Observational Studies

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Worst pain intensity and opioid intake during the early postoperative period were not associated with moderate-severe pain 12 months after total knee arthroplasty – a longitudinal study

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Abstract

Objectives: There are several known predictors of pain after total knee arthroplasty (TKA). However, it is unclear whether acute postoperative pain intensity and postoperative opioid intake are associated with pain 12 months after TKA. Thus, the aim of this study was to assess whether worst pain intensity and opioid intake during the early postoperative period are associated with moderate-severe pain 12 months after TKA.

Methods: A total of 202 patients undergoing primary TKA between October 2012 and September 2014 were prospectively enrolled. Age, sex, contralateral knee pain, BMI, physical status and opioid intake were collected preoperatively. Ketamine and daily opioid intake were collected on postoperative days (POD) 0–3. Using the Brief Pain Inventory, patients' "worst pain intensity" was measured preoperatively, on POD 0–4, and 12 months after TKA. Two logistic regression models evaluated the independent association of early postoperative pain intensity (model 1) and postoperative opioid intake (model 2) with moderate-severe pain 12 months after TKA, adjusting for possible confounders.
Results: In total, 187 patients with data at the 12 month postoperative follow-up were included in this analysis. Pain intensity on POD2 and POD3, as well as preoperative pain and BMI, were significantly associated with pain at 12 months in univariate models. However, in multivariable models adjusted for preoperative pain and BMI, neither pain intensity on POD 0–4 (model 1) nor opioid intake on POD 0–3 (model 2) were associated with pain at 12 months. Preoperative pain was still significant in both models, but BMI remained significant only in model 2.
Conclusions: Worst pain intensity and opioid intake during the early postoperative period were not associated with moderate-severe pain 12 months after TKA when controlling for potential confounders. More research is needed to confirm these findings.

Keywords: acute postoperative pain; associated factors; moderate-severe pain; postoperative opioid analgesic; total knee arthroplasty.

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Introduction

Moderate-severe pain persisting beyond 3 months after total knee arthroplasty (TKA) remains a major issue

affecting 10–34% of patients [1]. A number of preoperative risk factors have been identified as predictors of significant chronic pain following TKA, including psychological factors [2], pain intensity and widespread pain [3], female gender and younger age [4], higher body mass index (BMI) [5], and long-term use of opioids [6, 7]. In addition, patients' acute postoperative pain experiences have been identified as a potential contributor to chronic pain across diverse surgery types [8], including TKA [9–12]. However, prior studies of the association between acute and chronic pain following TKA have not accounted for patients' preoperative pain level, a key potential confounder that is known to predict pain following TKA [3, 13]. Moreover, prior studies have been limited by short follow-up periods (i.e., six months) [9–11], despite a systematic review [14] showing that clinically important improvement occurs in the 6–12 month recovery period. Thus, a 12 month follow-up period would allow for a more reliable determination of chronic pain. Research is therefore needed to determine whether acute pain intensity during the early postoperative period is independently associated with moderate severe pain 12 months after TKA, even when accounting for the potentially confounding effect of preoperative pain.

Opioids are an important component of multimodal perioperative pain management [15], and thus, their association with the development of moderate-severe postoperative pain following TKA also needs to be evaluated. Unfortunately, long-term, and even short-term, opioid administration, as well as high doses may result in patients becoming more sensitive to pain, potentially leading to more severe pain over time [16]. According to one study [17], use of opioids for more than one month prior to surgery was associated with more severe pain at rest and walking during the first six postoperative days after TKA. Long-term use of oral opioid medications for knee pain before surgery increased the risk of chronic pain for up to two years after TKA [6, 7]. These findings suggest that patients' preoperative opioid intake may be a potential risk factor for long-term pain and may be a potential confounder when assessing the relationship between postoperative opioid intake and moderate-severe pain following TKA. To our knowledge, only one study [18] found an association between a higher intraoperative remifentanil dose and severe pain one year after cardiac surgery.

Based on our review of the current evidence on the relationships between early postoperative pain intensity and postoperative opioid intake and chronic postoperative pain, we aimed to test the following hypotheses: (1) high levels of worst pain intensity in the early postoperative period are independently associated with moderate-severe pain 12 months after TKA; and (2) higher opioid intake in the early postoperative period is independently associated with moderate-severe pain 12 months after TKA.

Methods

This preplanned sub-study is part of a larger, prospective longitudinal study at Lovisenberg Diaconal Hospital, Oslo, Norway between October 2012 and September 2014 [19]. Inclusion criteria: primary TKA for osteoarthritis, age ≥18 years, able to read/write in Norwegian. Exclusion criteria: dementia or revision surgery.

Patients received information about the study by mail. Upon admission for TKA, a study nurse screened and formally invited eligible patients to participate. All patients signed a consent form.

All patients received similar posterior cruciate-retaining fixed modular-bearing implants. Unless contraindicated, patients received a neuraxial block with bupivacaine for anesthesia, followed by epidural analgesia with continuous infusions of bupivacaine 1 mg/mL, adrenaline 2 μg/mL, and fentanyl 2 μg/mL (5–12 mL/h), oral acetaminophen 1 g every 6 h, and celecoxib 200 mg plus controlled-release oxycodone 5–20 mg every 12 h. Alternatively, patients received total intravenous anesthesia and a continuous femoral nerve block with bupivacaine 2.5 mg/mL 4–10 mL/h. Ketamine infusion 1.5 μg/kg/min was available during the first 48 postoperative hours. Regional blocks were usually removed on postoperative day (POD)2 [19].

Pre- and postoperative data collection

On the day before surgery, patients completed a questionnaire that assessed demographics (age, sex), and preoperative contralateral knee pain. Pain was assessed pre-surgery, POD0–POD4, and 12 months after TKA. Follow-up questionnaires were returned in sealed, pre-paid envelopes. Preoperative clinical data (BMI, American Society of Anesthesiologists classification of physical status, and preoperative opioid use), and postoperative ketamine and daily opioid intake from POD0 until POD3, were obtained from patients' medical records. Opioid dosages were converted to morphine milligram equivalents using the European Association for Palliative Care recommendations [20].

The validated and reliable Norwegian version of the Brief Pain Inventory (BPI) [21] was used to assess pain severity and to determine the pain location(s) using a body map. We used the "worst pain intensity" item rated on an 11-point numeric rating scale (NRS) ranging from 0 (no pain) to 10 (worst imaginable pain) because it meets the main criteria defined in the FDA draft guidance for patient-reported outcomes in terms of ability to detect a clinically meaningful change [22]. The outcome was moderate-severe knee pain 12 months after TKA, defined as having a worst pain score ≥4 [23] during the last 24 h and a body map that indicated pain in the operated knee.

Table 1: Demographic and clinical characteristics of the sample (n=187).

Variables	Number (%)	Mean (SD)
Age at admission, years (range: 41–90)		68 (9)
Sex (female)	127 (68)	
Body mass index (kg/m2, range: 19.9–43.0)		29.0 (4.6)
ASA classification of physical status		2.0 (0.5)
Preoperative rating of worst pain intensity		5.4 (2.1)
Preoperative opioid use		
Yes	17 (9.1)	
No	170 (90.9)	
Preoperative contralateral knee pain		
Yes	55 (30.5)	
No	125 (69.5)	
Postoperative ketamine use		
Yes	28 (15)	
No	159 (85)	

ASA, American society of anesthesiologists; SD, standard deviation.

Table 2: Univariate logistic regression models assessing the strength of associations between potential covariates and moderate-severe pain 12 months after total knee arthroplasty (n=187).

Variable	OR	95% CI	p-Value
Age at admission, years	0.995	0.976–1.014	0.594
Sex (female)	0.924	0.459–1.858	0.825
Body mass index in kg/m^2	1.092	1.023–1.167	0.008[a]
ASA classification of physical status	1.633	0.822–3.244	0.161
Preoperative contralateral knee pain (yes)	1.067	0.729–1.561	0.739
Postoperative ketamine (yes)	1.241	0.517–2.978	0.629
Preoperative rating of worst pain intensity	1.466	1.235–1.739	<0.001[a]
Preoperative opioid use (yes)	2.366	0.858–6.526	0.096

OR, odds ratio; CI, confidence interval; ASA, American society of anesthesiologists; [a]denotes statistical significance.

Statistical analyses

All variables shown in Table 1 were initially considered as potential covariates. Due to collinearity between acute postoperative pain and postoperative opioid intake (tolerance range, 0.32–0.60; variance inflation factor range, 1.66–3.09), separate logistic regression models were fitted to assess the independent association of acute postoperative pain (Model 1) and postoperative opioid intake (Model 2) with moderate-severe pain 12 months after TKA. Variables that reached statistical significance in the univariate regressions shown in Table 2 were entered into the multivariable logistic regression models as confounders. The results are presented as odds ratios (OR) with 95% confidence intervals (CI). Analyses were performed using Stata/SE version 14.0 (StataCorp LP). p-values <0.05 were considered statistically significant.

Results

The initial study sample included 202 patients. Fifteen patients were excluded due to incomplete follow-up data, leaving 187 patients (93%) for analysis. At 12 months, 40% of patients rated their worst pain intensity in the moderate-severe range (NRS ≥ 4), and their mean worst pain score was 3.2 (SD=2.4). Demographic and clinical data are summarized in Table 1.

As illustrated in Figure 1, patients' mean worst pain intensity on the day of surgery was 4.3, with a peak of 5.9 on postoperative day two (POD2), followed by a decrease to 5.0 on both POD3 and POD4.

As shown in Figure 2, patients' mean daily morphine-equivalent dose of opioids on the day of surgery was 12.4 mg, with a peak of 15.6 mg on POD2 and a decrease to 10.7 mg on POD3.

We examined the univariate associations of the potential covariates with moderate-severe pain 12 months after TKA (see Table 2). Two covariates were significantly associated with moderate-severe pain 12 months after TKA: higher BMI (OR=1.1, 95% CI [1.0–1.2], p=0.03) and higher preoperative pain (OR=1.5, 95% CI [1.2–1.8], p=0.001). The remaining covariates did not reach the level of statistical significance in the univariate analyses and were not entered into the multivariate models.

Table 3 shows the estimates from the univariate and the multivariable logistic regression models for worst pain intensity on POD 0 to 4. The univariate analyses showed that worst pain intensity on POD2 (OR=1.2, [95% CI 1.0–1.3], p=0.027) and POD3 (OR=1.2, [95% CI 1.0–1.3], p=0.05) were significantly associated with moderate-severe pain 12 months after TKA. The multivariable logistic regression model included worst pain intensity on POD 0 to 4 as possible predictive factors and statistically significant covariates from the univariate analyses (i.e., BMI and preoperative pain) as possible confounders. Contrary to our first hypothesis, in the final model, the intensity of worst postoperative pain on days 0–4 was no longer significantly associated with moderate-severe pain 12 months after TKA. However, preoperative pain, but not BMI, remained statistically significant.

Table 4 shows the results from the univariate and multivariable logistic regression models for opioid intake on POD 0 to 3. The univariate analyses showed that postoperative opioid intake on days 0–3 was not significantly associated with moderate-severe pain at 12 months. The

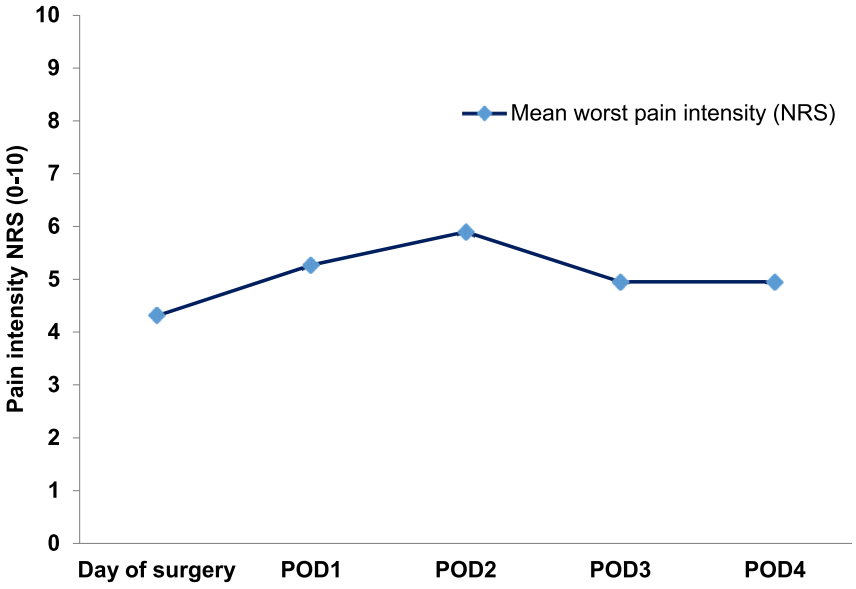

Figure 1: Mean value trajectory for postoperative ratings of worst pain intensity after TKA (n=187).
NRS, numeric rating scale; POD, postoperative day.

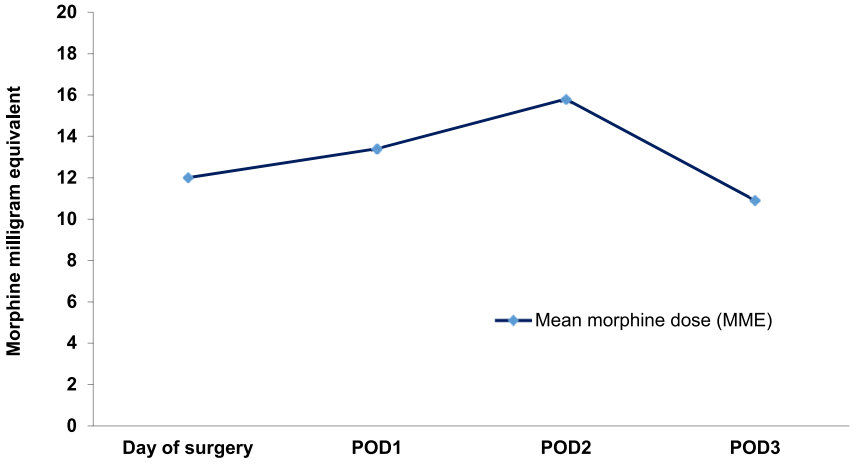

Figure 2: Mean value trajectory for postoperative opioid intake in morphine milligram equivalent (MME) dose after TKA (n=187).
POD, postoperative day.

Table 3: Model 1: univariate and multivariable logistic regression models evaluating the associations of daily ratings of early postoperative worst pain intensity and moderate-severe pain 12 months after total knee arthroplasty (n=187).

Variable	Univariate			Multivariable		
	OR	95% CI	p-Value	OR	95% CI	p-Value
Body mass index in kg/m^2	1.092	1.023–1.167	0.008[a]	1.061	0.976–1.154	0.165
Preoperative rating of worst pain intensity	1.466	1.235–1.739	<0.001[a]	1.455	1.173–1.805	0.001[a]
Early postoperative ratings of worst pain intensity						
POD0 (day of surgery)	1.025	0.928–1.133	0.619	1.008	0.865–1.176	0.914
POD1	1.072	0.952–1.208	0.253	0.999	0.839–1.188	0.994
POD2	1.184	1.019–1.376	0.027[a]	1.102	0.872–1.393	0.413
POD3	1.161	1.000–1.349	0.050[a]	0.912	0.693–1.199	0.509
POD4	1.116	0.973–1.278	0.115	1.091	0.829–1.435	0.532

POD, postoperative day; OR, odds ratio; CI, confidence interval; [a]denotes statistical significance.

Table 4: Model 2: Univariate and multivariable logistic regression models evaluating the associations of daily opioid intake and moderate-severe pain 12 months after total knee arthroplasty (n=187).

Variable	Univariate			Multivariable		
	OR	95% CI	p-Value	OR	95% CI	p-Value
Body mass index in kg/m^2	1.092	1.023–1.167	0.008[a]	1.090	1.015–1.170	0.018[a]
Preoperative rating of worst pain intensity	1.466	1.235–1.739	<0.001[a]	1.456	1.218–1.740	<0.001[a]
Early postoperative opioid intake						
POD0 (day of surgery)	1.011	0.989–1.033	0.336	1.007	0.979–1.035	0.606
POD1	1.014	0.982–1.048	0.384	1.002	0.957–1.050	0.914
POD2	1.019	0.983–1.057	0.308	1.021	0.965–1.081	0.464
POD3	0.994	0.961–1.030	0.777	0.961	0.915–1.011	0.131

POD, postoperative day; OR, odds ratio; CI, confidence interval. [a]Denotes statistical significance.

multivariable logistic regression model included postoperative opioid intake on days 0–3 as possible predictive factors and statistically significant covariates from the univariate analyses (i.e., BMI and preoperative pain) as possible confounders. Contrary to our second hypothesis, postoperative opioid intake on days 0–3 was not independently associated with moderate-severe pain 12 months after TKA in the final model, but both preoperative pain and BMI remained statistically significant.

Discussion

This study builds on prior studies of the relationships of early postoperative worst pain intensity and opioid intake to moderate-severe pain 12 months after TKA. However, a unique contribution of our study is that we controlled for multiple potential confounders, most importantly, preoperative pain, which is a known predictor of postoperative pain. This analysis adds to our understanding of the relationship between acute worst pain intensity and opioid intake trajectories, and moderate-severe pain 12 months after TKA. Contrary to our hypotheses, our study did not reveal any statistically significant associations between either early worst postoperative pain intensity or opioid intake and moderate-severe pain 12 months after TKA, when controlling for the potential confounders including preoperative pain and BMI.

Over the first 3–4 postoperative days, trajectories of patients' worst pain intensity and opioid intake followed a similar pattern, with relatively low intercepts, rising to peaks on POD2, followed by slight declines on POD3. The peak in worst pain intensity on POD2 coincided with the end of regional nerve blocks. As highlighted in a prior review [24], rebound pain after discontinuation of nerve block effects is a well-known issue that may be avoided by using a multimodal pain management regimen tailored to individual patients through systematic pain assessment [25]. In our study, patients' worst pain intensity levels on POD1 and POD2 were 5.3 and 5.9, respectively. These pain levels are comparable to previous studies following TKA [26, 27] or mixed surgical procedures [28, 29], which reported pain intensity levels ranging from 4.0 to 9.0, indicating suboptimal pain management. To optimize and individualize postoperative pain management, it is critical to determine whether pain is a result of poor pain management or modifiable preoperative risk factors for pain.

We hypothesized that greater worst pain intensity during the early postoperative period would be independently associated with moderate-severe pain 12 months after TKA. The univariate associations between some of the postoperative ratings of worst pain intensity (i.e., POD2 and POD3) and pain at 12 months were consistent with findings from four similar studies [9–12] that found acute pain intensity in the days and weeks following surgery increased the risk of moderate-severe postoperative pain in TKA patients. However, these associations did not remain statistically significant once we controlled for body mass index and preoperative pain. Interestingly, none of the previously mentioned studies controlled for preoperative pain, which may explain at least in part why our findings were not in line with previous studies. Furthermore, variation in the design of previous studies, such as using pain assessment scores at 2 and 8 weeks after TKA as predictor variables [11], using a retrospective design [12] or evaluating pain only six months after TKA [9–11], may also have contributed to the differences in findings. Our study's prospective design, earlier postoperative assessment points, and adjustment for key confounders may at least partially explain the differing results across studies. Our results from the multivariable models are consistent with previous research in patients undergoing total hip arthroplasty

surgery (THA) [30, 31], which found no link between acute and chronic postoperative pain intensity. However, hip and knee arthroplasty are not directly comparable, as THA patients are generally characterized by lower acute postoperative pain scores than TKA patients [32].

Postoperative opioid intake on days 0–3 was not independently associated with moderate-severe pain 12 months after TKA in either univariate or multivariable analyses. To our knowledge, no studies have evaluated the relationship between opioid intake in the immediate postoperative period and chronic postoperative pain following TKA. However, a study in cardiac surgery patients [18] found a link between higher intraoperative remifentanil doses and more severe thoracic pain after 12 months, suggesting that there is a dose-dependent relationship between higher intraoperative opioid doses and increased incidence of pain one year after surgery. While this finding contradicts our results, it could be explained by differences in study populations, study designs, and surgical procedures. Furthermore, in our study, patients' mean daily opioid intake was relatively low (<20 morphine milligram equivalent), which could reflect the potential opioid-sparing effect of the relatively complex multimodal analgesia [33]. Despite this, some patients experienced moderate-severe pain and were given a low-dose N methyl-D-aspartate receptor antagonist ketamine infusion as supplemental treatment within the first 48 h after surgery. According to a recent meta-analysis [34], ketamine is effective in reducing postoperative opioid intake in the first 24–48 h, along with decreased pain intensity. Ketamine is also hypothesized to decrease the probability of acute pain transitioning to chronic pain [35]. Neither pain intensity nor opioid intake during the early postoperative period were linked to the development of moderate-severe pain 12 months after TKA. A possible explanation could be the use of a multimodal analgesia approach in this study, which resulted in adequate acute pain management and lower opioid doses [36].

The results of this study are consistent with a systematic review [3] that identified preoperative pain as a risk factor for persistent pain. Moreover, the significant association between higher BMI and moderate-severe pain found in our study is in line with a study by Fisher et al. [5]. However, in another systematic review [37] that evaluated the effect of higher BMI on chronic postoperative pain, only four of the included studies found a significant association, while seven studies found no association, suggesting that this factor warrants more research.

This study's major strengths are its prospective cohort design and low attrition rate. Patients were included from all regions of Norway, which may have increased the generalizability of our findings. Despite our efforts to include all relevant confounders, some factors identified in previous studies, including psychological factors [2] and time spent in severe pain [38], were not measured in this study.

In conclusion, neither worst pain intensity nor opioid intake in the early postoperative period was associated with moderate-severe pain 12 months after TKA after controlling for relevant confounders. More research that addresses the limitations of this and other studies is needed to further advance our understanding of modifiable risk factors for chronic pain after TKA.

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References

1. 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: 1–12.

2. Khatib Y, Madan A, Naylor JM, Harris IA. Do psychological factors predict poor outcome in patients undergoing TKA? A systematic review. Clin Orthop Relat Res 2015;473:2630–8.
3. Lewis GN, Rice DA, McNair PJ, Kluger M. Predictors of persistent pain after total knee arthroplasty: a systematic review and meta-analysis. Br J Anaesth 2015;114:551–61.
4. Singh JA, Gabriel S, Lewallen D. The impact of gender, age, and preoperative pain severity on pain after TKA. Clin Orthop Relat Res 2008;466:2717–23.
5. Fisher DA, Dierckman B, Watts MR, Davis K. Looks good but feels bad: factors that contribute to poor results after total knee arthroplasty. J Arthroplasty 2007;22(6 Suppl 2):39–42.
6. Smith SR, Bido J, Collins JE, Yang H, Katz JN, Losina E. Impact of preoperative opioid use on total knee arthroplasty outcomes. J Bone Joint Surg Am 2017;99:803–8.
7. Zywiel MG, Stroh DA, Lee SY, Bonutti PM, Mont MA. Chronic opioid use prior to total knee arthroplasty. J Bone Joint Surg Am 2011;93:1988–93.
8. Katz J, Seltzer Z. Transition from acute to chronic postsurgical pain: risk factors and protective factors. Expert Rev Neurother 2009;9:723–44.
9. Buvanendran A, Della Valle CJ, Kroin JS, Shah M, Moric M, Tuman KJ, et al. Acute postoperative pain is an independent predictor of chronic postsurgical pain following total knee arthroplasty at 6 months: a prospective cohort study. Reg Anesth Pain Med 2019;44:e100036.
10. Thomazeau J, Rouquette A, Martinez V, Rabuel C, Prince N, Laplanche JL, et al. Predictive factors of chronic post-surgical pain at 6 months following knee replacement: influence of postoperative pain trajectory and genetics. Pain Physician 2016; 19:E729–41.
11. Singh JA, Lemay CA, Nobel L, Yang W, Weissman N, Saag KG, et al. Association of early postoperative pain trajectories with longer-term pain outcome after primary total knee arthroplasty. JAMA Netw Open 2019;2:e1915105.
12. Puolakka PA, Rorarius MG, Roviola M, Puolakka TJ, Nordhausen K, Lindgren L. Persistent pain following knee arthroplasty. Eur J Anaesthesiol 2010;27:455–60.
13. Correll D. Chronic postoperative pain: recent findings in understanding and management. F1000Res 2017;6:1054.
14. Browne JP, Bastaki H, Dawson J. What is the optimal time point to assess patient-reported recovery after hip and knee replacement? A systematic review and analysis of routinely reported outcome data from the english patient-reported outcome measures programme. Health Qual Life Outcome 2013;11:128.
15. Parvizi JMD, Miller AGM, Gandhi KMD. Multimodal pain management after total joint arthroplasty. [Review]. J Bone Jt Surg Am 2011;93:1075–84.
16. Yi P, Pryzbylkowski P. Opioid induced hyperalgesia. Pain Med 2015;16(1 Suppl):S32–6.
17. Aasvang EK, Lunn TH, Hansen TB, Kristensen PW, Solgaard S, Kehlet H. Chronic pre-operative opioid use and acute pain after fast-track total knee arthroplasty. Acta Anaesthesiol Scand 2016; 60:529–36.
18. van Gulik L, Ahlers SJ, van de Garde EM, Bruins P, van Boven WJ, Tibboel D, et al. Remifentanil during cardiac surgery is associated with chronic thoracic pain 1 yr after sternotomy. Br J Anaesth 2012;109:616–22.
19. Lindberg MF, Miaskowski C, Rustoen T, Rosseland LA, Paul SM, Lerdal A. Preoperative pain, symptoms, and psychological factors related to higher acute pain trajectories during hospitalization for total knee arthroplasty. PLoS One 2016;11: e0161681.
20. Caraceni A, Hanks G, Kaasa S, Bennett MI, Brunelli C, Cherny N, et al. Use of opioid analgesics in the treatment of cancer pain: evidence-based recommendations from the EAPC. Lancet Oncol 2012;13:e58–68.
21. Klepstad P, Loge JH, Borchgrevink PC, Mendoza TR, Cleeland CS, Kaasa S. The Norwegian brief pain inventory questionnaire: translation and validation in cancer pain patients. J Pain Symptom Manage 2002;24:517–25.
22. Atkinson TM, Mendoza TR, Sit L, Passik S, Scher HI, Cleeland C, et al. The brief pain inventory and its "pain at its worst in the last 24 hours" item: clinical trial endpoint considerations. Pain Med 2010;11:337–46.
23. Kapstad H, Hanestad BR, Langeland N, Rustøen T, Stavem K. Cutpoints for mild, moderate and severe pain in patients with osteoarthritis of the hip or knee ready for joint replacement surgery. BMC Musculoskelet Disord [Internet] 2008;9:55.
24. Dada O, Gonzalez Zacarias A, Ongaigui C, Echeverria-Villalobos M, Kushelev M, Bergese SD, et al. Does rebound pain after peripheral nerve block for orthopedic surgery impact postoperative analgesia and opioid consumption? A narrative review. Int J Environ Res Publ Health 2019;16:3257.
25. Muñoz-Leyva F, Cubillos J, Chin KJ. Managing rebound pain after regional anesthesia. Korean J Anesthesiol 2020;73: 372–83.
26. Pinto PR, McIntyre T, Ferrero R, Almeida A, Araujo-Soares V. Risk factors for moderate and severe persistent pain in patients undergoing total knee and hip arthroplasty: a prospective predictive study. PLoS One 2013;8:e73917.
27. Strassels SA, Chen C, Carr DB. Postoperative analgesia: economics, resource use, and patient satisfaction in an urban teaching hospital. Anesth Analg 2002;94:130–7.
28. Vasilopoulos T, Wardhan R, Rashidi P, Fillingim RB, Wallace MR, Crispen PL, et al. Patient and procedural determinants of postoperative pain trajectories. Anesthesiol 2021;134:421–34.
29. L'Hermite J, Pagé MG, Chevallier T, Occean B, Viel E, Bredeau O, et al. Characterisation of pragmatic postoperative pain trajectories over seven days and their association with Chronicity after 3 months: a prospective, pilot cohort study (PATCH study). Anaesth Crit Care Pain Med 2021;40:100793.
30. Clarke H, Kay J, Mitsakakis N, Katz J. Acute pain after total hip arthroplasty does not predict the development of chronic postsurgical pain 6 months later. J Anesth 2010;24:537–43.
31. Pagé MG, Katz J, Curtis K, Lutzky-Cohen N, Escobar EM, Clarke HA. Acute pain trajectories and the persistence of post-surgical pain: a longitudinal study after total hip arthroplasty. J Anesth 2016;30: 568–77.
32. Pinto PR, McIntyre T, Araujo-Soares V, Costa P, Ferrero R, Almeida A. A comparison of predictors and intensity of acute postsurgical pain in patients undergoing total hip and knee arthroplasty. J Pain Res 2017;10:1087–98.
33. Wardhan R, Chelly J. Recent advances in acute pain management: understanding the mechanisms of acute pain, the prescription of

opioids, and the role of multimodal pain therapy. F1000Res 2017; 6:2065.
34. Li Z, Chen Y. Ketamine reduces pain and opioid consumption after total knee arthroplasty: a meta-analysis of randomized controlled studies. Int J Surg 2019;70:70–83.
35. Chaparro LE, Smith SA, Moore RA, Wiffen PJ, Gilron I. Pharmacotherapy for the prevention of chronic pain after surgery in adults. Cochrane Database Syst Rev 2013;7: CD008307.
36. Li JW, Ma YS, Xiao LK. Postoperative pain management in total knee arthroplasty. Orthop Surg 2019;11:755–61.
37. Hernández C, Díaz-Heredia J, Berraquero ML, Crespo P, Loza E, Ruiz Ibán M. Pre-operative predictive factors of post-operative pain in patients with hip or knee arthroplasty: a systematic review. Reumatol Clínica 2015;11:361–80.
38. Fletcher D, Stamer UM, Pogatzki-Zahn E, Zaslansky R, Tanase NV, Perruchoud C, et al. Chronic postsurgical pain in Europe: an observational study. Eur J Anaesthesiol 2015;32:725–34.