■ HIP

Mid-term improvement of cognitive performance after total hip arthroplasty in patients with osteoarthritis of the hip

A PROSPECTIVE COHORT STUDY

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Aims

The aim of this study was to determine whether total hip arthroplasty (THA) for chronic hip pain due to unilateral primary osteoarthritis (OA) has a beneficial effect on cognitive performance.

Methods

A prospective cohort study was conducted with 101 patients with end-stage hip OA scheduled for THA (mean age 67.4 years (SD 9.5), 51.5% female (n = 52)). Patients were assessed at baseline as well as after three and months. Primary outcome was cognitive performance measured by d2 Test of Attention at six months, Trail Making Test (TMT), FAS-test, Rivermead Behavioural Memory Test (RBMT; story recall subtest), and Rey-Osterrieth Complex Figure Test (ROCF). The improvement of cognitive performance was analyzed using repeated measures analysis of variance.

Results

At six months, there was significant improvement in attention, working speed and concentration (d2-test; $p < 0.001$), visual construction and visual memory (ROCF; $p < 0.001$), semantic memory (FAS-test; $p = 0.009$), verbal episodic memory (RBMT; immediate recall $p = 0.023$, delayed recall $p = 0.026$), as well as pain ($p < 0.001$) with small to large effect sizes. Attention, concentration, and visual as well as verbal episodic memory improved significantly with medium effect sizes over $\eta^2_{partial} = 0.06$. In these cognitive domains the within-group difference exceeded the minimum clinically important difference.

Conclusion

THA is associated with clinically relevant postoperative improvement in the cognitive functions of attention, concentration, and memory. These data support the concept of a broad interaction of arthroplasty with central nervous system function.

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Introduction

Osteoarthritis (OA) of the hip is one of the most prevalent joint conditions in ageing populations worldwide,[1,2] and its prevalence is still increasing.[3] In addition to functional limitations such as decreased range of motion,[4] hip OA is characterized by chronic pain.[5,6]

There is a well-documented association between chronic pain of non-OA origin and cognitive decline.[7-14] This effect is particularly pronounced in elderly patients with pre-existing dementia or depressive symptoms.[15] Two recent meta-analyses describe cognitive impairment in verbal and non-verbal memory, attention, working memory, and visual construction, as well as impairment of executive functions (e.g. attention, cognitive flexibility, decision-making, planning) in patients with chronic pain compared to healthy control subjects.[10,11] The underlying reasons for the relationship between chronic pain and cognitive impairment have not yet been fully elucidated. One explanation may be that pain and cognition use overlapping neural networks.[16,17] The onset of chronic pain can lead to structural, functional, and chemical changes in the brain.[18,19] Chronic pain is associated with a decrease in grey matter volume in the dorsolateral prefrontal cortex, cingulate and mediofrontal cortex, thalamus,

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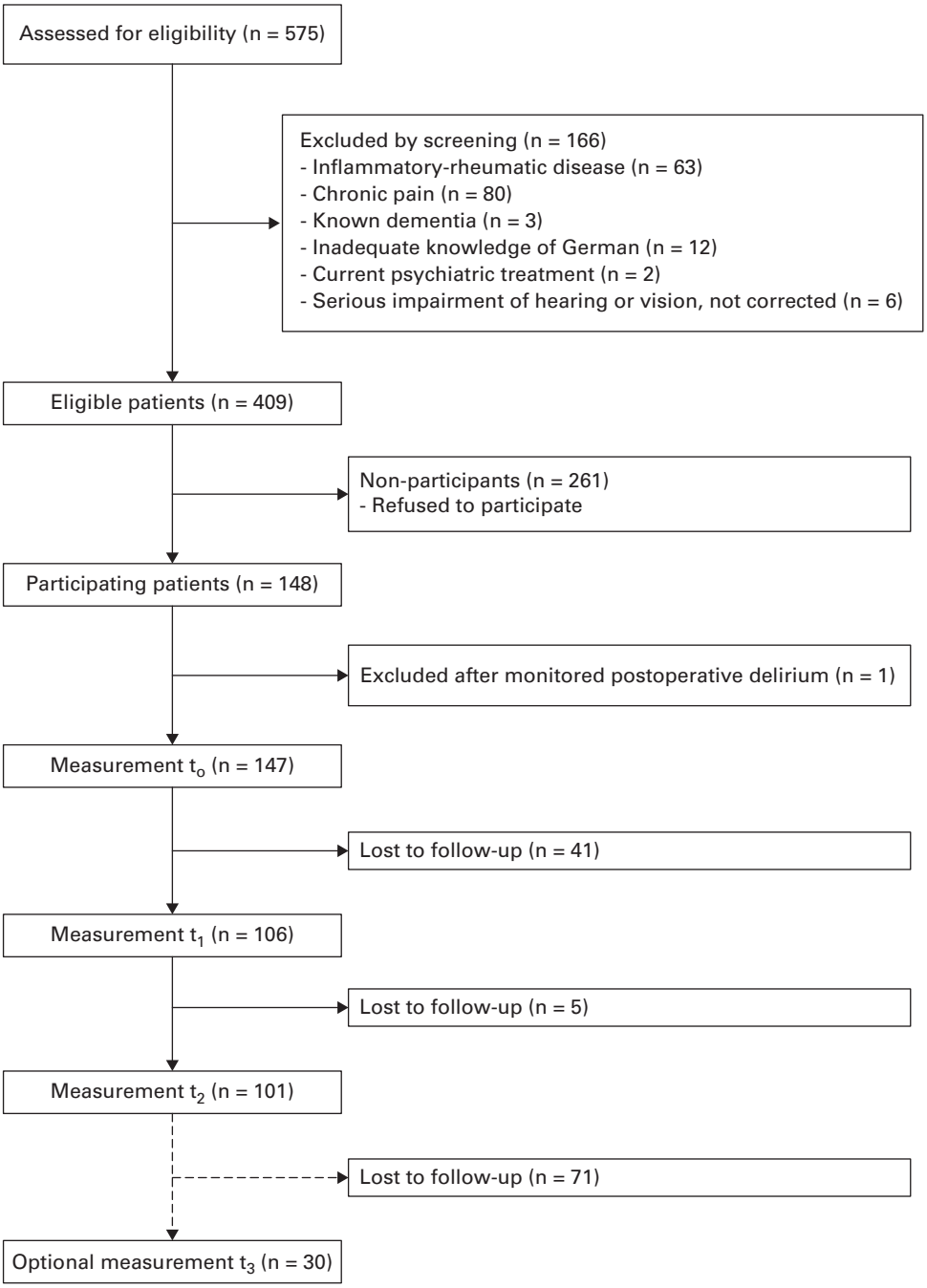

Fig. 1

Flowchart of participants in the study according to STROBE statement guidelines.

and insula.[11,20–25] These brain regions are also responsible for cognition and perception.[26] Work from our institution has previously described in patients with chronic pain due to hip OA, a significant decrease of grey brain matter volume in the anterior cingulate cortex (ACC), insula and operculum, dorsolateral prefrontal cortex, and the orbitofrontal cortex compared to healthy controls.[27,28] In addition, a normalization of grey matter was observed after pain elimination by THA. It was concluded that grey matter alterations are the consequence, not the cause, of chronic pain.

The purpose of the present study was to analyze whether THA, next to the effective elimination of chronic pain and normalization of gray matter, also leads to improved cognition.

Methods

Study design and patients. This prospective single-centre cohort study included patients with primary unilateral end-stage hip OA scheduled to undergo unilateral THA in our clinic. The study conformed to the principles of the Declaration

Table I. Dropout analysis: reasons for study discontinuation.

Reasons for dropping out	n (%)
No motivation to perform the neuropsychological assessment again	17 (36.2)
Other health problems	16 (34.0)
Lack of time due to employment or other activities	7 (14.9)
Not available or unknown relocated	3 (6.4)
Dissatisfied with THA	3 (6.4)
Deceased	1 (2.1)

THA, total hip arthroplasty.

of Helsinki,[29] was approved by the local research ethics committee (PV5016) and registered with ClinicalTrials.gov (NCT02997891). The diagnosis was confirmed by orthopaedic surgeons based on patients' symptoms, clinical examination, and radiograph images. The indication for surgery was fully independent from this study. Preoperative radiographs were used to determine the Kellgren-Lawrence (KL) grade to describe the severity of OA.[30] Surgery was performed either by a senior surgeon of our institution or by residents under direct supervision by a senior surgeon. Standard cementless press-fit acetabular components were used in all cases (Allofit; Zimmer Biomet, USA). Cemented and non-cemented femoral componenents were used, depending on age, bone quality and bone morphology (Zimmer Biomet MEM, CLS Spotorno, Fitmore; all Zimmer Biomet). All patients underwent general anaesthesia unless there were specific medical reasons for spinal anaesthesia.

All patients scheduled for THA were screened for eligibility. Patients with bilateral hip OA were excluded. The full list of exclusion criteria are shown in Figure 1. All included patients reported persistent or recurrent pain lasting longer than three months prior to screening. This definition of pain duration is unequivocal and operationalized.[31] Patients with additional chronic pain from sources other than unilateral hip OA were excluded. Consecutive eligible patients gave informed consent and were recruited as study participants and were treated by THA as an inpatient procedure, usually followed by a three-week rehabilitation programme.

Data were collected with standardized neuropsychological and patient-reported questionnaires preoperatively at admission (t_0), and postoperatively after three (t_1) and six months (t_2). Three and six months were chosen based on our previous observation that a normalization of brain grey matter is detectable as early as 16 to 18 weeks post-THA.[27,28] During the study period, we in addition added a voluntary further measuring point (t_3) with a minimum follow-up of 12 months to examine long-term effects in a sub-cohort of patients. A trained study nurse and trained medical research assistants (AS, MAK, NK, WH) performed the assessments at all measurement timepoints.

Outcome measures. Primary study outcome was change from baseline cognitive performance in various cognitive domains at six months: attention performance, conceptual tracking, planning and flexibility, verbal memory, verbal episodic memory, as well as visual construction and visual memory. Assessment was undertaken using established neuropsychological tests. Attention and concentration were assessed by the concentration performance scale of the d2 Test of Attention.[32] Conceptual tracking, planning, and flexibility was assessed by Trail Making Test (TMT).[33] Semantic memory was measured by the verbal fluency FAS-test,[34] and the verbal episodic memory by the Rivermead Behavioural Memory Test (RBMT) - story recall subtest.[35] Visual construction and visual memory were assessed

Table II. Baseline characteristics and demographic data of the included patients.

Baseline characteristic	Value
Participants, n	101
Sex, n (%)	
Male	49 (48.5)
Female	52 (51.5)
Formal school education, yrs; n (%)	
9	34 (33.7)
10	37 (36.6)
12+	21 (20.8)
Missing	9 (8.9)
Occupation, n (%)	
Full-time	19 (18.8)
Part-time	14 (13.9)
Unemployed/pension	61 (60.4)
Missing	7 (6.9)
Marital status, n (%)	
Single	8 (7.9)
Married	63 (62.4)
Divorced/separated	10 (9.9)
Widowed	13 (12.9)
Missing	7 (6.9)
ASA grade, n (%)	
I	17 (16.8)
II	68 (67.3)
III	16 (15.8)
Pain medication preoperative, n (%)	
None	51 (50.5)
NSAIDs and other nonopioid analgesics	43 (42.6)
Opioids	7 (6.9)
Kellgren-Lawrence grade, n (%)	
0	0 (0)
1	0 (0)
2	6 (5.9)
3	67 (66.3)
4	28 (27.7)
Stem fixation, n (%)	
Cemented	38 (37.6)
Uncemented	63 (62.4)
PHQ-9 Depression score, n (%)	
None (1 to 4)	36 (35.6)
Mild (5 to 9)	43 (42.6)
Moderate (10 to 14)	12 (11.9)
(Moderately) Severe (15 to 27)	4 (4.0)
Missing	6 (5.9)
Mean age, yrs (SD; range)	67.4 (9.5; 45 to 84)
Mean BMI, kg/m² (SD; range)	29.1 (5.1; 18.9 to 44.5)
Mean VAS pain (SD; range)	5.9 (2.1; 0 to 10)
Mean HHS (SD; range)	59.6 (12.9; 22 to 88)
Mean MMSE (SD; range)	28.6 (1.3; 24 to 30)

ASA, American Society of Anesthesiologists; HHS, Harris Hip Score; MMSE, Mini-Mental State Examination; NSAIDs, non-steroidal anti-inflammatory drugs; PHQ-9, Patient Health Questionnaire-9; SD, standard deviation; VAS, visual analogue scale.

Table III. Change in outcome measures at three and six months after total hip arthroplasty, using one-way repeated measures analysis of variance (n = 101). Data available for all patients at all three measurement timepoints.

Variable	Mean t_0 (SD)	Mean t_1 (SD)	Mean t_2 (SD)	Within-group differences*
Significant results				
d2	114.0 (37.2)	122.1†‡ (40.9)	130.1†‡§ (40.4)	$F(2; 157) = 14.03$ $p < 0.001$ $\eta^2_{partial} = 0.143$ MCID = 7.4
ROCF	108.2 (31.7)	121.0†‡ (34.6)	125.4†‡ (38.4)	$F(2;184) = 17.17$ $p < 0.001$ $\eta^2_{partial} = 0.157$ MCID = 6.3
FAS test	12.5 (4.7)	13.4 (5.2)	13.7†‡ (4.7)	$F(2; 186) = 4.82$ $p = 0.009$ $\eta^2_{partial} = 0.049$ MCID = 0.9
RBMT recall	6.0 (2.5)	6.7†‡ (2.5)	6.4 (2.8)	$F(2; 188) = 3.86$ $p = 0.023$ $\eta^2_{partial} = 0.039$ MCID = 0.5
RBMT delayed recall	4.2 (2.3)	5.4†‡ (2.3)	6.4†‡ (8.0)	$F(2; 102) = 4.89$ $p = 0.026$ $\eta^2_{partial} = 0.05$ MCID = 0.5
Non-significant results				
TMT A	41.9 (19.5)	40.1 (16.5)	40.1 (20.5)	$F(2; 160) = 0.95$ $p = 0.377$ $\eta^2_{partial} = 0.01$ MCID = 3.9
TMT B	93.9 (38.3)	92.9 (50.9)	89.4 (44.1)	$F(2; 184) = 0.93$ $p = 0.397$ $\eta^2_{partial} = 0.01$ MCID = 7.7

*Analysis of variance.
†Change exceeds the minimum clinically important difference.
‡Difference to preoperative assessment t_0 is significant ($p < 0.05$).
§Difference from assessment at t_1 to t_2 is significant ($p < 0.05$).
ANOVA, analysis of variance; d2, d2 Test of Attention - outcome scale: concentration performance; MCID, minimum clinically important difference; RBMT, Rivermead Behavioural Memory Test; ROCF, Rey-Osterrieth Complex Figure Test; SD, standard deviation; TMT, Trail Making Test.

by the Rey-Osterrieth Complex Figure Test (ROCF).[36] Further descriptions for each neuropsychological test are reported in the Supplementary Material. The primary outcome "cognitive performance" thus represents a complex multidimensional construct that consists of various cognitive domains which were assessed by each specific neuropsychological test. One could therefore regard each test result as a separate primary outcome. We chose to define the overarching multidimensional construct as primary outcome, as prior to the study initiation, it was completely uncertain whether there would be any effect on any of the specific tests for single domains. In such situations, it is legitimate to group together several tests in a complex multidimensional neuropsychological primary outcome. This was incorporated in the sample size calculation that was based on multiple cognitive domains representing the outcome.[32] Before assessment, dementia screening with the Mini-Mental State Examination (MMSE) was performed.[37] A cut-off for possible presence of cognitive impairment was set at 24 points and below, leading to exclusion from the study. The three-month period between t_1 and t_2 follow-up was considered sufficient to minimize learning effects. In addition, alternative versions available for some of the neuropsychological assessments (TMT, FAS-test, RBMT) were used in an alternate fashion.

Furthermore, pain, depression, and acute postoperative cognitive decline were assessed as confounding variables. A unidimensional single-item visual analogue scale (VAS-pain) was used to measure pain intensity within the last week before each test point. Pain values were measured by placing a mark on a 10 cm line representing a range between "no pain" and "worst pain". To confirm the efficacy of the intervention (THA) on functional outcome, all patients were assessed with the Harris Hip Score (HHS).[38] The HHS covers the domains pain, function, absence of deformity, as well as range of motion, with a possible maximum score of 100 points. Symptoms of depression were assessed by the Patient Health Questionnaire (PHQ-9).[39] Delirium was monitored for postoperatively and evidence of acute confusional state was extracted from the medical records. Since delirium after THA is an acute disorder of cognition, and can have effects on cognitive performance up to six months postoperatively,[40–42] patients with postoperative cognitive decline were excluded from the analysis. All further medical parameters, e.g. method of femoral component fixation, American Society of Anesthesiologists (ASA) grade,[43] preoperative pain medication, and KL grade were extracted from the medical records.

Sample size calculation. The expected effect size was estimated from pooled standard mean differences reported in a meta-analysis on working memory impairment in patients with chronic pain.[10] To our knowledge, there are no studies that have assessed the degree of cognitive improvement in terms of reversibility after cognitive decline. Thus, a small effect of 0.15 was assumed. With an α risk of 0.05 and a statistical power of 0.95, a total sample size of 97 patients was required to calculate repeated measures analyses of variance (ANOVA). Considering an estimated dropout rate of 33% during follow-up, approximately 150 patients would be required. The dropout rate estimate was rather high compared to other studies. This was justified by the fact that the cognitive examination required about 45 minutes to 60 minutes, and patients have to revisit the hospital on two occasions for completion of the study, and did not receive any financial recompense. In addition, a relevant number of the patients were not of retirement age and possibly were no longer able to reattend as they may have returned to their full-time occupation.

Statistical analysis. The primary outcome, improvement of cognitive performance, was evaluated using one-way repeated measures analysis of variance (rmANOVA) to determine whether significant differences exist among measuring points.

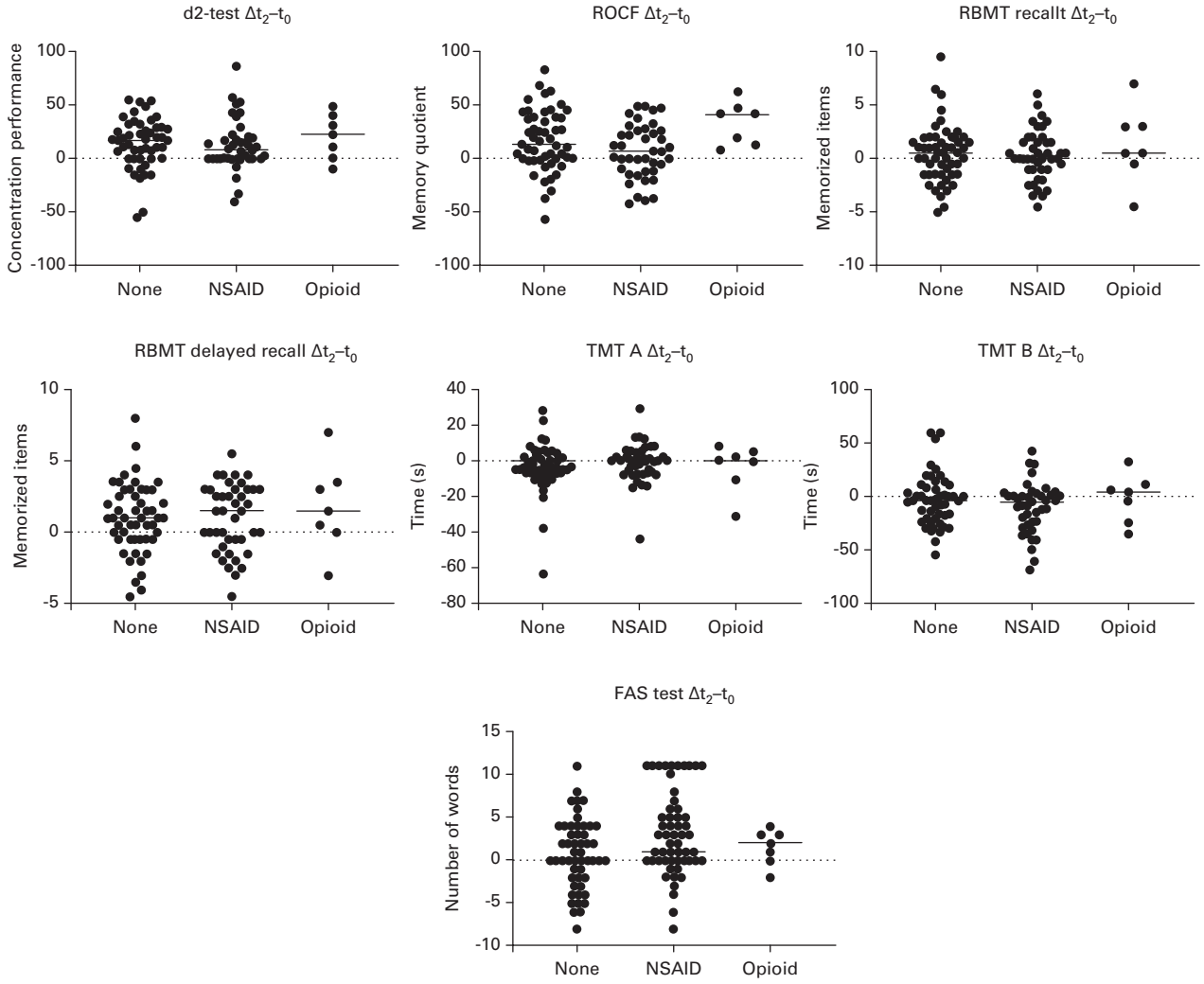

Fig. 2

Change from baseline in outcome measures at six months after total hip arthroplasty related to analgesia group (n = 101) measured with the Kruskal-Wallis test. NSAID, non-steroidal anti-inflammatory drugs; RBMT, Rivermead Behavioural Memory Test; ROCF, Rey-Osterrieth Complex Figure Test; TMT, Trail Making Test.

Effect sizes were reported as partial eta squared ($\eta^2_{partial} \approx 0.01$ small effect, $\eta^2_{partial} \approx 0.06$ medium effect, $\eta^2_{partial} \approx 0.14$ large effect). To verify whether significant changes are clinically meaningful, the distribution-based minimum clinically important difference (MCID) was calculated by multiplying the standard deviation (SD) of the baseline scores by 0.2, corresponding to a small effect size.[44] Difference scores (calculated by subtracting pre-treatment scores from post-treatment scores) served as dependent variable for independent-samples *t*-test to examine the effect of depression and pain on the change of cognitive performance. To examine the influence of medication, non-parametric one-way ANOVA (Kruskal-Wallis test) was conducted to evaluate differences between patients taking no regular medication (n = 51), non-steroidal anti-inflammatory drugs (NSAIDs), non-opioid medication (n = 43), and opioid medication (n = 7). All analyses were performed with data of patients who participated at all three measurement points. Descriptive statistics were calculated to present demographic data by means, SDs, and percentages. To investigate whether the study participants differed on sex, age, pain, depression, ASA grade, and level of education compared to those who were lost to follow-up, independent-samples *t*-test for continuous, Mann-Whitney U test for ordinal, and chi-squared or Fisher's exact test for categorical variables were calculated. All analyses were performed using SPSS v. 25 (IBM, USA) for Windows. Statistical significance was set to a two-tailed p-value of 0.05.

Results

The study enrolled 148 patients out of a total of 575 possible participants who were screened for eligibility. One participant was excluded from further analysis because of postoperative delirium. No patient scored 24 points and below in the MMSE dementia screening. A total of 46 patients withdrew their participation and were recorded as lost to follow-up. Thus, the final sample consisted of 101 patients. Patients who withdrew from the study were interviewed by telephone

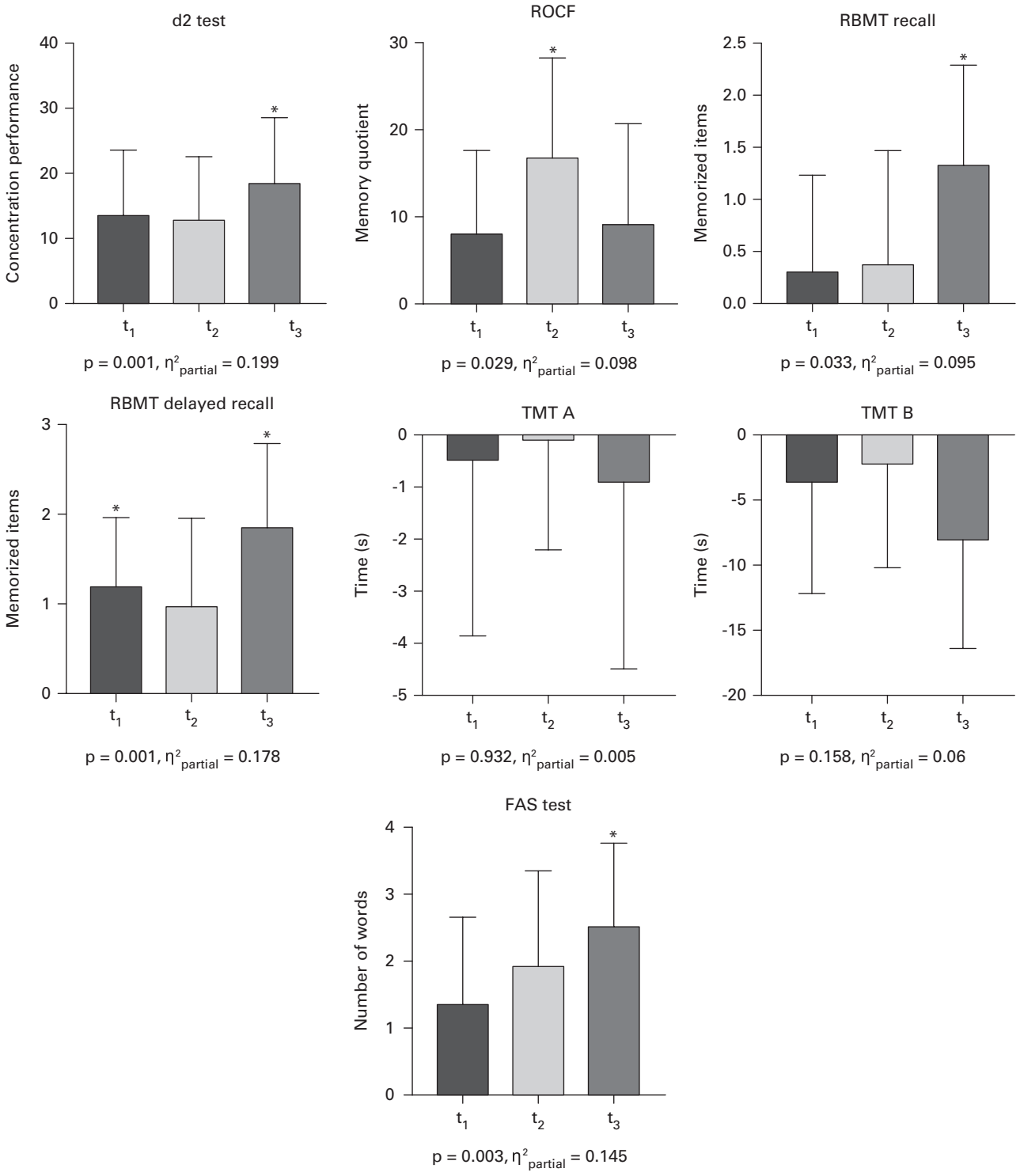

Fig. 3

Long-term improvement of cognitive performance (n = 30) displayed as change in neuropsychological outcome from baseline across measurement points with 95% confidence intervals. RBMT, Rivermead Behavioural Memory Test; ROCF, Rey-Osterrieth Complex Figure Test; TMT, Trail Making Test.

to record the reasons for withdrawal (Table I). A total of 30 patients took part in the optional additional measurement t_3 (study extension beyond protocol) (Figure 1). No major perioperative surgical complications occurred in the per protocol (PP) study population or in patients who withdrew from the study.

Baseline characteristics. The majority of patients were female (51.5%; n = 52), with a mean age of 67.4 years (SD 9.5), and were of German origin (97.9%). Most participants completed nine (33.7%) or ten years (36.6%) of formal school education and were retired (in receipt of a pension; 55.4%) at the time of the study (Table II). No neurological comorbidities were reported. One subject had mild Parkinson's disease.

The mean KL grade was 3.2 (SD 0.5) and preoperative pain (VAS) was 5.9 (SD 2.2). All patients had a KL grade of at least two points, referring to the definitive presence of osteophyte formation. Cemented femoral component fixation was used in 38 patients (37.6%) and cementless in 63 patients (62.4%). The majority of patients had an ASA grade of 2 (67.3%), indicating mild systemic disease most commonly with no functional limitations.[45] The Patient Health Questionnaire-9 (PHQ-9) identified a prevalence rate of 15.9% for a concurrent depressive disorder (major depression), 11.9% reported moderate, and 4.0% moderately severe to severe symptoms.

Change in cognitive performance efficacy analysis. At six months, the THA patients reported a significant decrease of pain (mean Δ -4.8 (SD 2.4); $p < 0.001$, rmANOVA; $\eta^2_{partial} = 0.732$) and a significant improvement in the HHS (Δ +34.5 (12 to 5); $p < 0.001$, rmANOVA; $\eta^2_{partial} = 0.779$), indicating the clinical benefit of the THA. Concerning cognitive function, the main effect at six months following THA was significant for the d2-test CP ($p < 0.001$, rmANOVA; $\eta^2_{partial} = 0.143$). Similarly, ROCF memory quotient ($p < 0.001$, rmANOVA; $\eta^2_{partial} = 0.157$), FAS-test ($p = 0.009$, rmANOVA; $\eta^2_{partial} = 0.049$), RBMT immediate recall ($p = 0.023$, rmANOVA; $\eta^2_{partial} = 0.039$), and RBMT delayed recall ($p = 0.026$, rmANOVA; $\eta^2_{partial} = 0.05$), demonstrated significant changes, indicating that the tested cognitive domains significantly improved after THA. No significant effects were found for TMT (Table III). The within-group difference for d2-test CP, ROCF memory quotient, FAS-test, and RBMT delayed recall exceeded the MCID both in the PP and ITT analysis. The presence or diagnosis of a major depression (PHQ-9 > 9) as a confounding variable had no significant effect on the change in cognitive performance in all examined neuropsychological tests, compared to patients without depressive symptoms. The level of preoperative pain (VAS) also had no significant impact on the change in cognitive performance. Preoperatively, type of medication had a significant impact on d2-test CP ($p = 0.023$, Kruskal-Wallis test). A Dunn-Bonferroni post hoc analysis revealed a trend that patients with opioid intake had decreased d2-test results compared to patients who had taken no medication ($p = 0.025$), and to patients with NSAID pain medication without opioids ($p = 0.033$). Despite this confounding effect at baseline, the type of medication had no significant effect on the change in cognitive performance in all examined neuropsychological tests pre- versus postoperatively (Figure 2).

Lost to follow-up analyses. The rate of patient compliance was compared to lost to follow-up, based on sex, age, pain, depression, ASA grade, and level of education. The analyses showed that patients who withdrew prematurely from the study had a lower level of formal school education ($p = 0.008$, Mann-Whitney U-test) and a higher ASA grade ($p = 0.002$, Mann-Whitney U-test). The reasons for withdrawal from the study are listed in Table I.

Long-term improvement of cognitive performance. The beyond protocol extended study group, included long-term follow-up of 30 patients, 60% of whom were female (n = 18), with a mean age of 66.4 years (SD 8.8), and mean follow-up of 17.4 months (SD 4.5) with a minimum of 12 and a maximum of 25 months. The long-term study sub-group revealed that all neuropsychological outcome scores evolve with time (Figure 3). The long-term effect of THA to the measurement point t_3 was significant for d2-test CP ($p = 0.001$, rmANOVA; $\eta^2_{partial} = 0.199$), ROCF memory quotient ($p = 0.029$, rmANOVA; $\eta^2_{partial} = 0.098$), FAS-test ($p = 0.003$, rmANOVA; $\eta^2_{partial} = 0.145$), RBMT immediate recall ($p = 0.033$, rmANOVA; $\eta^2_{partial} = 0.095$), and RBMT delayed recall ($p = 0.001$, rmANOVA; $\eta^2_{partial} = 0.178$). Again, no significant effect was found for TMT. However, no further significant improvement was observed between the measurement point t_2 and t_3.

Discussion

We have investigated the change in cognitive performance in patients with unilateral primary hip OA treated by THA. We found that THA is associated with significant longitudinal improvements in measures of a variety of cognitive abilities: attention and concentration, working speed, and visual construction, as well as semantic, verbal episodic and visual memory.

The observed mid-term effects on cognitive performance were particularly large for visual construction and memory (PP: $\eta^2_{partial} = 0.157$) as well as attention and concentration (PP: $\eta^2_{partial} = 0.143$). The long-term results, at a mean of 17 months after THA, showed further significant effect sizes. Due to the small sample size (n = 30) long-term data could not be generalized. Further studies with larger patient numbers will be required to confirm long-term effects before definitive conclusions can be reached.

Overall, these data point towards a possible functional relationship between the reduction of pain, the normalization of brain grey matter,[27,28] and the improvement of cognitive performance after THA, but causation requires further studies. Most observed significant changes were clinically important. The MCID calculation demonstrated that four out of five significant changes in cognitive performance are clinically important.

To our surprise, depression had no significant influence on the changes of cognitive performance in this study. This was not necessarily to be expected, as depression has been related to cognitive impairment in several previous studies.[46–48] One possible explanation for this discrepancy may be that the power analysis for the present study was designed to detect a significant longitudinal change in cognitive performance in patients without severe pre-existing neuropsychological disorders. It is probable that the number of patients included with depression was too small to reveal potentially significant effects. Another possible explanation could be that a distinction may be necessary between depressive symptoms induced by chronic pain and depression independent of pain.[49,50] It is conceivable that the effect of pain on cognition is much stronger than the effect of depression on cognition in patients with chronic OA pain. This explanation is compatible with overlapping neuronal networks for pain and cognition.[16,17] Further study is required to

understand the mutual relationship between pain, pain-induced depression, and depression independent of pain and cognition.

The present findings suggest that opioids or other analgesics had no influence on the change in cognitive performance. Although we found significant differences at baseline, the change in cognitive performance proceeds in a rather parallel course in all three medication groups. Therefore we consider it unlikely that the use of opioids was a significant confounding factor on the main result and conclusions of the present study.

This study has clear strengths: it is the first study to investigate the impact of arthroplasty on cognitive function in a sample of patients with chronic pain due to OA. Only established and standardized neuropsychological tests were used to examine a variety of different cognitive domains, which gives validity to the data and conclusions.

A weakness of the study was that there was no control group (CG). However, choosing a valid CG is essentially impossible. In the initial study protocol, a healthy CG was intended, but recruitment was soon discontinued as this kind of CG was found not to be suitable for comparison. A healthy CG without intervention would not be comparable at baseline and throughout the course of the study. A more appropriate CG would be represented by patients with similar severity of OA and chronic pain, but delayed surgical intervention for at least six months. For ethical and medical reasons, such a CG is not possible in our society and clinical environment.

Another limitation is that, as in all neuropsychological longitudinal studies, we cannot entirely exclude a specific learning bias by which the effect sizes may be overestimated. To counteract this bias, we have used alternative versions of the neuropsychological test wherever possible. Also, based on the literature for the neuropsychological test battery that we used, it is unlikely that a significant learning effect with large effect sizes comes into play at three-month intervals between tests.[51–54]

The lost to follow-up rate of 31.3% was high. This may be explained by the fact that with a mean of 48 minutes, the processing time to finish the neuropsychological testing (excluding the questionnaires) was long, and may have been too bothersome for participants to repeat. The neuropsychological test battery contained a large number of individual tests by intention in order to increase the generalizability of results. Of note, patients with a lower level of formal school education and more severe illnesses were more likely to discontinue participation in the study. Reasons for discontinuation or dropout are listed in Table I. Patients with "other health problems" mainly suffered from recent onset back pain, were care home residents with other ongoing health conditions, or had undergone further operations or procedures due to other underlying diseases without direct relation to OA. There were no THA-related major complications (e.g. infection, fracture, dislocation, loosening, nerve damage) either in the study population or among patients who were lost to follow-up.

Despite the dropout rate of > 30%, there was a sufficient number of patients to meet the requirements of the power analysis. Accordingly, both ITT and PP analysis showed significant results. Finally, screening for postoperative cognitive decline was not robust. We did not apply validated instruments such as 3D-CAM or CAM-S to assess delirium.[55] Clinical evaluation was carried out immediately postoperatively by the anaesthetic service and by the study nurse, two days post-THA. Serious abnormalities in behaviour or orientation were noted and reported. The complication of a postoperative cognitive dysfunction (POCD) developing secondary to a delirium represents a multifactorial prolonged decline in cognitive function. Recent study results and a meta-analysis suggest that POCD does not occur in THA patients to the same degree that would be expected based on comparative major surgery in other disciplines.[56,57] This is in line with the low number of POCD in the present study, as well as a positive effect of THA on cognitive performance.

In conclusion, this is the first study to describe the impact of hip arthroplasty on cognition in patients with OA. The concept of evaluating the impact of THA on cognitive performance is completely novel and clinically potentially highly relevant. The present results show that THA leads to a measurable increase in a wide spectrum of cognitive performance. This contributes to a new field of research into the interaction of arthroplasty with the central nervous system. Benefits of hip arthroplasty thus go beyond physical function and pain reduction. They may include improved overall neuropsychological prognosis, which has broader implications not only for individuals but also for health economics and society.

Take home message

- Total hip arthroplasty is associated with clinically relevant postoperative improvement of the cognitive functions of attention, concentration, and memory.
- These data support the concept of a broad interaction of total joint replacement with central nervous system function.

Animation

An animation is available alongside the online version of this article.

Supplementary material

Brief description of applied neuropsychological tests.

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