surgery, with the potential to positively influence the postoperative course by managing expectations [37].

Limitations

Our study has several limitations. We included only patients who presented with primary OA and excluded those who had rheumatic conditions, which may limit the applicability of our results to patient populations other than OA. However, primary OA remains the most common indication for THA, and thus our results are applicable to the majority of patients undergoing THA. Second, our study is limited by the fact that 27.0% of patients (n = 190) did not respond to the follow-up questionnaire. To address potential bias and to improve generalizability, we

conducted an analysis of the loss to follow-up subgroup regarding demographic and clinical variables as well as mental health and substance use disorders (tobacco, alcohol), which showed no significant differences between our study cohort and the loss to follow-up subgroup (Supplemental Table 1). Additionally, the results may be affected by loss to follow-up, as patients who did not complete follow-up assessments may experience less favorable outcomes or might be affected by higher psychological distress [38]. Our study did not differentiate between treated and untreated components of MetS, which may influence outcomes differently. However, for clinical practice, the diagnosis independent of therapy is of high informational value for surgeons to differentiate patients who might be at risk for worse outcomes. Finally, we did not observe significant differences in complications between the groups. This may largely be attributable to the size of the groups.

Conclusion

In conclusion, the present study showcases that MetS is associated with impaired physical and psychological outcomes after THA, with dyslipidemia appearing as a particularly relevant contributing factor. These findings support the need for integrated preoperative assessment that includes both metabolic risk profiling and mental health screening. Surgeons and multidisciplinary teams should consider tailored perioperative strategies, including patient counseling and potential referral for metabolic and psychological optimization, to improve recovery. Future research should focus on whether targeted preoperative interventions for metabolic and mental health factors can improve postoperative outcomes in this growing patient population.

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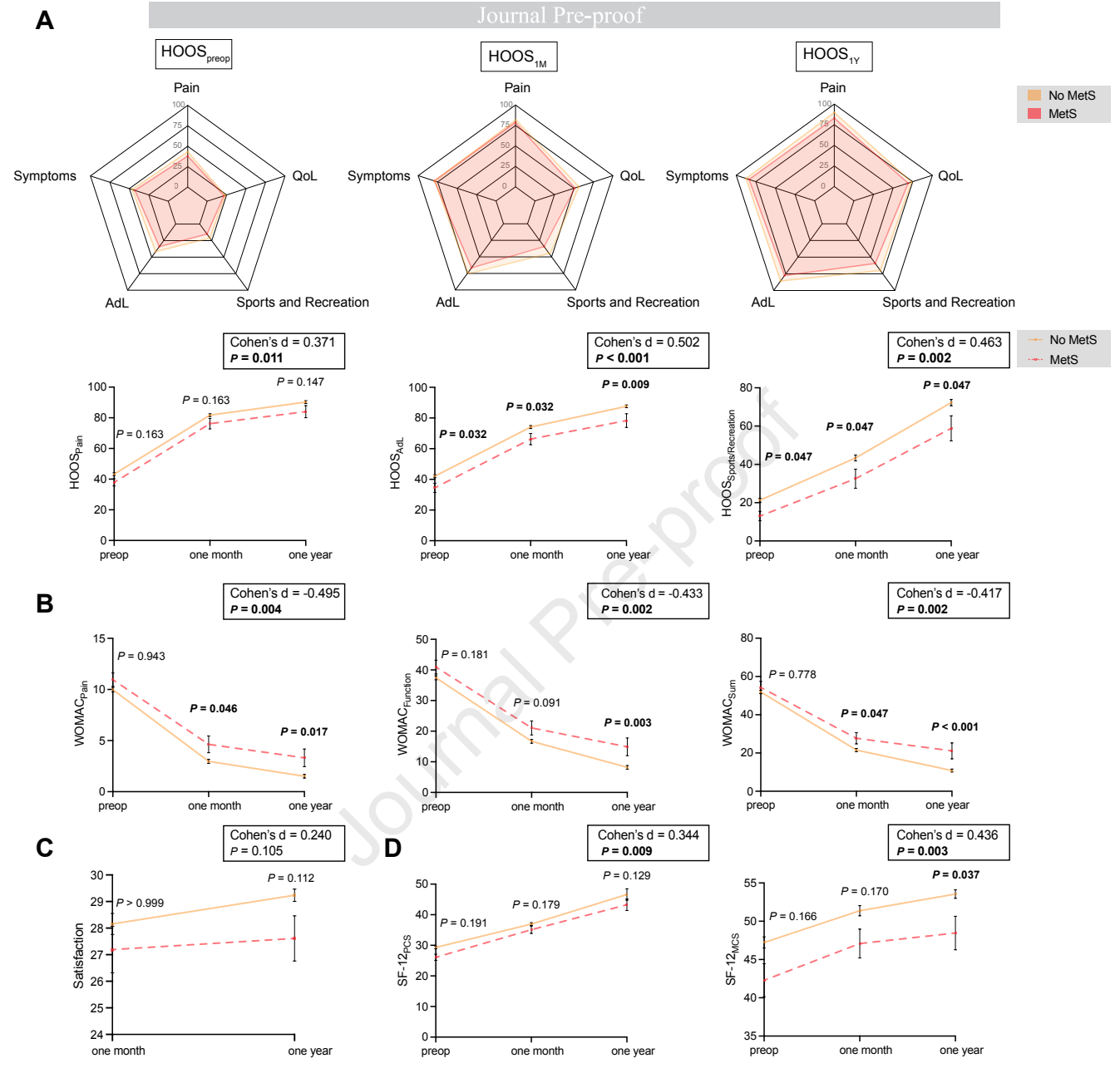
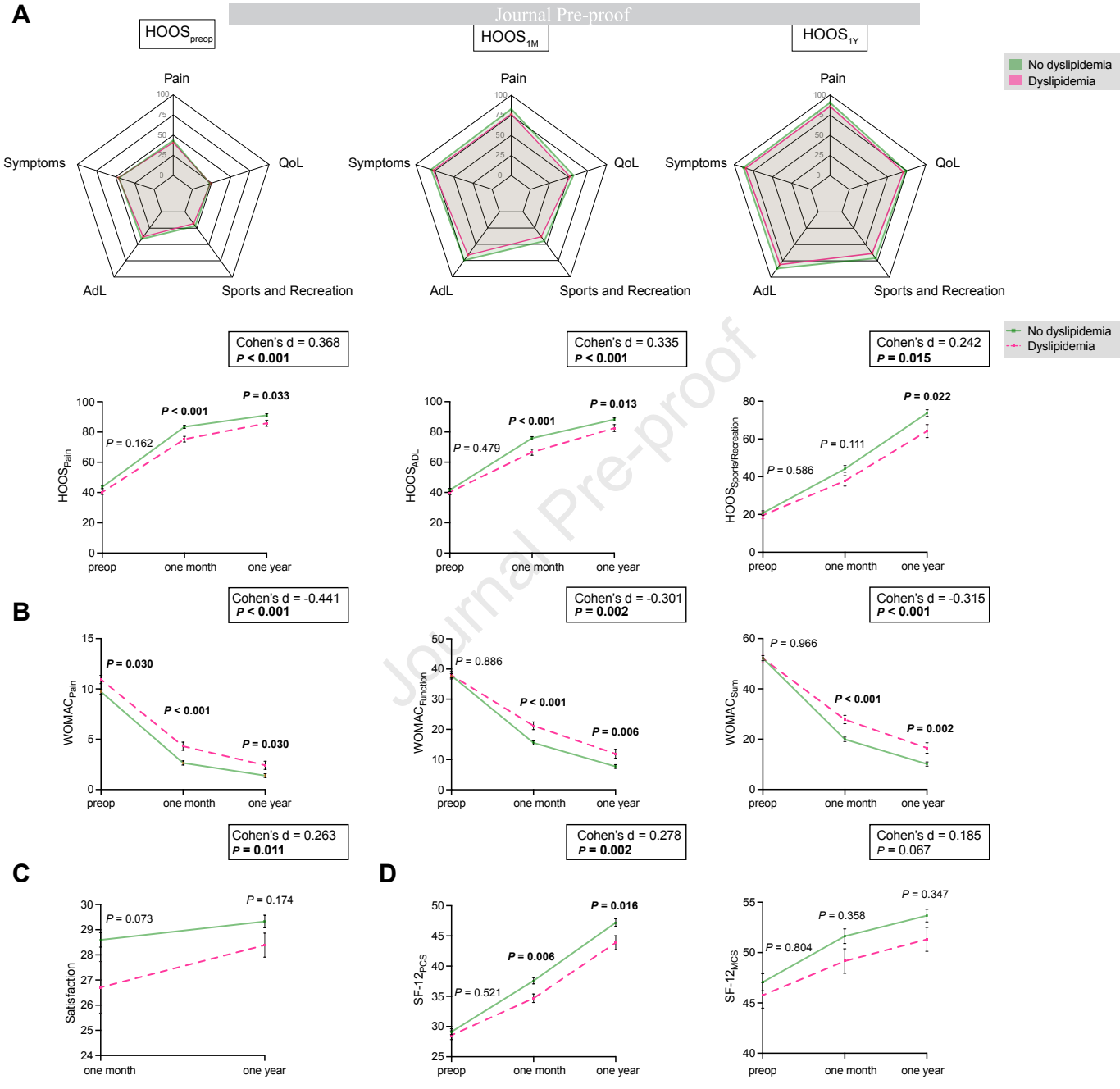
Tables

Table 1. Demographic characteristics and clinical data of the patient cohort grouped into No MetS and MetS.

	Overall (n = 514)	**No MetS (n = 455)**	**MetS (n = 59)**	***P*-value**
Demographics				
Age in years (mean, SD)	69 (11)	69 (10)	70 (8)	0.493
Body mass index (mean, SD)	28.6 (5.0)	27.9 (4.8)	34.1 (3.7)	< **0.001**
Women (n, %)	293 (57.0)	260 (57.1)	33 (55.9)	0.860
Metabolic syndrome (MetS) components				
Obesity (n, %)	182 (35.4)	123 (27.0)	59 (100)	< **0.001**
Hypertension (n, %)	354 (68.9)	295 (64.8)	59 (100)	< **0.001**
T2DM (n, %)	54 (10.5)	26 (5.7)	28 (47.5)	< **0.001**
Dyslipidemia (n, %)	153 (29.8)	108 (23.7)	45 (76.3)	< **0.001**
Mental health and substance use				
Reported mental health disorder (n, %)	43 (8.4)	36 (7.9)	7 (11.9)	0.315
Tobacco use disorder[1] (n, %)	42 (9.8)	34 (8.9)	8 (17.8)	0.066
Alcohol use disorder[1] (n, %)	7 (1.6)	7 (1.8)	0 (0.0)	> 0.999

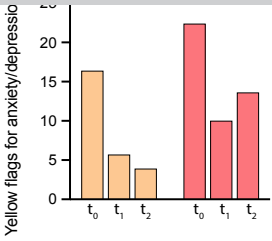
Abbreviations: MetS = metabolic syndrome, SD = standard deviation, T2DM = Type 2 Diabetes Mellitus.
[1]Substance use is not documented for total patient cohort (Overall = 427, No MetS n = 382, MetS n = 45)





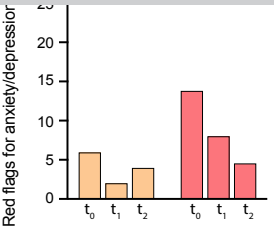
t_0 : preoperative
t_1 : one month
t_2 : one year

A



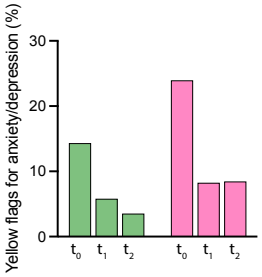
t_0 P = 0.260
t_1 P = 0.249
t_2 P = 0.006

No MetS
MetS



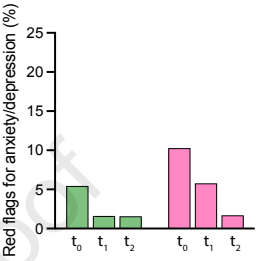
t_0 P = 0.026
t_1 P = 0.017
t_2 P = 0.100

B



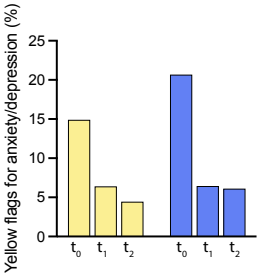
t_0 P = 0.009
t_1 P =0.352
t_2 P = 0.044

No dyslipidemia
Dylipidemia



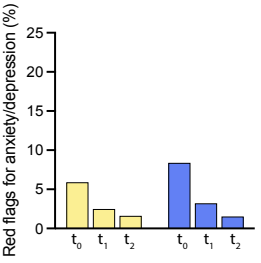
t_0 P = 0.026
t_1 P = 0.018
t_2 P = 0.932

C



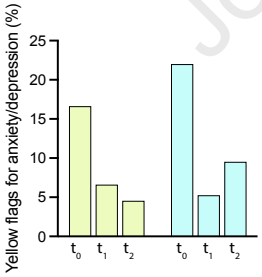
t_0 P =0.100
t_1 P =0.985
t_2 P =0.484

No obesity
Obesity



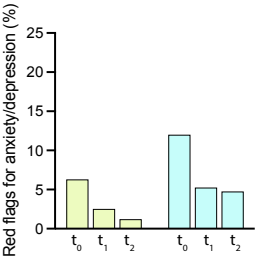
t_0 P = 0.290
t_1 P = 0.654
t_2 P = 0.945

D



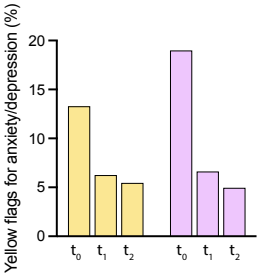
t_0 P = 0.100
t_1 P = 0.747
t_2 P = 0.167

No T2DM
T2DM



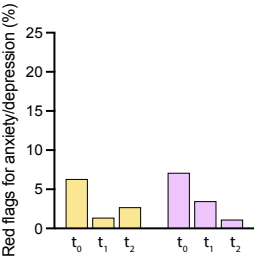
t_0 P = 0.130
t_1 P = 0.331
t_2 P = 0.085

E



t_0 P = 0.117
t_1 P = 0.883
t_2 P = 0.167

No HTN
HTN



t_0 P = 0.745
t_1 P = 0.212
t_2 P = 0.269

Figure legends

Figure 1: The presence of metabolic syndrome (MetS) is associated with worse functional outcomes in patients undergoing total hip arthroplasty (THA).

A) Visualization of the Hip disability and Osteoarthritis Outcome Score (HOOS) dimensions over time using spider charts (top panel), along with assessments of the HOOS subscales (pain, activities of daily living (AdL), and sports and recreation) in patients who do and do not have MetS (MetS: 11.5% (n = 59), No MetS: 88.5% (n = 455)). B) Evaluation of hip function *via* the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) in patients who do and do not have MetS. C) Evaluation of patient satisfaction (ZUF-8). D) Analysis of health-related quality of life (12-Item Short-Form Health Survey (SF-12) physical component scores (PCS) and mental component scores (MCS)). Dashed lines indicate patients who have MetS, and solid lines represent patients who do not have MetS. Group means are displayed by dots, and error bars indicate the standard error of the mean (SEM). Statistical analysis was performed using repeated measures analysis of variance (ANOVA) with time as the within-subjects factor and MetS status as the between-subjects factor. Significant interaction effects (time x group) indicate differential changes in outcomes over time between groups (Holm). *Post hoc* analyses were performed to assess between-group differences at baseline, one month, and one year postoperatively. Exact *P*-values and effect sizes (Cohen's *d*) are displayed. *P*-values < 0.05 were considered statistically significant. Abbreviations: MetS = metabolic syndrome, SEM = standard error of means.

Figure 2: Patients who have dyslipidemia report worse hip function and satisfaction after total hip arthroplasty.

A) Visualization of the Hip disability and Osteoarthritis Outcome Score (HOOS) dimensions over time using spider charts (top panel), along with detailed assessment of HOOS subscales

(pain, activities of daily living (AdL), and sports and recreation) in patients who do and do not have dyslipidemia (dyslipidemia: 29.8% (n = 153), No dyslipidemia: 70.2% (n = 361)). B) Evaluation of hip function *via* the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) in patients who do and do not have dyslipidemia. C) Analysis of patient satisfaction (ZUF-8) and D) health-related quality of life (12-Item Short-Form Health Survey (SF-12) physical component scores (PCS) and mental component scores (MCS)) in patients who do and do not have dyslipidemia. Dashed lines indicate patients who have dyslipidemia, and solid lines represent patients who do not have dyslipidemia. Group means are displayed by dots, and error bars indicate the standard error of the mean (SEM). Statistical analysis was performed using repeated measures analysis of variance (ANOVA) with time as the within-subjects factor and dyslipidemia status as the between-subjects factor. Significant interaction effects (time x group) indicate differential changes in outcomes over time between groups (Holm). *Post hoc* analyses were performed to assess between-group differences at baseline, one month, and one year postoperatively. Exact *P*-values and effect sizes (Cohen's *d*) are displayed. *P*-values < 0.05 were considered statistically significant.

Figure 3: Metabolic Syndrome (MetS) and dyslipidemia are associated with an increased presence of depression one year after total hip arthroplasty (THA).

Prevalence of depressive and anxiety symptoms based on the Patient Health Questionnaire-4 (PHQ-4), at baseline (t_0), one month (t_1), and one year (t_2) after THA for patients who do and do not have A) MetS, B) dyslipidemia, C) obesity, D) type 2 diabetes mellitus (T2DM), and E) hypertension (HTN). Bars represent the proportion of patients reporting yellow flags (PHQ-4 score: 6 to 8) and red flags (PHQ-4 score: 9 to 12), indicating moderate and severe psychological distress, respectively. Statistical analysis was performed using Fisher's Exact Test. *P*-values are reported for each time point.

Supplemental Materials and Methods

Sample size calculation

Sample size calculation was performed using G*Power software v. 3.1.9.6 (Heinrich-Heine-Universität Düsseldorf, Germany) for a repeated measures analysis of variance (rmANOVA) with a between-within interaction (MetS status x time). Due to the lack of prior comparable studies, a small-to-moderate effect size ($f = 0.14$), $\alpha = 0.05$, power = 0.80, three repeated measurements, and a correlation of 0.5 between time points was assumed. A total sample size of 84 patients (42 per group) was required to achieve the desired level of statistical power.

Data Analyses

Statistical analyses were performed using JASP (version 0.19.1, University of Amsterdam, Netherlands) and GraphPad Prism (version 10.5, GraphPad Software, San Diego, California, USA). Continuous variables are presented as means and standard deviations (SD). Normality of the distribution was assessed using Shapiro-Wilk tests. Accordingly, group comparisons were conducted using Student's *t*-tests for normally distributed data, whereas Mann-Whitney U tests were used for non-normally distributed data. Categorical variables are presented as numbers and percentages and were analyzed using *Chi*-square and Fisher's Exact Tests. To evaluate the effect of metabolic syndrome (MetS) and its individual components on patient-reported outcome measures (PROMs) over time, repeated measures ANOVAs were conducted. Time (preoperative, one month, and one year postoperative) was included as a within-subjects factor, and MetS and the component status (yes/no) as a between-subjects factor. The interaction terms (Time x MetS) were tested to assess whether changes in PROMs over time differed between groups. Mauchly's tests were used to assess sphericity. If violated, Greenhouse-Geisser corrections were applied. *Post hoc* comparisons were adjusted for

multiple testing using the Holm method. Furthermore, effect sizes (Cohen's d) were calculated to outline the extent of observed differences. To evaluate the independent association of individual MetS components with outcomes, multivariable linear and logistic regression models were performed. Each model included the four MetS components, obesity (BMI ≥ 30), hypertension, type 2 diabetes mellitus, and dyslipidemia as simultaneous predictors. Outcomes assessed at the one-year follow-up included hip function, pain, satisfaction, quality of life, and psychological distress. Results are reported as unstandardized and standardized coefficients or odds ratios with 95% confidence intervals. Statistical significance was defined as $P < 0.05$.

Supplemental Table 1: Comparison of demographic characteristics and clinical data between the study cohort and the loss to follow-up subgroup.

	Study cohort (n = 514)	**Loss to follow-up (n = 190)**	***P*-value**
Demographics			
Age in years (mean, SD)	69 (11)	69 (9)	0.266
Body mass index (mean, SD)	28.6 (5.0)	29.3 (5.7)	0.245
Women (n, %)	293 (57.0)	104 (54.7)	0.590
Metabolic syndrome (MetS) (n, %)	59 (11.5)	24 (12.6)	0.674
components			
Obesity (n, %)	182 (35.4)	73 (38.4)	0.460
Hypertension (n, %)	354 (68.9)	131 (68.9)	0.985
T2DM (n, %)	54 (10.5)	20 (10.5)	0.994
Dyslipidemia (n, %)	153 (29.8)	64 (33.7)	0.318
Mental health and substance use			
Reported mental health disorder (n, %)	43 (8.4)	17 (8.9)	0.879
Tobacco use disorder[1] (n, %)	42 (9.8)	25 (15.2)	0.081
Alcohol use disorder[1] (n, %)	7 (1.6)	7 (4.3)	0.072

Abbreviations: MetS = metabolic syndrome, SD = standard deviation, T2DM = Type 2 Diabetes Mellitus.
[1]Substance use is not documented for all patients (Study cohort n = 427, loss to follow-up n = 164)

Supplemental Table 2: Assessment of hip function through the Hip disability and Osteoarthritis Outcome Score (HOOS) in patients who do and do not have obesity.

HOOS Category		No Obesity		Obesity				Averaged over time	
		Mean	SD	Mean	SD	*P*-value	Cohen's d	*P*-value	Cohen's d
Pain	T_0	43.8	15.0	40.9	14.4	0.341	0.187	0.427	0.076
	T_1	81.0	15.3	81.4	16.0	1.000	-0.030		
	T_2	90.0	15.8	88.9	16.3	1.000	0.072		
Symptoms	T_0	46.6	17.2	46.0	19.4	0.768	0.040	0.724	0.031
	T_1	79.1	13.8	81.4	14.3	0.300	-0.151		
	T_2	88.8	13.0	85.6	17.9	0.201	0.204		
Sports and Recreation	T_0	23.0	17.5	15.6	15.6	**0.001**	0.318	**0.002**	0.298
	T_1	43.5	24.6	39.7	26.1	0.224	0.164		
	T_2	74.3	25.2	64.7	30.0	**0.009**	0.413		
AdL	T_0	43.4	16.3	37.5	15.4	**0.006**	0.362	**0.015**	0.23
	T_1	73.7	16.8	73.0	17.2	0.713	0.045		
	T_2	88.3	15.1	83.7	18.6	**0.036**	0.282		
QoL	T_0	25.1	15.3	22.3	16.1	0.358	0.144	0.154	0.124
	T_1	55.5	20.9	55.1	20.3	0.881	0.018		
	T_2	75.7	22.6	71.5	23.5	0.358	0.210		

T_0: preoperative, T_1: 1 month postoperative, T_2: 1 year postoperative, Abbreviations: SD = Standard deviation, AdL = Activities of daily living, QoL = Quality of life

Supplemental Table 3: Assessment of hip function through the Western Ontario and McMaster Universities Arthritis Index (WOMAC) in patients who do and do not have obesity.

		No Obesity		Obesity				Averaged over time	
WOMAC Category		Mean	SD	Mean	SD	*P*-value	Cohen's d	*P*-value	Cohen's d
Pain	T_0	9.9	3.3	10.4	3.3	0.950	-0.151	0.653	-0.048
	T_1	3.2	2.9	3.0	3.1	1.000	0.054		
	T_2	1.6	2.7	1.8	2.8	1.000	-0.046		
Function	T_0	36.4	11.6	40.4	11.0	**0.010**	-0.354	**0.016**	-0.221
	T_1	17.0	11.2	17.3	11.2	0.816	-0.027		
	T_2	7.8	10.1	10.9	12.5	**0.031**	-0.281		
Stiffness	T_0	4.9	1.5	4.8	1.6	0.729	0.043	0.926	-0.008
	T_1	2.3	1.4	2.1	1.4	0.505	0.125		
	T_2	1.2	1.4	1.5	1.7	0.329	-0.192		
Sum	T_0	50.7	15.7	54.7	15.1	0.054	-0.266	**0.037**	-0.186
	T_1	22.0	14.5	22.3	14.5	0.890	-0.015		
	T_2	10.4	13.7	14.6	17.6	0.054	-0.278		

T_0: preoperative, T_1: 1 month postoperative, T_2: 1 year postoperative, Abbreviations: SD = Standard deviation

Supplemental Table 4: Assessment of health-related quality of life measured *via* the SF-12 in patients who do and do not have obesity.

		No Obesity		Obesity				Averaged over time	
SF-12		Mean	SD	Mean	SD	*P*-value	Cohen's d	*P*-value	Cohen's d
PCS	T_0	29.9	7.3	27.3	6.1	**0.007**	0.316	**0.001**	0.277
	T_1	37.1	7.8	36.1	6.5	0.274	0.121		
	T_2	47.4	9.3	44.2	10.4	**0.014**	0.394		
MCS	T_0	48.0	11.9	44.6	12.6	0.122	0.311	**0.046**	0.192
	T_1	51.4	11.0	50.3	10.9	0.788	0.103		
	T_2	53.6	8.8	51.9	11.2	0.518	0.162		

T_0: preoperative, T_1: 1 month postoperative, T_2: 1 year postoperative, Abbreviations: PCS = physical component score, MCS = mental component score

Supplemental Table 5: Assessment of pain at rest in patients who do and do not have obesity.

		No Obesity		Obesity				Averaged over time	
		Mean	SD	Mean	SD	*P*-value	Cohen's d	*P*-value	Cohen's d
VAS	T_0	1.8	1.4	2.0	1.7	1.000	-0.148	0.361	-0.128
	T_1	1.3	1.6	1.5	1.7	1.000	-0.110		
	T_2	1.2	2.2	1.4	1.9	1.000	-0.127		

T_0: preoperative, T_1: 1 month postoperative, T_2: 1 year postoperative, Abbreviations: VAS = Visual Analogue Scale

Supplemental Table 6: Assessment of hip function through the Hip disability and Osteoarthritis Outcome Score (HOOS) in patients who do and do not have Type 2 Diabetes mellitus (T2DM).

		No T2DM		T2DM				Averaged over time	
HOOS Category		Mean	SD	Mean	SD	*P*-value	Cohen's d	*P*-value	Cohen's d
Pain	T_0	42.8	14.5	41.3	18.0	1.000	0.095	0.631	0.078
	T_1	81.1	15.3	80.9	17.8	1.000	0.013		
	T_2	89.7	15.5	87.8	21.3	1.000	0.127		
Symptoms	T_0	46.1	17.7	48.8	21.0	1.000	-0.171	0.846	0.029
	T_1	79.9	13.9	78.2	15.9	1.000	0.108		
	T_2	87.9	14.0	85.5	22.9	1.000	0.148		
Sports and Recreation	T_0	20.7	16.8	17.7	17.6	0.887	0.125	0.400	0.129
	T_1	42.8	24.9	37.4	28.9	0.887	0.227		
	T_2	71.0	26.7	70.1	33.3	0.887	0.036		
AdL	T_0	41.5	16.0	38.9	18.7	0.855	0.153	0.228	0.192
	T_1	73.6	16.7	70.2	19.8	0.855	0.207		
	T_2	87.0	16.1	83.4	21.4	0.855	0.216		
QoL	T_0	24.1	15.7	23.1	15.2	1.000	0.046	0.749	0.047
	T_1	55.5	21.1	51.9	16.3	1.000	0.182		
	T_2	74.0	22.8	75.8	25.1	1.000	-0.086		

T_0: preoperative, T_1: 1 month postoperative, T_2: 1 year postoperative, Abbreviations: SD = Standard deviation, T2DM = Type 2 Diabetes mellitus, AdL = Activities of daily living, QoL = Quality of life

Supplemental Table 7: Assessment of hip function through the Western Ontario and McMaster Universities Arthritis Index (WOMAC) in patients who do and do not have Type 2 Diabetes mellitus (T2DM).

WOMAC Category		No T2DM		T2DM				Averaged over time	
		Mean	SD	Mean	SD	*P*-value	Cohen's d	*P*-value	Cohen's d
Pain	T_0	10.1	3.3	9.8	3.9	1.000	0.115	0.610	-0.102
	T_1	3.1	2.9	3.7	3.0	1.000	-0.199		
	T_2	1.6	2.7	2.3	3.6	1.000	-0.222		
Function	T_0	37.7	11.4	39.5	13.7	0.422	-0.163	0.096	-0.255
	T_1	16.9	11.0	20.0	13.3	0.342	-0.270		
	T_2	8.6	10.6	12.4	15.5	0.262	-0.333		
Stiffness	T_0	4.8	1.5	4.8	1.9	1.000	0.040	0.731	0.05
	T_1	2.2	1.4	2.1	1.3	1.000	0.048		
	T_2	1.3	1.5	1.2	2.0	1.000	0.062		
Sum	T_0	52.2	15.2	52.0	20.0	0.957	0.011	0.111	-0.239
	T_1	21.9	14.2	26.1	16.9	0.396	-0.281		
	T_2	11.4	14.0	18.1	24.6	0.094	-0.447		

T_0: preoperative, T_1: 1 month postoperative, T_2: 1 year postoperative, Abbreviations: SD = Standard deviation, T2DM = Type 2 Diabetes mellitus

Supplemental Table 8: Assessment of health-related quality of life measured *via* the SF-12 in patients who do and do not have Type 2 Diabetes mellitus (T2DM).

		No T2DM		T2DM				Averaged over time	
SF-12		Mean	SD	Mean	SD	*P*-value	Cohen's d	*P*-value	Cohen's d
PCS	T_0	29.1	7.1	27.5	6.1	0.807	0.198	0.738	0.050
	T_1	36.8	7.4	36.5	7.6	1.000	0.035		
	T_2	46.2	9.9	46.9	9.8	1.000	-0.084		
MCS	T_0	46.7	12.0	46.7	14.1	1.000	0.001	0.819	-0.038
	T_1	50.7	11.1	53.0	9.7	1.000	-0.208		
	T_2	53.1	9.7	52.0	10.8	1.000	0.093		

T_0: preoperative, T_1: 1 month postoperative, T_2: 1 year postoperative, Abbreviations: SD = Standard deviation, T2DM = Type 2 Diabetes mellitus

Supplemental Table 9: Assessment pain at rest in patients who do and do not have Type 2 Diabetes mellitus (T2DM).

		No T2DM		T2DM				Averaged over time	
		Mean	SD	Mean	SD	*P*-value	Cohen's d	*P*-value	Cohen's d
VAS	T_0	1.9	1.5	1.9	1.7	1.000	0.015	0.342	-0.221
	T_1	1.3	1.6	1.9	2.4	1.000	-0.339		
	T_2	1.3	1.9	1.9	3.1	1.000	-0.338		

T_0: preoperative, T_1: 1 month postoperative, T_2: 1 year postoperative, Abbreviations: SD = Standard deviation, T2DM = Type 2 Diabetes mellitus, VAS = Visual Analogue Scale

Supplemental Table 10 :Assessment of hip function through the Hip disability and Osteoarthritis Outcome Score (HOOS) in patients who do and do not have hypertension (HTN).

		No HTN		HTN				Averaged over time	
HOOS Category		Mean	SD	Mean	SD	*P*-value	Cohen's d	*P*-value	Cohen's d
Pain	T_0	43.1	14.1	42.4	15.2	0.980	0.047	0.332	0.095
	T_1	82.6	14.7	80.3	15.9	0.721	0.148		
	T_2	90.5	16.0	89.1	16.1	0.980	0.090		
Symptoms	T_0	46.0	16.3	46.5	18.8	1.000	-0.033	0.680	0.037
	T_1	80.0	13.8	79.7	14.2	1.000	0.021		
	T_2	89.0	13.9	87.0	15.4	0.837	0.124		
Sports and Recreation	T_0	21.3	15.3	20.0	17.6	0.555	0.054	0.579	0.054
	T_1	39.4	23.4	43.7	26.1	0.365	-0.182		
	T_2	75.5	23.7	68.7	28.7	0.148	0.289		
AdL	T_0	42.8	15.1	40.5	16.7	0.236	0.141	**0.038**	0.199
	T_1	76.0	15.3	89.1	14.9	0.164	0.239		
	T_2	89.1	14.9	85.5	17.3	0.164	0.217		
QoL	T_0	22.7	15.0	24.6	15.9	0.950	-0.094	0.941	-0.007

T_1	55.5	20.6	55.0	20.8	1.000	0.025
T_2	74.9	23.1	73.9	23.0	1.000	0.049

T_0: preoperative, T_1: 1 month postoperative, T_2: 1 year postoperative, Abbreviations: SD = Standard deviation, HTN = Hypertension, AdL = Activities of daily living, QoL = Quality of life

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Supplemental Table 11: Assessment of hip function through the Western Ontario and McMaster Universities Arthritis Index (WOMAC) in patients who do and do not have hypertension (HTN).

WOMAC Category		No HTN		HTN				Averaged over time	
		Mean	SD	Mean	SD	*P*-value	Cohen's d	*P*-value	Cohen's d
Pain	T_0	9.8	2.9	10.2	3.5	0.298	-0.161	**0.033**	-0.230
	T_1	2.6	2.7	3.4	3.0	0.216	-0.247		
	T_2	1.1	2.2	2.0	3.0	0.112	-0.283		
Function	T_0	36.9	11.0	38.2	11.8	0.347	-0.116	**0.038**	-0.194
	T_1	15.5	10.3	18.0	11.6	0.126	-0.224		
	T_2	7.1	9.7	9.8	11.6	0.126	-0.241		
Stiffness	T_0	4.8	1.4	4.9	1.6	0.952	-0.055	0.299	-0.264
	T_1	2.1	1.4	2.2	1.3	0.952	-0.079		
	T_2	1.2	1.4	1.4	1.6	0.762	-0.140		
Sum	T_0	51.4	14.6	52.5	16.1	0.557	-0.072	0.071	-0.166
	T_1	20.2	13.5	23.2	14.9	0.175	-0.195		
	T_2	9.6	13.3	13.1	16.1	0.172	-0.230		

T_0: preoperative, T_1: 1 month postoperative, T_2: 1 year postoperative, Abbreviations: SD = Standard deviation, HTN = Hypertension

Supplemental Table 12: Assessment of health-related quality of life measured *via* the SF-12 in patients who do and do not have hypertension (HTN).

		No HTN		HTN				Averaged over time	
SF-12		Mean	SD	Mean	SD	*P*-value	Cohen's d	*P*-value	Cohen's d
PCS	T_0	29.6	6.7	28.7	7.2	0.303	0.110	**0.007**	0.236
	T_1	38.0	7.5	36.1	7.3	0.076	0.233		
	T_2	48.3	9.7	45.3	9.8	**0.042**	0.365		
MCS	T_0	48.2	12.8	46.0	11.9	0.736	0.198	0.268	0.109
	T_1	52.4	10.2	50.2	11.3	0.632	0.199		
	T_2	52.5	10.0	53.2	9.7	1.000	-0.070		

T_0: preoperative, T_1: 1 month postoperative, T_2: 1 year postoperative, Abbreviations: SD = Standard deviation, HTN = Hypertension, PCS = physical component score, MCS = mental component score

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		No HTN		HTN				Averaged over time	
VAS		Mean	SD	Mean	SD	*P*-value	Cohen's d	*P*-value	Cohen's d
VAS	T_0	1.7	1.5	2.0	1.5	1.000	−0.186	0.292	-0.159
	T_1	1.1	1.5	1.5	1.7	1.000	−0.267		
	T_2	1.3	2.0	1.3	2.1	1.000	−0.022		

T_0: preoperative, T_1: 1 month postoperative, T_2: 1 year postoperative, Abbreviations: SD = Standard deviation, HTN = Hypertension, VAS = Visual Analogue Scale

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Supplemental Table 14: Complications and adverse events in the study cohort within one year postoperatively.

	Overall (n = 514)	No MetS (n = 455)	MetS (n = 59)	*P*-value
Total (n, %)	61 (11.9)	51 (10.8)	10 (16.4)	0.201
Patients affected (n, %)	57 (11.1)	48 (10.9)	9 (15.8)	0.273
Complications requiring surgical revision (n, %)				
Periprosthetic joint infection	3 (0.6)	3 (0.7)	0 (0.0)	> 0.999
Periprosthetic fracture	3 (0.6)	2 (0.4)	1 (1.7)	0.307
Dislocation/Instability	3 (1.2)	4 (0.9)	2 (3.4)	0.144
Other reasons	3 (0.6)	3 (0.7)*	0 (0.0)	> 0.999
Complications not requiring surgical revision (n, %)				
APHA	10 (1.9)	9 (2.0)	1 (1.7)	> 0.999
Wound complication	9 (1.8)	9 (2.0)	0 (0.0)	0.607
Neural deficit	1 (0.2)	0 (0.0)	1 (1.7)	0.115
Vascular injury	0 (0.0)	0 (0.0)	0 (0.0)	> 0.999
AKI	11 (2.1)	8 (1.8)	3 (5.1)	0.122
UTI	1 (0.2)	1 (0.2)	0 (0.0)	> 0.999
Others	14 (2.9)	12 (2.6)**	2 (3.4)***	0.669

Abbreviations: MetS = metabolic syndrome, APHA = Acute posthemorrhagic anemia, AKI = Acute kidney injury, UTI = urinary tract infection

* Psoas impingement, fascial insufficiency, torn intraarticular redon drainage residue

** Hematemesis, tachyarrhythmia absoluta, urinary retention, central anticholinergic syndrome, pneumonia, cholecystolithiasis, hypertensive derailment, medico-toxic liver damage

*** Ileus, atrial flutter

Statistical comparisons were performed by using Fisher's Exact Test.

Supplemental Table 15: Multivariable linear regression models evaluating the association between individual metabolic syndrome components and HOOS outcome scores at one-year follow-up.

	Overall model fit							95% CI	
HOOS Category	adjusted R^2	*P*-value		B	Standard Error	β	p	Lower	Upper
Pain	0.010	0.113	Intercept (M1)	91.484	1.734		**< 0.001**	88.074	94.894
			Obesity	-1.689	1.911	-0.048	0.377	-5.448	2.070
			HTN	-0.797	2.099	-0.022	0.704	-4.925	3.331
			T2DM	-2.344	2.891	-0.045	0.418	-8.031	3.342
			Dyslipidemia	-4.159	2.061	-0.114	**0.044**	-8.213	-0.105
Symptoms	0.010	0.097	Intercept (M1)	90.234	1.535		**< 0.001**	87.216	93.252
			Obesity	-3.212	1.692	-0.100	0.058	-6.539	0.115
			HTN	-1.167	1.847	-0.035	0.528	-4.798	2.464
			T2DM	-0.312	2.594	-0.006	0.904	-5.412	4.788
			Dyslipidemia	-2.895	1.801	-0.088	0.109	-6.436	0.646
Sports and Recreation	0.045	**< 0.001**	Intercept (M1)	78.576	2.801		**< 0.001**	73.068	84.084
			Obesity	-7.559	3.131	-0.128	**0.016**	-13.717	-1.401
			HTN	-6.576	3.403	-0.107	0.054	-13.269	0.117
			T2DM	-4.196	4.705	-0.048	0.373	-13.450	5.058
			Dyslipidemia	-6.514	3.334	-0.107	0.052	-13.071	0.043
ADL	0.051	**< 0.001**	Intercept (M1)	90.508	1.771		**< 0.001**	87.025	93.991
			Obesity	-3.285	1.975	-0.086	0.097	-7.168	0.599
			HTN	-2.910	2.153	-0.073	0.177	-7.144	1.325
			T2DM	-7.364	3.008	-0.128	**0.015**	-13.279	-1.449
			Dyslipidemia	-4.731	2.109	-0.121	**0.025**	-8.877	-0.584
QoL	0.003	0.281	Intercept (M1)	76.698	2.379		**< 0.001**	72.019	81.377
			Obesity	-3.721	2.642	-0.075	0.160	-8.917	1.474
			HTN	-0.815	2.873	-0.016	0.777	-6.466	4.835
			T2DM	0.339	4.044	0.004	0.933	-7.614	8.292
			Dyslipidemia	-4.483	2.814	-0.087	0.112	-10.017	1.050

Abbreviations: ADL = Activities of daily living, QoL = Quality of Life, HTN = Hypertension, T2DM = Type 2 Diabetes mellitus

Supplemental Table 16: Multivariable linear regression models evaluating the association between individual metabolic syndrome components and WOMAC outcome scores at one-year follow-up.

	Overall model fit							95% CI	
WOMAC Category	adjusted R^2	*P*-value		B	Standard Error	β	p	Lower	Upper
Pain	0.014	0.062	Intercept (M1)	1.313	0.315		**< 0.001**	0.694	1.931
			Obesity	0.324	0.347	0.051	0.351	-0.358	1.006
			HTN	0.276	0.381	0.041	0.468	-0.472	1.025
			T2DM	0.383	0.524	0.040	0.466	-0.649	1.414
			Dyslipidemia	0.790	0.373	0.120	**0.035**	0.056	1.523
Function	0.052	**< 0.001**	Intercept (M1)	6.230	1.162		**< 0.001**	3.945	8.516
			Obesity	2.379	1.294	0.095	0.067	-0.166	4.923
			HTN	1.673	1.411	0.064	0.236	-1.101	4.447
			T2DM	5.026	1.973	0.133	**0.011**	1.147	8.906
			Dyslipidemia	3.073	1.379	0.120	**0.026**	0.362	5.784
Stiffness	0.013	0.066	Intercept (M1)	1.023	0.152		**< 0.001**	0.725	1.321
			Obesity	0.331	0.167	0.104	**0.049**	0.002	0.660
			HTN	0.213	0.183	0.064	0.244	-0.146	0.572
			T2DM	-0.405	0.256	-0.084	0.115	-0.909	0.099
			Dyslipidemia	0.224	0.178	0.069	0.209	-0.126	0.574
Sum	0.041	**< 0.001**	Intercept (M1)	8.403	1.534		**< 0.001**	5.387	11.419
			Obesity	2.944	1.697	0.090	0.084	-0.393	6.282
			HTN	2.126	1.848	0.062	0.251	-1.509	5.761
			T2DM	5.220	2.606	0.105	**0.046**	0.097	10.344
			Dyslipidemia	4.003	1.807	0.119	**0.027**	0.450	7.556

Abbreviations: HTN = Hypertension, T2DM = Type 2 Diabetes mellitus

Supplemental Table 17: Multivariable linear regression models evaluating the association between individual metabolic syndrome components and VAS score at one-year follow-up.

	Overall model fit							95% CI	
	adjusted R^2	*P*-value		B	Standard Error	β	p	Lower	Upper
VAS	0.036	**0.029**	Intercept (M1)	0.926	0.294		**0.002**	0.347	1.505
			Obesity	0.063	0.311	0.015	0.839	-0.551	0.677
			HTN	-0.037	0.336	-0.008	0.912	-0.700	0.625
			T2DM	0.189	0.474	0.030	0.691	-0.747	1.124
			Dyslipidemia	1.038	0.327	0.234	**0.002**	0.392	1.684

Abbreviations: VAS = Visual Analogue Scale, HTN = Hypertension, T2DM = Type 2 Diabetes mellitus

Supplemental Table 18: Multivariable linear regression models evaluating the association between individual metabolic syndrome components and SF-12 score at one-year follow-up.

SF-12	Overall model fit			B	Standard Error	β	p	95% CI	
	adjusted R^2	*P*-value						Lower	Upper
PCS	0.051	< **0.001**	Intercept (M1)	49.325	1.004		< **0.001**	47.350	51.300
			Obesity	-2.466	1.108	-0.115	**0.027**	-4.645	-0.286
			HTN	-2.891	1.210	-0.129	**0.017**	-5.270	-0.512
			T2DM	-1.974	1.694	-0.061	0.245	-5.304	1.357
			Dyslipidemia	-2.243	1.176	-0.102	0.057	-4.555	0.069
MCS	0.014	0.057	Intercept (M1)	53.569	0.983		< **0.001**	51.635	55.502
			Obesity	-2.274	1.085	-0.110	**0.037**	-4.407	-0.140
			HTN	1.538	1.184	0.071	0.195	-0.790	3.866
			T2DM	-0.359	1.658	-0.012	0.829	-3.619	2.901
			Dyslipidemia	-2.607	1.151	-0.123	**0.024**	-4.870	-0.344

Abbreviations: PCS = physical component score, MCS = mental component score, HTN = Hypertension, T2DM = Type 2 Diabetes mellitus

Supplemental Table 19: Multivariable linear regression models evaluating the association between individual metabolic syndrome components and ZUF-8 score at one-year follow-up.

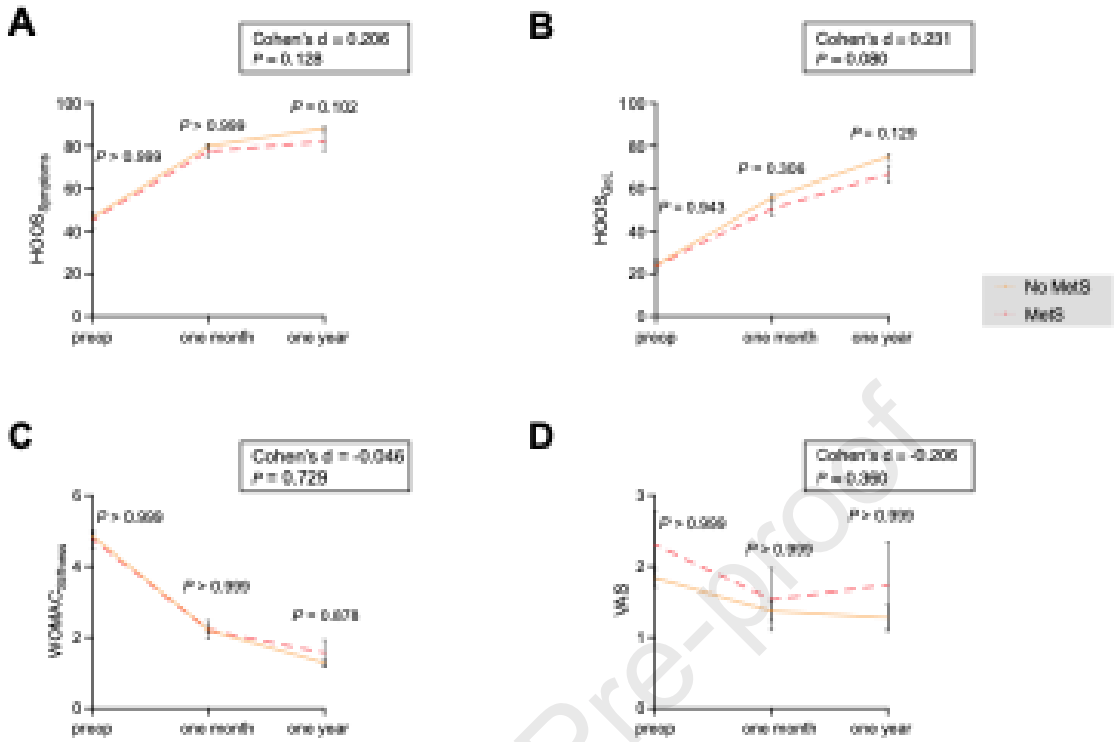
	Overall model fit							95% CI	
Satisfaction	adjusted R^2	*P*-value		B	Standard Error	β	p	Lower	Upper
ZUF-8	0.013	0.067	Intercept (M1)	29.493	0.413		**< 0.001**	28.681	30.304
			Obesity	-0.641	0.457	-0.074	0.162	-1.540	0.259
			HTN	-0.020	0.498	-0.002	0.969	-0.999	0.960
			T2DM	-0.684	0.701	-0.052	0.330	-2.063	0.694
			Dyslipidemia	-1.019	0.487	-0.114	**0.037**	-1.977	-0.062

Abbreviations: HTN = Hypertension, T2DM = Type 2 Diabetes mellitus

Supplemental Table 20: Multivariable logistic regression models evaluating the association between individual metabolic syndrome components and PHQ-4 score at one-year follow-up.

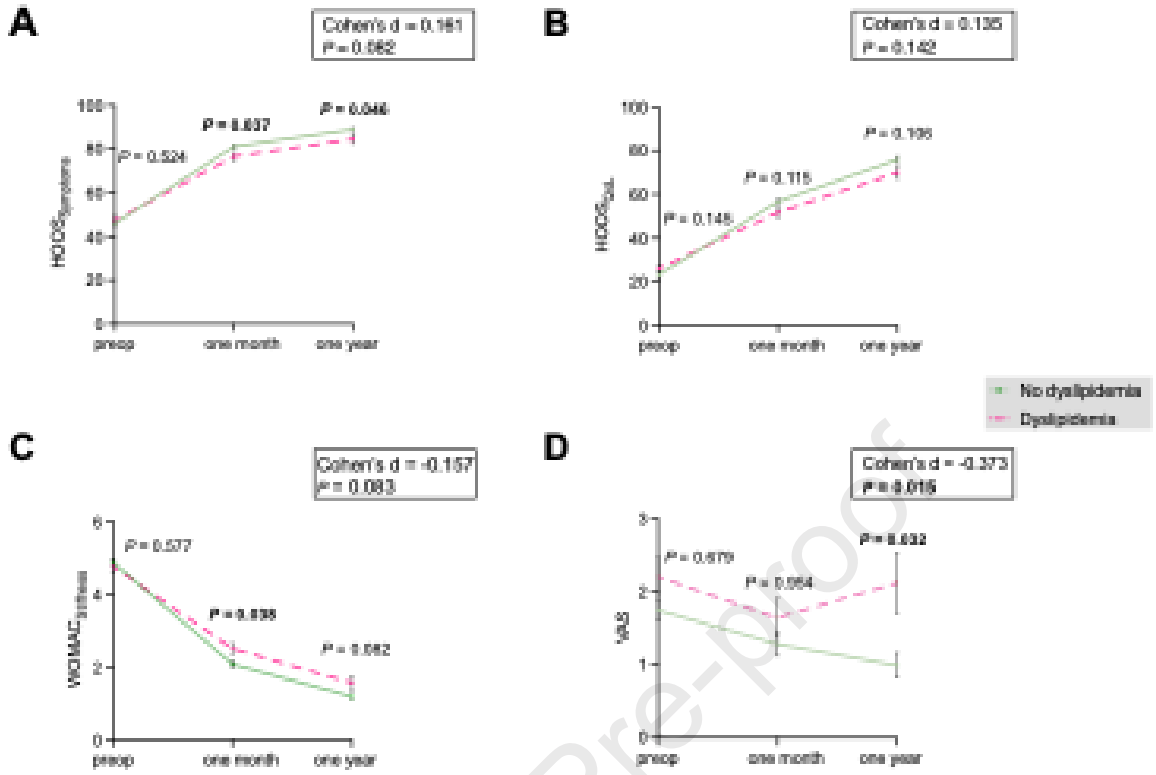
	Overall model fit								Wald Test			95% CI	
PHQ-4	χ^2	*P*-value	Nagelkerke R^2		Estimate	Standard Error	Odds Ratio	z	Wald Statistic	df	p	Lower	Upper
Red flags	4.570	0.334	0.080	Intercept (M1)	-3.658	0.645	0.026	-5.668	32.124	1	< **0.001**	-4.923	-2.393
				Obesity	-0.160	0.916	0.852	-0.175	0.031	1	0.861	-1.956	1.635
				HTN	-1.527	1.032	0.217	-1.480	2.190	1	0.139	-3.549	0.495
				T2DM	2.004	1.047	7.422	1.915	3.668	1	0.055	-0.047	4.056
				Dyslipidemia	0.256	0.990	1.292	0.258	0.067	1	0.796	-1.685	2.196
Yellow flags	6.324	0.176	0.051	Intercept (M1)	-3.152	0.471	0.043	-6.696	44.833	1	< **0.001**	-4.074	-2.229
				Obesity	0.374	0.495	1.453	0.756	0.571	1	0.450	-0.596	1.343
				HTN	-0.662	0.575	0.516	-1.152	1.327	1	0.249	-1.789	0.465
				T2DM	0.663	0.630	1.941	1.053	1.109	1	0.292	-0.571	1.898
				Dyslipidemia	1.070	0.521	2.915	2.053	4.215	1	**0.040**	0.049	2.091

Abbreviations: HTN = Hypertension, T2DM = Type 2 Diabetes mellitus



Supplemental Figure 1: Limited differences in specific subdomains in patients who have metabolic syndrome (MetS).

A) Assessment of the Hip disability and Osteoarthritis Outcome Score (HOOS) subscales symptoms, and B) quality of life (QoL) in patients who do and do not have MetS. C) Assessment of Stiffness *via* the Western Ontario and McMaster Universities Arthritis Index (WOMAC) in patients who do and do not have MetS. D) Evaluation of pain at rest through the Visual Analogue Scale (VAS) in patients who do and do not have MetS. Dashed lines indicate patients who have MetS, and solid lines represent patients who do not have MetS. Group means are displayed by dots, and error bars indicate the standard error of the mean (SEM). Statistical analysis was performed using repeated measures ANOVA with time as the within-subjects factor and MetS status as the between-subjects factor. Significant interaction effects (time x group) indicate differential changes in outcomes over time between groups (Holm). Exact *P*-values and effect sizes (Cohen's d) are displayed. *P*-values < 0.05 were considered statistically significant.



Supplemental Figure 2: Patients who have dyslipidemia report increased pain at rest after total hip arthroplasty (THA).

A) Assessment of the Hip disability and Osteoarthritis Outcome Score (HOOS) subscales symptoms, and B) quality of life (QoL) in patients who do and do not have dyslipidemia. C) Assessment of Stiffness *via* the Western Ontario and McMaster Universities Arthritis Index (WOMAC) in patients who do and do not have dyslipidemia. D) Evaluation of pain at rest through the Visual Analogue Scale (VAS) in patients who do and do not have dyslipidemia. Dashed lines indicate patients who have dyslipidemia, and solid lines represent patients who do not have dyslipidemia. Group means are displayed by dots, and error bars indicate the standard error of the mean (SEM). Statistical analysis was performed using repeated measures ANOVA with time as the within-subjects factor and MetS status as the between-subjects factor. Significant interaction effects (time x group) indicate differential changes in outcomes over time between groups (Holm). Exact *P*-values and effect sizes (Cohen's d) are displayed. *P*-values < 0.05 were considered statistically significant.