doi: 10.2490/prm.20220009 Progress in Rehabilitation Medicine 2022; Vol. 7, 20220009

ORIGINAL ARTICLE

Central Sensitization and Postoperative Improvement of Quality of Life in Total Knee and Total Hip Arthroplasty: A Prospective Observational Study

Eiji Sasaki, MD, PhD [a] Takayuki Kasai, PhD [b] Ryo Araki, MD, PhD [a,b] Tomoyuki Sasaki, MD, PhD [b] Yuji Wakai, MD, PhD [b] Koichi Akaishi, MD, PhD [b] Daisuke Chiba, MD, PhD [a] Yuka Kimura, MD, PhD [a] Yuji Yamamoto, MD, PhD [a] Eiichi Tsuda, MD, PhD [c] and Yasuyuki Ishibashi, MD, PhD [a]

Background: While total knee arthroplasty (TKA) and total hip arthroplasty (THA) lead to excellent clinical outcomes, some patients experience residual surgical site pain and reduced satisfaction. This prospective observational study investigated the prevalence of preoperative and postoperative residual central sensitization (CS) after TKA and THA. The influence of residual CS on the improvement in quality of life (QOL) was also investigated. **Methods:** The participants were 40 patients who underwent TKA and 47 patients who underwent THA. CS was measured using the central sensitization inventory (CSI) questionnaire. Knee symptoms were evaluated using the Knee Injury and Osteoarthritis Outcome Scales (KOOS), and hip symptoms were evaluated using the Japanese Orthopedic Association Hip-disease Evaluation Questionnaires (JHEQ). General QOL was evaluated using EuroQOL (EQ-5D-5*l*). Regression analysis was performed to estimate factors related to low QOL after surgery. **Results:** Preoperatively, 47.5% of TKA patients and 66.0% of THA patients were CS positive (P=0.083), which reduced to 10.0% (P=0.042) and 25.5% (P=0.202), respectively, 3 months after surgery. Although the improvements in KOOS subscales and EQ-5D-5*l* scores in TKA patients with residual CS were significantly lower than in those without residual CS, residual CS status had no effect on JHEQ subscales and EQ-5D-5*l* scores in THA patients. Regression analysis indicated that EQ-5D-5*l* was negatively correlated with CSI in the TKA group (P=0.017). In contrast, CSI was not correlated with EQ-5D-5*l* in the THA group (P=0.206). **Conclusion:** Postoperative QOL improvement was achieved 3 months after THA regardless of residual CS status. In contrast, preoperative CS was negatively associated with the improvement in QOL after TKA.

Key Words: central sensitization; quality of life; total hip arthroplasty; total knee arthroplasty

INTRODUCTION

Both total knee arthroplasty (TKA) and total hip arthroplasty (THA) are established surgical procedures for severe knee and hip osteoarthritis that lead to excellent outcomes and patient satisfaction.[1–4] However, despite favorable clinical outcomes, there remain discrepancies between postoperative subjective and objective scales, with patient-based outcome scores and satisfaction being relatively low in some cases.[5–7] Some patients reportedly experience residual surgical site pain and chronic postsurgical pain (CPSP).[8] A systematic review reported that 8.0–26.5% of TKA recipients and 4.8–20.5% of THA recipients reported postoperative residual pain.[9]

As one of the key causative factors of CPSP, central sensitization (CS) is a potential therapeutic target.[10] CS influences

Received: November 2, 2021, Accepted: January 24, 2022, Published online: February 23, 2022
[a] Department of Orthopaedic Surgery, Hirosaki University Graduate School of Medicine, Hirosaki, Japan
[b] Department of Orthopaedic Surgery, Hirosaki Memorial Hospital, Hirosaki, Japan
[c] Department of Rehabilitation Medicine, Hirosaki University Graduate School of Medicine, Hirosaki, Japan
Correspondence: Eiji Sasaki, MD, PhD, Department of Orthopaedic Surgery, Hirosaki University Graduate School of Medicine, 5 Zaifu-cho, Hirosaki, Aomori 036-8562, Japan, E-mail: e_sasaki@hirosaki-u.ac.jp

sensitivity and the spread of pain via enhanced responsiveness of nociceptors.[11–14] Despite the high prevalence of CS in end-stage OA, estimated as 20%,[15] the relationship between the severity of CS and recovery after surgery and clinical outcomes remains unclear. Furthermore, postoperative satisfaction among THA recipients is reportedly superior to that of TKA recipients.[16–18] The influence of CS or other related intrinsic psychological background factors on postoperative clinical outcomes following TKA and THA is not fully understood.[19]

This study aimed to investigate the prevalence of preoperative and postoperative residual CS after TKA and THA. Furthermore, the influence of residual CS on improvements after surgery was also investigated. We hypothesized that residual CS is more common in TKA patients than in THA patients and leads to inferior postoperative outcomes.

MATERIALS AND METHODS

Patients

We prospectively enrolled patients who underwent primary TKA or primary THA at our institution between January 2018 and March 2019. Inclusion criteria for TKA were patients with Kellgren-Lawrence grade 3 and 4 who underwent primary TKA for end-stage knee OA, regardless of their age. Also, the inclusion criteria for THA were primary or secondary hip OA with Kellgren-Lawrence grade 3 and 4 with no dislocation or acute hip fracture. Patients who underwent revision surgery and those with joint infection, lateral type knee osteoarthritis, osteonecrosis of the femoral head, undertreatment of rheumatoid arthritis or psychiatric disease, and any malignancy, were excluded. Finally, a total of 40 TKA patients (6 men and 34 women) and 47 THA patients (1 man and 46 women) were included. This study was performed in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. All participants gave their written informed consent, and the study was conducted with the approval of the Ethics Committee of Hirosaki Memorial Hospital (2018–01).

Surgical Procedures for TKA

Cruciate-substitute TKAs were performed using the measured resection technique without a navigation system. A medial parapatellar approach was used to expose the knee. Femoral osteotomy was done using an intramedullary guide. The tibial osteotomy was done using an extramedullary guide with a varus/valgus of 0° and a slightly posterior slope. The gap distance was measured with a tensor. The soft tissue balance was adjusted for straight alignment with minimized medial soft tissue release in a step-by-step manner such that the medial and lateral gap difference was less than 3 mm at both full extension and 90° flexion. Finally, the components were implanted using a cementless technique.

Surgical Procedures for THA

Antero-lateral approach THAs were performed without a navigation system with the patient in the supine position. The target angles of cup insertion were 40° inclination and 15° anteversion (radiographic definition). The femur was placed in extension, external rotation, and adduction for femoral stem insertion. Intraoperative fluoroscopic images were captured to examine cup positioning, femoral component size, and alignment. Leg length was determined using the cup-head traction distance during traction in the neutral position. Anterior stability was assessed by measuring 20° extension and maximum external rotation. Posterior stability was assessed by measuring 90° flexion and maximum internal rotation.

The standard postoperative rehabilitation program involved weight bearing (as tolerated with a walking aid) starting from the day after surgery for both TKA and THA patients. All patients were allowed to perform full weight bearing and were discharged after ensuring stable/healed surgical wounds and adequate mobility to perform daily activities.

Evaluation of Central Sensitization

CS was evaluated using the central sensitization inventory (CSI).[20] This self-report questionnaire exhibits satisfactory psychometric strength, clinical utility, and initial construct validity. The complete version comprises 25 items. However, we also used a shorter version consisting of nine items (CSI-9) that was locally available. Scores were assigned from 0 (best) to 4 (worst) for each item. The maximum total score was 100 points for the full version of the CSI and 36 points for CSI-9, wherein a higher score indicates more severe CS. CSI-9 has been validated using Spearman's correlation coefficient (r=0.91) with respect to the full version of CSI.[21] Based on this previous report,[21] we assigned patients to the CS group if they scored 10 points or higher on CSI-9.

Patient Satisfaction

To further evaluate the health-related quality of life (HR-QOL) of patients, we used EuroQoL-5-dimensions 5-levels (EQ-5D-5*l*) in the form of self-reported questionnaires.[22] Among generic scales, the EQ-5D-5*l* has been widely used

to measure HR-QOL in patients with OA.[23,24] The EQ-5D-5*l* self-report questionnaire measures five domains of HR-QOL, namely mobility, self-care, usual activities, pain/discomfort, and anxiety/depression.[22] Each of the five domains is assessed by a single question with three response levels (no problem, some problems, and extreme problems). These results are coded and converted to a useful score with the help of tables of values.[25] The EQ-5D-5*l* scoring algorithm was first developed using time trade-off-based preference scores for a sample of these health states from a representative sample of the UK general population[22]; the Japanese version of the EQ-5D-5*l* has also been validated against the English version.[25] This EQ-5D-5*l* algorithm is used worldwide and can yield scores ranging from −0.111 to 1.000, wherein negative scores represent health states worse than being dead, 0 represents being dead, and 1.00 represents a state of complete health.

Evaluation of Knee Symptoms

TKA patient-reported outcome measures were evaluated using the Knee Injury and Osteoarthritis Outcome Scales (KOOS).[26,27] KOOS consists of 42 knee-related items, and each item is scored from 0 to 4. Summed scores in five subscales (symptoms, pain, activities of daily living, sports, and QOL) are converted to 100 points as the best condition. Due to limitations with respect to postoperative activity, KOOS sports items were not considered in this study.

Evaluation of Hip Symptoms

Patient-reported outcomes were evaluated using the Japanese Orthopedic Association Hip-Disease Evaluation Questionnaires (JHEQ) for THA patients.[28] The JHEQ is a validated self-administered questionnaire for evaluating the quality of life of Asian patients with hip diseases. JHEQ has three subscales, i.e., pain, movement, and mental condition, and the scores for each range from 0 (worst) to 28 (best) points. The total score of the JHEQ ranges from 0 (worst) to 84 (best) points.

Evaluation of Pain Catastrophizing

Pain catastrophizing was determined using the Japanese version of the Pain Catastrophizing Scale (PCS),[29] a 13-item self-report questionnaire that helps measure maladaptive thoughts regarding pain; each item is rated on a 5-point Likert-type scale (0=not at all; 4=all the time), and higher scores reflect a greater degree of pain-related catastrophizing. The PCS contains three dimensions of pain catastrophizing: rumination, helplessness, and magnification. Rumination represents repeated pain-related thoughts, helplessness indicates the state of feeling helpless in dealing with a painful situation, and magnification represents an exaggeration of the perception of threat arising from pain; the Japanese version has been found to be valid and reliable.[29]

Statistical Analysis

The survey items were measured before surgery and 3 months after surgery to evaluate the short-term outcomes and their correlation with preoperative CS status.[9] Preoperative PCS, CSI, and EQ-5D-5*l* scores were compared between the TKA and THA groups using the Mann–Whitney U test. The preoperative and postoperative prevalences of CS in TKA and THA patients were estimated. Among those with CS before surgery, patients were divided into the improved (I) group and the remained (R) group, based on the CS status 3 months after surgery. KOOS subscales, JHEQ subscales, and the EQ-5D-5*l* scores of the I and R groups were compared using the Mann–Whitney U test. To investigate the association between postoperative EQ-5D-5*l* scores and CS, linear regression analysis was performed with EQ-5D-5*l* as the dependent variable, and age, sex, body mass index (BMI), bilateral surgery, CSI-25, PCS, and KOOS subscales or JHEQ subscales as independent variables. To avoid multicovariance, KOOS QOL and JHEQ mental scores were not included in the models. Data input and analysis were performed using IBM SPSS version 27.0 (IBM Corp., Armonk, NY, USA). A P-value of less than 0.05 was considered statistically significant.

RESULTS

The mean ages (with standard deviations) of TKA and THA patients were 71.5 ± 5.3 and 63.0 ± 7.5 years, respectively (P=0.015). The mean BMIs calculated from the patients' height and weight were 26.7 ± 3.6 kg/m^2 in TKA patients and 24.5 ± 4.0 kg/m^2 in THA patients (P<0.001). The patient demographic data are summarized in **Table 1**. There were no significant differences in terms of preoperative PCS or EQ-5D-5*l* scores between the TKA and THA groups **(Table 1)**. In contrast, CSI-25 and CSI-9 scores of the THA group were significantly higher than those of the TKA group. Preoperatively, 47.5% of the TKA group and 66.0% of the THA group (P=0.083) were CS positive; 3 months after surgery, these percentages had shrunk to 10.0% (P=0.042) and 25.5% (P=0.202), respectively. Among the 19 TKA patients with preoperative CS, 4 (21.1%) were included in the R group. Their KOOS pain, KOOS symptoms, and EQ-5D-

Table 1. Comparison of preoperative clinical conditions between total knee arthroplasty and total hip arthroplasty patients

	TKA	THA	P-value
Sample size	40	47	
Female, %	34 (85.0%)	46 (97.9%)	0.045
Age, years	71.5 ± 5.3	63.0 ± 7.5	0.015
Body mass index, kg/m^2	26.7 ± 3.6	24.5 ± 4.0	<0.001
Bilateral surgery	19 (47.5%)	10 (21.3%)	0.010
Pain catastrophizing scale	31.3 ± 12.0	28.6 ± 10.7	0.246
CSI-25	19.7 ± 10.6	23.8 ± 10.2	0.037
CSI-9	9.4 ± 5.1	11.6 ± 5.2	0.028
Patients with CS (CSI-9≥10)	19	31	
EQ-5D-5*l*	0.56 ± 0.16	0.53 ± 0.20	0.518

Data were compared using the Mann–Whitney U test or Fisher's direct test.
CSI, central sensitization inventory.

Table 2. Comparison of knee symptoms and QOL after TKA

	I group n = 15	R group n = 4	P-value
KOOS Pain	40.6 ± 22.6	8.3 ± 15.9	0.027
KOOS Symptom	34.5 ± 18.9	–6.3 ± 17.1	0.002
KOOS ADL	28.9 ± 23.5	3.3 ± 10.7	0.062
KOOS QOL	32.5 ± 25.2	18.8 ± 17.7	0.411
EQ-5D-5*l*	0.32 ± 0.19	–0.04 ± 0.27	0.020

TKA patients with preoperative positive CS were divided into an improved (I) group and a remaining (R) group, based on the CS status 3 months after surgery. Scores were compared using the Mann–Whitney U test.

Table 3. Comparison of hip symptoms and QOL after THA

	I group n = 19	R group n = 12	P-value
JHEQ Pain	16.9 ± 7.2	14.2 ± 6.2	0.205
JHEQ Movement	13.6 ± 5.9	11.1 ± 6.4	0.306
JHEQ Mental	14.2 ± 7.5	11.8 ± 4.9	0.435
JHEQ Total	44.7 ± 16.2	37.0 ± 15.0	0.236
EQ-5D-5*l*	0.37 ± 0.27	0.27 ± 0.24	0.367

Data were compared using the Mann-Whitney U test.

5*l* scores were significantly lower than those of the I group **(Table 2)**. Among the 31 THA patients with preoperative CS, although 12 (38.7%) were included in the R group, there was no significant difference between the I and R groups for the JHEQ subscale scores or EQ-5D-5*l* scores **(Table 3)**. Regression analysis showed that, whereas the EQ-5D-5*l* scores were negatively correlated with CSI-25 in the TKA group (P=0.017), EQ-5D-5*l* scores were not correlated with CSI-25 in the THA group (P=0.206) **(Tables 4 and 5)**.

DISCUSSION

Even though this was a short-term observational study, the preoperative CS, as evaluated using CIS-25, was negatively associated with the general QOL improvement after TKA. In contrast, satisfactory outcomes following THA were not associated with preoperative CS status. However, a certain number of patients did suffer CS after THA. Among TKA patients, 47.5% and 10.0% were CS positive before and after surgery, respectively. Furthermore, the 66.0% of preoperative

Table 4. Factors related to the postoperative EQ-5D-5*l* score of TKA patients

	β	P-value
Female	–0.31	0.021
Age	0.02	0.915
Body mass index	–0.07	0.641
Bilateral surgery	0.19	0.265
Preoperative CSI-25	–0.44	0.017
Preoperative PCS	0.24	0.110
Preoperative KOOS Pain	–0.23	0.445
Preoperative KOOS Symptoms	0.13	0.636
Preoperative KOOS ADL	–0.35	0.192

Linear regression analysis was performed with the postoperative EQ-5D-5*l* score as the dependent variable, and age, body mass index, pain catastrophizing scale (PCS), central sensitization inventory (CSI), and knee injury and osteoarthritis outcome scales (KOOS) as independent variables.

Table 5. Factors related to the postoperative EQ-5D-5*l* score of THA patients

	β	P-value
Female	0.01	0.985
Age	–0.07	0.614
Body mass index	–0.08	0.542
Bilateral surgery	0.36	0.010
Preoperative CSI-25	–0.20	0.206
Preoperative PCS	0.24	0.122
Preoperative JHEQ Pain	–0.17	0.363
Preoperative JHEQ Movement	–0.25	0.148

Linear regression analysis was performed with the postoperative EQ-5D-5*l* score as the dependent variable, and age, body mass index, pain catastrophizing scale (PCS), central sensitization inventory (CSI), and Japanese Orthopedic Association Hip-disease Evaluation Questionnaire (JHEQ) subscales as independent variables.

CS-positive THA patients had reduced to 25.5% by 3 months after surgery. These results suggested that postoperative residual CS was not rare, even though the widespread hyperesthesia and enhanced spatial summation were normalized following TKA.[30] These results stress the need to consider early preoperative or perioperative intervention for CS.

Nearly half of all THA and TKA patients had preoperative CS, a frequency that is markedly higher than that in the general population. A previous epidemiological study showed that the prevalence of CS in the general population was 14.0% and was not correlated with their Kellgren–Lawrence grade.[31] However, knee OA patients who developed CS suffered from nocturnal knee pain and their sleep quality and general QOL diminished significantly.[16,31,32] The proportion of patients who are CS positive just before undergoing TKA is reportedly in the range 24–48%,[33,34] which is similar to that observed in our study. In contrast, only a few studies have reported the prevalence of CS in patients with hip OA. A systematic review showed that the prevalence of neuropathic-like pain was 40% in knee OA patients and 29% in hip OA patients.[35]

Furthermore, in both the TKA and THA groups, some patients with preoperative CS also had CS 3 months after surgery. Residual CS after TKA is known to reduce patients' postoperative QOL.[36] Severe and long-lasting postoperative pain results in chronic postsurgical pain (CPSP) and should ideally be avoided.[37] We observed differences in postoperative improvements in symptoms and QOL with respect to preoperative CS between TKA and THA, despite a high prevalence of preoperative and postoperative CS for both surgeries. Among previous reports, some showed equal improvements or greater improvements following TKA than THA in disease-specific variables and in general health-related quality of life,[38,39] whereas some reports showed less improvement after TKA than after THA.[40,41] Preoperative anxiety and psychological distress among patients were

reportedly higher before TKA than THA.[39] Our study could not identify why THA led to improved postoperative symptoms regardless of preoperative CS status. However, a systematic review reported that psychological factors influence outcomes after TKA and THA; patients with more pain catastrophizing preoperatively experienced more pain after TKA surgery.[42]

Our results suggest that preoperative CS and its persistence following surgery significantly influenced postoperative outcomes and satisfaction in TKA patients. Appropriate intervention for preoperative CS may help improve patient satisfaction. OA patients with CS reportedly experience depressive conditions or pain catastrophizing.[20] In contrast, it is reported that the descending pain inhibitory pathway was a potential cause for chronic pain in end-stage OA.[43] To prevent CPSP, early administration of duloxetine to patients before TKA could improve clinical outcomes.[33] Furthermore, cognitive-behavioral therapy may help diminish the negative impact of preoperative kinesiophobia and CS in TKA patients.[44] We inferred that evaluating the preoperative CS status and carrying out early intervention could help improve postoperative QOL, especially in TKA patients.

There were several limitations to this study in addition to the small sample size. First, CS was evaluated using only self-reported questionnaires. It is known that the diagnostic capability of CSI-9 is inferior to that of physical examinations with pain stimulation.[45–47] Moreover, the CSI-9 cutoff value for CS was set at 10 points, based on the literature[21]; this point should be investigated precisely in patients with knee osteoarthritis in a future study. Second, EQ-5D-5*l* was used as a uniform scoring system for both surgeries because common patient-reported outcome scores for both TKA and THA were not available. Third, a postoperative examination should have been considered for statistical analysis to evaluate the influence of invasiveness and surgical techniques on postoperative satisfaction or symptoms, even though the same surgeon performed the surgeries. Fourth, the postoperative evaluation was performed only at 3 months after surgery. The WOMAC score of THA patients reportedly improves earlier than that of TKA patients.[38] We believe that long-term observation might reveal an association between CS and residual symptoms. Despite these limitations, we observed apparent differences in postoperative responses in patients with preoperative CS who underwent TKA or THA. We found that preoperative intervention would likely benefit patients suffering from terminal OA and CS.

CONCLUSIONS

We investigated the prevalence of preoperative CS and postoperative residual CS after TKA and THA and evaluated the influence of residual CS on the improvement of general QOL after surgery. Postoperative improvement was observed 3 months after THA regardless of high residual CS. In contrast, preoperative CS was negatively associated with improvement after TKA.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

1. Ritter MA, Keating EM, Sueyoshi T, Davis KE, Barrington JW, Emerson RH: Twenty-five-years and greater, results after nonmodular cemented total knee arthroplasty. J Arthroplasty 2016;31:2199–2202. DOI:10.1016/j.arth.2016.01.043, PMID:27430182
2. Maniwa K, Ishibashi Y, Tsuda E, Yamamoto Y, Inoue R, Otsuka H: Accuracy of image-free computer navigated total knee arthroplasty is not compromised in severely deformed varus knees. J Arthroplasty 2013;28:802–806. DOI:10.1016/j.arth.2012.09.014, PMID:23453557
3. Kahlenberg CA, Nwachukwu BU, McLawhorn AS, Cross MB, Cornell CN, Padgett DE: Patient satisfaction after total knee replacement: a systematic review. HSS J 2018;14:192–201. DOI:10.1007/s11420-018-9614-8, PMID:29983663
4. Shan L, Shan B, Suzuki A, Nouh F, Saxena A: Intermediate and long-term quality of life after total knee replacement: a systematic review and meta-analysis. J Bone Joint Surg Am 2015;97:156–168. DOI:10.2106/JBJS.M.00372, PMID:25609443
5. Sasaki E, Tsuda E, Yamamoto Y, Meada S, Otsuka H, Ishibashi Y: Relationship between patient-based outcome score and conventional objective outcome scales in post-operative total knee arthroplasty patients. Int Orthop 2014;38:373–378. DOI:10.1007/s00264-013-2064-5, PMID:23974838
6. Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KD: Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? Clin Orthop Relat Res 2010;468:57–63. DOI:10.1007/s11999-009-1119-9, PMID:19844772

7. Ali A, Sundberg M, Robertsson O, Dahlberg LE, Thorstensson CA, Redlund-Johnell I, Kristiansson I, Lindstrand A: Dissatisfied patients after total knee arthroplasty: a registry study involving 114 patients with 8-13 years of followup. Acta Orthop 2014;85:229–233. DOI:10.3109/17453674.2014.916487, PMID:24786904
8. Lavand'homme P, Thienpont E: Pain after total knee arthroplasty: a narrative review focusing on the stratification of patients at risk for persistent pain. Bone Joint J 2015;97-B(Suppl A):45–48. DOI:10.1302/0301-620X.97B10.36524, PMID:26430086
9. Beswick AD, Wylde V, Gooberman-Hill R, Blom A, Dieppe P: What proportion of patients report long-term pain after total hip or knee replacement for osteoarthritis? A systematic review of prospective studies in unselected patients. BMJ Open 2012;2:e000435. DOI:10.1136/bmjopen-2011-000435, PMID:22357571
10. Petersen KK, Graven-Nielsen T, Simonsen O, Laursen MB, Arendt-Nielsen L: Preoperative pain mechanisms assessed by cuff algometry are associated with chronic postoperative pain relief after total knee replacement. Pain 2016;157:1400–1406. DOI:10.1097/j.pain.0000000000000531, PMID:27331347
11. Bajaj P, Bajaj P, Graven-Nielsen T, Arendt-Nielsen L: Osteoarthritis and its association with muscle hyperalgesia: an experimental controlled study. Pain 2001;93:107–114. DOI:10.1016/S0304-3959(01)00300-1, PMID:11427321
12. Imamura M, Imamura ST, Kaziyama HH, Targino RA, Hsing WT, De Souza LP, Cutait MA, Fregni F, Camanho GL: Impact of nervous system hyperalgesia on pain, disability, and quality of life in patients with knee osteoarthritis: a controlled analysis. Arthritis Rheum 2008;59:1424–1431. DOI:10.1002/art.24120, PMID:18821657
13. Latremoliere A, Woolf CJ: Central sensitization: a generator of pain hypersensitivity by central neural plasticity. J Pain 2009;10:895–926. DOI:10.1016/j.jpain.2009.06.012, PMID:19712899
14. Loeser JD, Treede RD: The Kyoto Protocol of IASP Basic Pain Terminology. Pain 2008;137:473–477. DOI:10.1016/j.pain.2008.04.025, PMID:18583048
15. Petersen KK, Arendt-Nielsen L, Simonsen O, Wilder-Smith O, Laursen MB: Presurgical assessment of temporal summation of pain predicts the development of chronic postoperative pain 12 months after total knee replacement. Pain 2015;156:55–61. DOI:10.1016/j.pain.0000000000000022, PMID:25599301
16. Hochman JR, Gagliese L, Davis AM, Hawker GA: Neuropathic pain symptoms in a community knee OA cohort. Osteoarthritis Cartilage 2011;19:647–654. DOI:10.1016/j.joca.2011.03.007, PMID:21440077
17. Bourne RB, Chesworth B, Davis A, Mahomed N, Charron K: Comparing patient outcomes after THA and TKA: is there a difference? Clin Orthop Relat Res 2010;468:542–546. DOI:10.1007/s11999-009-1046-9, PMID:19760472
18. Zhai H, Geng H, Bai B, Wang Y: Differences in 1-year outcome after primary total hip and knee arthroplasty: a cohort study in older patients with osteoarthritis. Orthopade 2019;48:136–143. DOI:10.1007/s00132-018-3636-2, PMID:30264214
19. Campbell CM, Buenaver LF, Finan P, Bounds SC, Redding M, McCauley L, Robinson M, Edwards RR, Smith MT: Sleep, pain catastrophizing, and central sensitization in knee osteoarthritis patients with and without insomnia. Arthritis Care Res 2015;67:1387–1396. DOI:10.1002/acr.22609, PMID:26041510
20. Mayer TG, Neblett R, Cohen H, Howard KJ, Choi YH, Williams MJ, Perez Y, Gatchel RJ: The development and psychometric validation of the central sensitization inventory. Pain Pract 2012;12:276–285. DOI:10.1111/j.1533-2500.2011.00493.x, PMID:21951710
21. Nishigami T, Tanaka K, Mibu A, Manfuku M, Yono S, Tanabe A: Development and psychometric properties of short form of central sensitization inventory in participants with musculoskeletal pain: a cross-sectional study. PLoS One 2018;13:e0200152. DOI:10.1371/journal.pone.0200152, PMID:29975754
22. Dolan P: Modeling valuations for EuroQol health states. Med Care 1997;35:1095–1108. DOI:10.1097/00005650-199711000-00002, PMID:9366889
23. Brazier JE, Harper R, Munro J, Walters SJ, Snaith ML: Generic and condition-specific outcome measures for people with osteoarthritis of the knee. Rheumatology 1999;38:870–877. DOI:10.1093/rheumatology/38.9.870, PMID:10515649
24. Fransen M, Edmonds J: Reliability and validity of the EuroQol in patients with osteoarthritis of the knee. Rheumatology 1999;38:807–813. DOI:10.1093/rheumatology/38.9.807, PMID:10515639
25. Team JE: The development of the Japanese EuroQol instrument [in Japanese]. J Health Care Soc. 1997;8:109–123.

26. Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD: Knee Injury and Osteoarthritis Outcome Score (KOOS)—development of a self-administered outcome measure. J Orthop Sports Phys Ther 1998;28:88–96. DOI:10.2519/jospt.1998.28.2.88, PMID:9699158
27. Nakamura N, Takeuchi R, Ishikawa H, Saito T, Sawaguchi T, Goldhahn S: Cross-cultural adaptation and validation of the Japanese Knee Injury and Osteoarthritis Outcome Score (KOOS). J Orthop Sci 2011;16:516–523. DOI:10.1007/s00776-011-0112-9, PMID:21766211
28. Matsumoto T, Kaneuji A, Ichiseki T, Hiejima Y, Sugiyama H, Akiyama H, Atsumi T, Ishii M, Izumi K, Ito H, Okawa T, Ohzono K, Otsuka H, Kishida S, Kobayashi S, Sawaguchi T, Sugano N, Nakajima I, Nakamura S, Hasegawa Y, Fukuda K, Fujii G, Mawatari T, Mori S, Yasunaga Y, Yamaguchi M, The Subcommittee on Hip Disease Evaluation of the Clinical Outcome Committee of the Japanese Orthopaedic Association: Japanese Orthopaedic Association Hip Disease Evaluation Questionnaire (JHEQ): a patient-based evaluation tool for hip-joint disease. J Orthop Sci 2012;17:25–38. DOI:10.1007/s00776-011-0166-8, PMID:22045450
29. Matsuoka H, Sakano Y: Assessment of cognitive aspect of pain: development, reliability, and validation of Japanese version of Pain Catastrophizing Scale. Jpn J Psychosom 2007;47:95–102.
30. Graven-Nielsen T, Wodehouse T, Langford RM, Arendt-Nielsen L, Kidd BL: Normalization of widespread hyperesthesia and facilitated spatial summation of deep-tissue pain in knee osteoarthritis patients after knee replacement. Arthritis Rheum 2012;64:2907–2916. DOI:10.1002/art.34466, PMID:22421811
31. Sasaki E, Ota S, Chiba D, Kimura Y, Sasaki S, Ando M, Yamamoto Y, Tsuda E, Ishibashi Y: Association between central sensitization and increasing prevalence of nocturnal knee pain in the general population with osteoarthritis from the Iwaki Cohort Study. J Pain Res 2021;14:2449–2458. DOI:10.2147/JPR.S318038, PMID:34413679
32. Sasaki E, Tsuda E, Yamamoto Y, Maeda S, Inoue R, Chiba D, Okubo N, Takahashi I, Nakaji S, Ishibashi Y: Nocturnal knee pain increases with the severity of knee osteoarthritis, disturbing patient sleep quality. Arthritis Care Res 2014;66:1027–1032. DOI:10.1002/acr.22258, PMID:24470323
33. Koh IJ, Kim MS, Sohn S, Song KY, Choi NY, In Y: Duloxetine reduces pain and improves quality of recovery following total knee arthroplasty in centrally sensitized patients: a prospective, randomized controlled study. J Bone Joint Surg Am 2019;101:64–73. DOI:10.2106/JBJS.18.00347, PMID:30601417
34. Kim SH, Yoon KB, Yoon DM, Yoo JH, Ahn KR: Influence of centrally mediated symptoms on postoperative pain in osteoarthritis patients undergoing total knee arthroplasty: a prospective observational evaluation. Pain Pract 2015;15:E46–E53. DOI:10.1111/papr.12311, PMID:25980527
35. Zolio L, Lim KY, McKenzie JE, Yan MK, Estee M, Hussain SM, Cicuttini F, Wluka A: Systematic review and meta-analysis of the prevalence of neuropathic-like pain and/or pain sensitization in people with knee and hip osteoarthritis. Osteoarthritis Cartilage 2021;29:1096–1116. DOI:10.1016/j.joca.2021.03.021, PMID:33971205
36. Petersen KK, Simonsen O, Laursen MB, Nielsen TA, Rasmussen S, Arendt-Nielsen L: Chronic postoperative pain after primary and revision total knee arthroplasty. Clin J Pain 2015;31:1–6. DOI:10.1097/AJP.0000000000000146, PMID:25485953
37. Werner MU, Kongsgaard UE: I. Defining persistent post-surgical pain: is an update required? Br J Anaesth 2014;113:1–4. DOI:10.1093/bja/aeu012, PMID:24554546
38. Dailiana ZH, Papakostidou I, Varitimidis S, Liaropoulos L, Zintzaras E, Karachalios T, Michelinakis E, Malizos KN: Patient-reported quality of life after primary major joint arthroplasty: a prospective comparison of hip and knee arthroplasty. BMC Musculoskelet Disord 2015;16:366. DOI:10.1186/s12891-015-0814-9, PMID:26612135
39. Lindner M, Nosseir O, Keller-Pliessnig A, Teigelack P, Teufel M, Tagay S: Psychosocial predictors for outcome after total joint arthroplasty: a prospective comparison of hip and knee arthroplasty. BMC Musculoskelet Disord 2018;19:159. DOI:10.1186/s12891-018-2058-y, PMID:29788969
40. Kiebzak GM, Campbell M, Mauerhan DR: The SF-36 general health status survey documents the burden of osteoarthritis and the benefits of total joint arthroplasty: but why should we use it? Am J Manag Care 2002;8:463–474. PMID:12019598

41. Wylde V, Blom AW, Whitehouse SL, Taylor AH, Pattison GT, Bannister GC: Patient-reported outcomes after total hip and knee arthroplasty: comparison of midterm results. J Arthroplasty 2009;24:210–216. DOI:10.1016/j.arth.2007.12.001, PMID:18534427
42. Vissers MM, Bussmann JB, Verhaar JA, Busschbach JJ, Bierma-Zeinstra SM, Reijman M: Psychological factors affecting the outcome of total hip and knee arthroplasty: a systematic review. Semin Arthritis Rheum 2012;41:576–588. DOI:10.1016/j.semarthrit.2011.07.003, PMID:22035624
43. Nelson FR: A background for the management of osteoarthritic knee pain. Pain Manag 2014;4:427–436. DOI:10.2217/pmt.14.40, PMID:25494694
44. Kazarian GS, Anthony CA, Lawrie CM, Barrack RL: The impact of psychological factors and their treatment on the results of total knee arthroplasty. J Bone Joint Surg Am 2021;103:1744–1756. DOI:10.2106/JBJS.20.01479, PMID:34252068
45. Arendt-Nielsen L, Skou ST, Nielsen TA, Petersen KK: Altered central sensitization and pain modulation in the CNS in chronic joint pain. Curr Osteoporos Rep 2015;13:225–234. DOI:10.1007/s11914-015-0276-x, PMID:26026770
46. Arendt-Nielsen L: Pain sensitisation in osteoarthritis. Clin Exp Rheumatol 2017;35(Suppl 107):68–74. PMID:28967356
47. Fingleton C, Smart K, Moloney N, Fullen BM, Doody C: Pain sensitization in people with knee osteoarthritis: a systematic review and meta-analysis. Osteoarthritis Cartilage 2015;23:1043–1056. DOI:10.1016/j.joca.2015.02.163, PMID:25749012