THE EUROPEAN SOCIETY OF MEDICINE
Medical Research Archives, Volume 14 Issue 4

REVIEW ARTICLE

Postoperative Complications in Patients with Sleep ApneaUndergoing Unicompartmental Knee Arthroplasty

Kevin L. Mekkawy, DO[1]; Hugo C. Rodriguez, DO, MBS[1,2*]; Gabriel Delgado, BS[3]; Raul G. Gosthe, MD[4]; Arturo Corces, MD[1]; Martin W. Roche, MD[2,4]; Jan Peiter Hommen, MD[5]

[1]Larkin Community Hospital, Department of Orthopaedic Surgery, South Miami, Florida, USA
[2]Hospital for Special Surgery, West Palm Beach, Florida, USA
[3]Lewis Katz School of Medicine at Temple University, Philadelphia, Pennsylvania, USA
[4]Holy Cross Orthopedic Institute, Holy Cross Health, Fort Lauderdale, Florida, USA
[5]Hommen Orthopedic Institute, Miami, Florida, USA

*hcrodrig2112@gmail.com

OPEN ACCESS

PUBLISHED
30 April 2026

CITATION
Mekkawy, K.L., Rodriguez, H.C., et al., 2026. Postoperative Complications in Patients with Sleep ApneaUndergoing Unicompartmental Knee Arthroplasty. Medical Research Archives, [online] 14(4). https://doi.org/10.18103/mra.v14i4.7310

DOI
https://doi.org/10.18103/mra.v14i4.7310

ISSN
2375-1924

ABSTRACT

Introduction: Sleep apnea has been shown to affect cognition, immunity, and bone mineralization negatively. The effects of sleep apnea on unicompartmental knee arthroplasty outcomes are not well defined. The purpose of this study is to assess postoperative medical and implant-related complications, and healthcare utilization in patients with and without sleep apnea undergoing unicompartmental knee arthroplasty.

Methods: A retrospective review of a private insurance claims database was conducted from 2010 to 2021. All cases of unicompartmental knee arthroplasty and those with a prior diagnosis of sleep apnea were identified using their corresponding diagnosis and procedural codes. Patients undergoing unicompartmental knee arthroplasty with a diagnosis of sleep apnea were matched to control patients 1:2 based on demographic and comorbidity profiles. Outcomes assessed were 90-day medical complications, 2-year implant complications, cost of care, length of stay, and 90-day readmission rates.

Results: A total of 16,080 sleep apnea patients were matched to 31,684 control patients. The sleep apnea group had significantly higher rates of all 90-day medical complications when compared to the control group (all $P<0.01$). Sleep apnea patients also had significantly greater odds of falls (OR, 3.04; CI, 2.71-3.41, $P<0.001$). Likewise, the sleep apnea group had significantly greater odds of prosthetic joint infection, dislocation, mechanical loosening, and periprosthetic fracture than the control group (all $P<0.01$). There were no significant differences in the odds of arthrofibrosis ($p=0.186$). Additionally, mean cost ($3,141 vs. $2,895, $P<0.001$) and mean length of stay (3.9 vs. 1.9 days, $P<0.001$) were significantly greater in the study group.

Conclusions: Sleep apnea in patients undergoing unicompartmental knee arthroplasty is associated with a significant risk of medical and implant-related complications, especially pneumonia, thromboembolic complications, and falls. It is prudent for orthopedic surgeons to identify those with sleep apnea, with possible early intervention prior to surgery to improve outcomes.

Level of evidence: III, retrospective case-control study.

Keywords: sleep apnea; unicompartmental knee arthroplasty; outcomes; complications.

Introduction

Sleep apnea (SA) is the most common sleep disturbance, characterized by repeated episodes of breathing cessation during sleep, that affects approximately 22 million in the United States alone[1,2]. People who are overweight, those who smoke, males, and those of advanced age are at an increased risk of developing SA[1]. This condition, however, can affect anyone regardless of age, gender, or body mass index. Repeated apneic events associated with SA and hypoxia have been shown to have drastic effects on cortisol, testosterone and blood pressure, as well as produce a proinflammatory state[3]. Untreated SA can lead to elevated blood pressure, cardiovascular disease, stroke, daytime sleepiness and fatigue, depression, and impaired cognitive function[3].

The reported prevalence of SA has continuously increased, in part due to longer life spans as well as increasing rates of obesity[4]. Similarly, advanced age and obesity are well-established causes of osteoarthritis (OA). The prevalence of SA in patients who are undergoing elective primary joint arthroplasty is estimated to be greater than in the general population[5,6]. Thus, SA is a common issue for surgeons treating patients with knee osteoarthritis and can result in uncharacteristic postoperative issues. Unicompartmental knee arthroplasty (UKA) partial knee replacement, is a less invasive surgery than total knee arthroplasty, with decreased bony and soft tissue resection[7]. Therefore, blood loss and operative times are generally decreased, reducing the risk of postoperative complications, including deep vein thrombosis, pulmonary embolism, and infection[7-9]. UKA is in an appropriate patient offers a less traumatic surgical option as compared to total joint arthroplasty.

Although It has been shown that patients who have SA are at increased risk for venous thromboembolism following total joint arthroplasty[10,11]; the risk of medical complications and prosthetic complications following UKA are not well defined in the literature. Therefore, the purpose of this study was to assess 90-day medical complications, 2-year falls, implant-related complications, and healthcare utilization following UKA in patients who have SA and a matched-control cohort.

Methods

A retrospective query was conducted from January 2010 to October 2021 of the 157Ortho dataset within the PearlDiver database (PearlDiver Technologies, Colorado Springs, CO, USA). This study period was chosen due to restrictions in the database at the time of data acquisition at the time of study (December, 2024). PearlDiver has been validated and has been used extensively in the orthopedic literature. This database contains over 157 million patient records and is compliant with Health Insurance Portability and Affordability Act, data is acquired from patients throughout the United States of America. Patients were queried using Current Procedure Technology (CPT), as well as the International Classification of Disease (ICD) 9th and 10th revision codes.

Patients diagnosed with sleep apnea were identified using ICD-9-D-3720 through ICD-9-D-3729, and ICD-10-D-G4730 through ICD-10-D-G4739. Cases of UKA were queried using CPT-27446, as well as ICD-10-P codes 0SRC0L, 0SRC0M, 0SRD0L, and 0SRD0M. Patients undergoing UKA who had a prior diagnosis of SA were matched to a control cohort in a 1:5 fashion, controlling for age, gender, and comorbidity profiles (diabetes mellitus, tobacco use, obesity, hypertension, and chronic obstructive pulmonary disease).

The primary outcomes assessed were 90-day medical complications {myocardial infarction], cerebrovascular accident [CVA], deep vein thrombosis [DVT], pulmonary embolism [PE], urinary tract infection [UTI], wound complication, acute kidney injury, pneumonia, sepsis, and transfusions), and 2-year falls and implant-related complications (prosthetic joint infection [PJI], dislocation, mechanical loosening, periprosthetic fracture, and arthrofibrosis). Secondary outcomes were medical utilization, including costs of care, readmission within 90-days, and length of stay. Reimbursement was utilized as a surrogate for costs of care, which is an accurate depiction of the actual cost of the surgical event and has been extensively used in literature[12-14].

All statistical analysis was performed with R, version 4.2.1 software (R Foundation for Statistical Computation, Vienna, Austria). Categorical variables are described using frequencies and percentages, while continuous variables are presented using means and standard deviations. Student's T-test was used to assess differences in age between groups. Welch's T-tests were used to

evaluate differences in length of stay and costs of care between groups. Chi-squared or Fisher's exact tests were used for categorical variables, where appropriate. Logistic regression was utilized to assess for significance in complication rates between the SA and control groups. Results are reported as odds ratios (ORs) and 95% confidence intervals (CIs). Statistical significance was set at an alpha of less than 0.05.

Results

Following the inclusion and matching process, 16,080 SA patients were matched to 31,684 control patients with no SA diagnosis. The results of the matching process were successful, with no differences seen between cohorts in regard to age, gender, or comorbidity burdens (Table 1).

Table 1. Demographic and comorbidity characteristics of UKA patients with sleep apnea and a matched-control cohort

Patient Demographic	Sleep Apnea N = 16,080 n (%)	Control N = 31,684 n (%)	*p*-Value
Age*	60.8 ± 9.3	61.0 ± 9.1	0.103
Gender			
Female	7,712 (48.0)	15,258 (48.2)	0.692
Male	8,368 (52.0)	16,426 (51.8)	
Comorbidity			
COPD	5,073 (31.5)	9,873 (31.2)	0.394
Diabetes mellitus	6,908 (43.0)	13,548 (42.8)	0.683
Hypertension	13,290 (82.6)	26,255 (82.9)	0.563
Obesity	9,007 (56.0)	17,659 (55.7)	0.568
Tobacco use	6,476 (40.3)	12,724 (40.2)	0.817

UKA, unicompartmental knee arthroplasty; COPD, chronic obstructive pulmonary disease
* given as mean ± standard deviation

NINETY-DAY MEDICAL COMPLICATIONS

The SA cohort had significantly greater rates of all medical complications assessed (all P < 0.001). The greatest increase in odds was that of pneumonia (OR: 6.79; 95% CI: 5.47 - 8.42; P < 0.001), cerebrovascular accident (OR: 5.86; 95% CI: 3.75 - 9.14; P < 0.001), myocardial infarction (OR: 4.61; 95% CI: 3.30 - 6.45; P < 0.001), and urinary tract infection (OR: 4.59; 95% CI: 4.00 - 5.27; P < 0.001) (Table 2).

Table 2. 90-day medical complications and utilization between UKA patients with sleep apnea and a matched-control cohort

Complication	Sleep Apnea (%)	Control (%)	OR	95% CI	*p*-Value
Pneumonia	2.27	0.34	6.79	5.47 - 8.42	< 0.001
CVA	0.48	0.08	5.86	3.75 - 9.14	< 0.001
MI	0.71	0.15	4.61	3.30 - 6.45	< 0.001
UTI	4.15	0.93	4.59	4.00 - 5.27	< 0.001
Sepsis	0.90	0.23	3.94	1.97 - 5.22	< 0.001
AKI	1.60	0.44	3.66	2.98 - 4.50	< 0.001
PE	0.45	0.16	2.83	1.98 - 4.05	< 0.001
DVT	2.20	0.97	2.29	1.97 - 2.67	< 0.001
Transfusion	0.36	0.16	2.20	1.51 - 3.20	< 0.001
Wound	0.98	0.58	1.69	1.37 - 2.09	< 0.001

UKA, unicompartmental knee arthroplasty; OR, odds ratio; CI, confidence interval; MI, myocardial infarction; CVA, cerebrovascular accident; DVT, deep vein thrombosis; PE, pulmonary embolism; UTI, urinary tract infection; AKI, acute kidney injury

TWO-YEAR FALLS AND IMPLANT RELATED COMPLICATIONS

Falls and implant-related complications within 2-years postoperatively are summarized in Table 3. UKA patients who had SA had significantly greater odds of falls than the control group (OR: 3.04; 95% CI: 2.71 - 3.41; P < 0.001). The SA group had significantly greater odds of periprosthetic fracture (OR: 1.69; 95% CI: 1.15 - 2.49; P = 0.008), dislocation (OR: 1.52; 95% CI: 1.22 - 1.91; P < 0.001), prosthetic joint infection (OR: 1.45; 95% CI: 1.27 - 1.65; P < 0.001), and mechanical loosening (OR: 1.35; 95% CI: 1.15 - 1.67; P < 0.001). There were no significant differences in rates of arthrofibrosis between cohorts (P = 0.229) (Figure 1).

Table 3. Two-year falls and implant related complications between UKA patients with sleep apnea and a matched-control cohort

Complication	Sleep Apnea (%)	Control (%)	OR	95% CI	*p*-Value
Falls	4.65	1.58	3.04	2.71 - 3.41	< 0.001
PFx	0.30	0.18	1.69	1.15 - 2.49	0.008
DL	0.84	0.55	1.52	1.22 - 1.91	< 0.001
PJI	2.50	1.74	1.45	1.27 - 1.65	< 0.001
ML	1.75	1.31	1.35	1.16 - 1.57	< 0.001
Fibrosis	0.27	0.21	1.27	0.86 - 1.86	0.229

UKA, unicompartmental knee arthroplasty; OR, odds ratio; CI, confidence interval; PJI, periprosthetic joint infection; DL, dislocation; ML, mechanical loosening; PFx, periprosthetic fracture

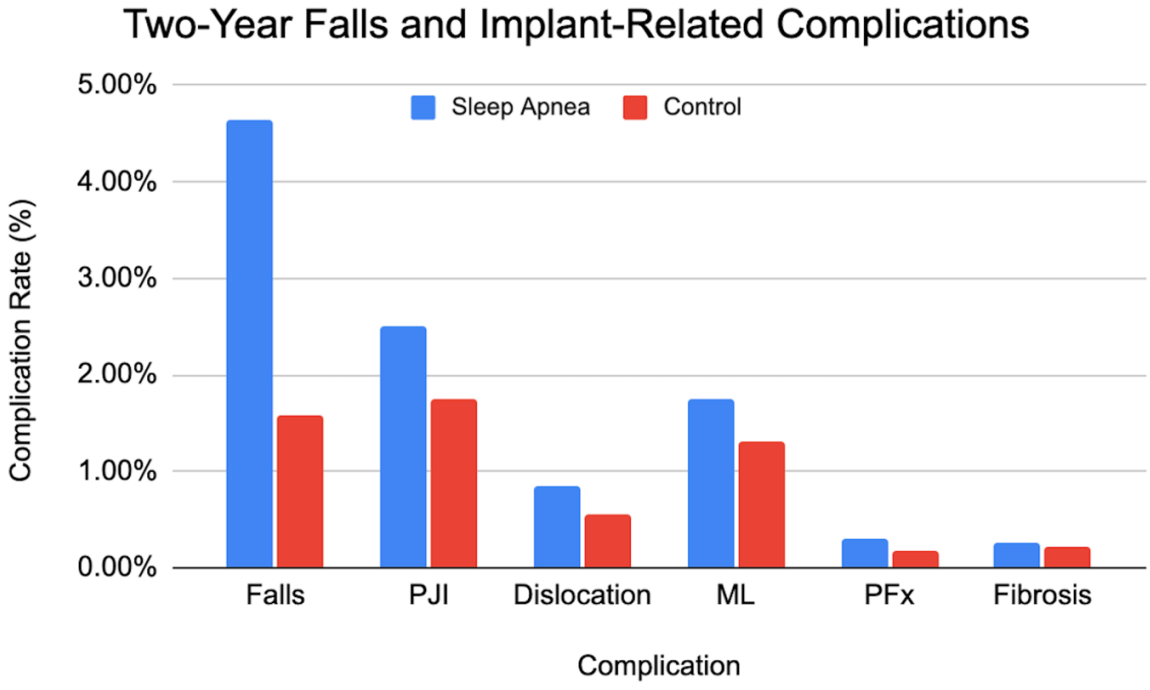

Figure 1. Two-year falls implant-related complication rate following unicompartmental knee arthroplasty between patients with sleep apnea and matched-control patients.

HEALTHCARE UTILIZATION

Episode-of-care costs were significantly higher in patients with SA undergoing UKA ($3,141 vs. $2,895; P < 0.001). There were no significant differences in 90-day readmissions between cohorts (2.83% vs. 2.75%, P = 0.877). Length of stay was significantly longer in the SA group than in the control group (3.9 vs. 1.9 days, P < 0.001) (Table 4).

Table 4. Medical and healthcare utilization between UKA patients with sleep apnea and a matched-control cohort

Utilization	Sleep Apnea	Control	OR	95% CI	*p*-Value
Cost of Care ($)*	3,141 ± 5,349	2,895 ± 4,852			< 0.001
Readmission	2.83%	2.75%	1.01	0.90 - 1.13	0.877
Length of Stay (d)*	3.9 ± 5.9	1.9 ± 1.9			< 0.001

* Given as mean ± standard deviation

UKA, unicompartmental knee arthroplasty; OR, odds ratio; CI, confidence interval

Discussion

Our study demonstrated that patients with SA were at significantly greater risk of developing medical complications and prosthetic complications following a UKA compared to those without SA. We found a significantly heightened risk among patients with SA for developing the following medical complications: nearly 7-fold increased likelihood of developing pneumonia, 6-fold for CVA, approximately 4.6-fold for MI and UTI, around 4-fold for sepsis, 3.66-fold for AKI, 2.83-fold for PE, and 2.29- fold for DVT. We also found that patients with SA were over 3 times more likely to experience falls, over 1.5 times more likely to develop periprosthetic fractures and dislocations, and about 1.4 times likely to have periprosthetic joint infection and mechanical loosening. Finally, the results showed a significant increase in the cost of care and length of stay in patients with SA compared to those without.

The results in this study were consistent with the literature that showed patients who have SA experience increased postoperative medical complications after orthopedic procedures[11,15]. Studies have shown SA to be a risk factor for pneumonia, sepsis, and various infections[16]. SA is characterized by hypercapnia, which induces systemic inflammation due to elevated proinflammatory molecules and compromised immunity arising from impaired neutrophil and macrophage function, which increase susceptibility to pneumonia and sepsis[17-21]. Additionally, apneic episodes stimulate inspiration against a collapsed airway, creating a buildup of negative intrathoracic pressure and producing a vacuum effect through the upper airway, predisposing the lower respiratory tract to increased aspiration of pathogen-containing upper airway contents and leading to pneumonia[22]. In individuals with SA, the risk of cardiorespiratory events is heightened 24 hours post joint arthroplasty[23]. This is attributed to patients being predominantly supine coupled with the interaction between opioids, the basis of postop analgesia, and anesthetic agents, which increase pharyngeal collapse and decrease ventilator response, exacerbating SA and respiratory failure[15,23].

These increased episodes of hypoxia also activate the sympathetic stress response, therefore elevating blood pressure and cardiac work. This then triggers an inflammatory response that promotes endothelial dysfunction, oxidative stress, and blood coagulability increasing the risk of thromboembolic complications like venous thromboembolisms, CVA, and MI[24]. Studies have shown the hypercoagulable state seen in SA is created by the inflammatory response to hypoxemia, which amplifies the levels of D-dimers, plasminogen activator inhibitor-1, and coagulation factors XIIa, VIIa, and thrombin[25]. These mechanisms combine with the increase in sympathetic surges due to surgical stress and the increase in blood stasis due to supine positioning to account for Gupta's 22% incidence of cardiovascular complications post joint arthroplasty in patients with SA compared to the 9% incidence seen in the control group[23,26]. It is worth noting that patients who receive continuous positive airway pressure achieve a reversal of these hematologic and pulmonary irregularities as soon as two weeks[25]. SA has also been shown to induce acute kidney injury and chronic kidney disease because of the subsequent hypertension, free radical production, endothelial injury, and hypoxemia-related initiation of the renin-angiotensin-aldosterone system[27]. While AKIs are one of the most common medical complications post joint arthroplasty[28], it has been shown SA significantly amplifies these risks[11].

Besides medical complications, multiple studies have linked SA to impaired cognition, which may contribute to patient falls, and bone metabolism

and integrity leading to fractures and implant complications[11,29-32]. SA was identified as a predisposing factor for postoperative delirium in patients without dementia undergoing elective total joint replacement[11,33]; increasing risk of falls and accidents[34], which may explain the 3-fold increase in odds of falls we observed in SA patients. Nocturnal hypoxia, a prominent characteristic of SA, exhibits catabolic effects on bone through the accumulation of hypoxia-inducible factor 1α, present on osteoblasts, which directly stimulates osteoclast activity and inhibits anabolic effects of parathyroid hormone on bone[35-38]. Hypoxia also induces persistent ischemic injury, creating an inflammatory, acidotic, and antioxidant-deprived environment in bone which has been associated with osteoclast stimulation, inhibition of mineral deposition by osteoblasts, and altered collagen structure. These mechanisms contribute to heightened bone resorption, reduced bone mass, and increased risk of fractures[29]. This negative impact on bone integrity and metabolism could potentially compromise implant fixation and explain the increase in early implant-related complications like periprosthetic fractures, mechanical loosening, and dislocation as seen in this study and others[11].

Finally, as physicians aim to enhance patient outcomes and curtail costs, the literature illustrates that SA was responsible for billions of dollars in healthcare costs in 2015[39]. This present study shows that episode-of-care costs were significantly higher in patients who had SA compared to patients without SA, and stay an average of 2 full days longer in the hospital. Studies have shown that individuals with SA post total joint arthroplasty incur heightened costs because of complications requiring ICU level of care, increased length of stay, and increased resource utilization such as need for intubation/mechanical ventilation, CPAP machines, and antibiotics[15,23]. For example, Vakharia et al. also found increased risk of DVT and PE in patients with SA following total joint arthroplasty, which incurred additional costs of $17,114 and $9,345, respectively[11]. This data is consistent with other orthopedic procedures that saw a higher cost of care in patients with SA compared to patients without SA[11].

While the study boasts numerous strengths, such as a large sample size with strong statistical power that controlled for other major comorbidities, it is not without several limitations. First, the validity of the results relies on the data quality and accuracy of the procedural and diagnostic coding of the database[40]. Second, diagnosing SA poses a specific challenge as reports indicate 40-60% of surgical patients have undiagnosed obstructive SA[41-43]. Third, there was no way to stratify the SA group according to the severity of their condition or their treatment status, which could have elicited insightful data. Lastly, as there were restrictions within the database on when data could be curated, the time period of January 2010 to October 20, although vast, could have time points in which techniques and protocols for performing UKAs and treating SA could have changed.

Conclusion

This study demonstrates that patients who have SA undergoing primary UKA face a heightened risk of medical complications, early implant-related complications as well as increased costs and LOS. Appropriate risk stratification, patient education, and postoperative management should be a priority to mitigate potential complications in patients with SA undergoing UKA.

Conflict of Interest Statement:

The authors declare that they have no competing interests.

Funding Statement:

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Acknowledgements:

None.

Declarations

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE: IRB exempt.

CONSENT FOR PUBLICATION: not applicable.

AVAILABILITY OF DATA AND MATERIALS: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request. Original data in the form of articles used in this review are available with public access.

Authors' Contributions:

The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Author contributions:
1) substantial contributions to conception and design (KM, HCR, JPH), acquisition of data (KM), or analysis (KM, HCR) and interpretation (KM, GD, HR, KM, RG, AC, MR, JPH) of data.
2) drafting (KM, GD, HCR, KM) the article or revising it critically (KM, GD, HCR, KM, RG, AC, MR, JPH) for important intellectual content.
3) final approval of the version to be published (all authors).

List of Abbreviations

SA, sleep apnea; UKA, unicompartmental knee arthroplasty; ICD, International Classification of Disease; CPT, Current Procedural Terminology; CVA, cerebrovascular accident; MI, myocardial infarction; DVT, deep vein thrombosis; PE, pulmonary embolism; UTI, urinary tract infection; PJI, prosthetic joint infection; OR, odds ratio; CI, confidence interval.

References:

1. Senaratna C V., Perret JL, Lodge CJ, et al. Prevalence of obstructive sleep apnea in the general population: A systematic review. Sleep Med Rev. 2017;34:70-81. doi:10.1016/j.smrv.2016.07.002

2. Mehra R, Stone KL, Blackwell T, et al. Prevalence and correlates of sleep-disordered breathing in older men: Osteoporotic fractures in men sleep study. J Am Geriatr Soc. 2007;55(9):1356-1364. doi:10.1111/j.1532-5415.2007.01290.x

3. Al Lawati NM, Patel SR, Ayas NT. Epidemiology, Risk Factors, and Consequences of Obstructive Sleep Apnea and Short Sleep Duration. Prog Cardiovasc Dis. 2009;51(4):285-293. doi:10.1016/j.pcad.2008.08.001

4. Wang Y, Beydoun MA, Min J, Xue H, Kaminsky LA, Cheskin LJ. Has the prevalence of overweight, obesity and central obesity leveled off in the United States? Trends, patterns, disparities, and future projections for the obesity epidemic. doi:10.1093/ije/dyz273

5. Harrison MM, Childs A, Carson PE. Incidence of Undiagnosed Sleep Apnea in Patients Scheduled for Elective Total Joint Arthroplasty. Published online 2003. doi:10.1016/S0883-5403(03)00459-5

6. Mekkawy KL, Heifner J, Rodriguez HC, Hernandez M, Corces A, Hommen JP. Sleep Apnea in Patients Undergoing Reverse Shoulder Arthroplasty is Associated with Greater Complications and Healthcare Utilization. Semin Arthroplasty. 2024. DOI: 10.1053/j.sart.2024.02.010.

7. Roche MW, Law TY, Vakharia RM, Mekkawy KL, Rodriguez HC. Mid-Term Survivorship, Radiographic and Functional Outcomes of Robotic-Assisted Medial Unicompartmental Knee Arthroplasty. Surg Technol Int. 2023;25;42:sti42/1660. DOI:10.52198/23.STI.42.OS163860.

8. Roche MW, Vakharia RM, Law TY, Rodriguez HC, Mekkawy KL, Sodhi N, Dubin J, Hameed D, Mont MA. Excellent 10-Year Survivorship and Patient Satisfaction of Robotic-Arm Assisted Unicompartmental Knee Arthroplasty. J Orthop. DOI: 10.1016/j/jor.2024.02.044doi:10.1007/S00590-015-1610-9

9. Ghomrawi HM, Eggman AA, Pearle AD. Effect of Age on Cost-Effectiveness of Unicompartmental Knee Arthroplasty Compared with Total Knee Arthroplasty in the U.S. The Journal of Bone and Joint Surgery. 2015; 97(5):396-402

10. Tang A, Aggarwal VK, Yoon RS, Liporace, FA, Schwarzkopf R. The Effect of Obstructive Sleep Apnea on Venous Thromboembolism Risk in Patients Undergoing Total Joint Arthroplasty. Published online 2022. doi:10.5435/JAAOSGlobal-D-21-00248

11. Vakharia RM, Cohen-Levy WB, Vakharia AM, Donnally CJ, Law TY, Roche MW. Sleep Apnea Increases Ninety-Day Complications and Cost Following Primary Total Joint Arthroplasty. Journal of Arthroplasty. 2019;34(5):959-964.e1. doi:10.1016/j.arth.2018.12.018

12. Rosas S, Sabeh KG, Buller LT, Law TY, Roche MW, Hernandez VH. Medical Comorbidities Impact the Episode-of-Care Reimbursements of Total Hip Arthroplasty. J Arthroplasty. 2017;32(7):2082-2087. doi:10.1016/j.arth.2017.02.039

13. Weisberg MD, Ng MK, Magruder ML, Vakharia RM, Roche MW, Erez O. The Association of Cannabis Use Disorder and Perioperative Complications After Primary Total Knee Arthroplasty. J Am Acad Orthop Surg. 2022;30(7):313-320. doi:10.5435/JAAOS-D-21-00703

14. Belatti DA, Pugely AJ, Phisitkul P, Amendola A, Callaghan JJ. Total joint arthroplasty: trends in medicare reimbursement and implant prices. J Arthroplasty. 2014;29(8):1539-1544. doi:10.1016/j.arth.2014.03.015

15. Carr JB, Cancienne JM, Werner BC. Obstructive sleep apnea affects complication rates following knee arthroscopy but use of continuous positive airway pressure is not protective against complications. Knee Surgery, Sports Traumatology, Arthroscopy. 2019;27(2):534-540. doi:10.1007/S00167-018-5144-7/TABLES/3

16. Truong KK, Lam MT, Grandner MA, et al. Timing matters: circadian rhythm in sepsis, obstructive lung disease, obstructive sleep apnea, and cancer. Ann Am Thorac Soc 2016; 13: 1144–1154.

17. Ruiz FS, Andersen ML, Martins RC, et al. Immune alterations after selective rapid eye movement or total sleep deprivation in healthy male volunteers. Innate Immun 2012;18:44-54.

18. Gates KL, Howell HA, Nair A, et al. Hypercapnia impairs lung neutrophil function and increases mortality in murine pseudomonas pneumonia. Am J Respir Cell Mol Biol 2013; 49: 821-8.

19. Huang YS, Guilleminault C, Hwang FM, et al. Inflammatory cytokines in pediatric obstructive sleep apnea. Medicine (Baltimore) 2016; 95: e4944.

20. Rittirsch D, Flierl MA, Ward PA. Harmful molecular mechanisms in sepsis. Nat Rev Immunol 2008; 8: 776–787.

21. Martínez-García MÁ, Chiner E. Sleep apnoea and risk of post-operative infection: Beyond cardiovascular impact. European Respiratory Journal. 2017;49(4). doi:10.1183/13993003.00292-2017

22. Dempsey JA, Veasey SC, Morgan BJ, et al. Pathophysiology of sleep apnea. Physiol Rev 2010;90:47-112.

23. Gupta RM, Parvizi J, Hanssen AD, and Gay PC. Postoperative Complications in Patients With Obstructive Sleep Apnea Syndrome Undergoing Hip or Knee Replacement: A Case-Control Study. 2001.

24. Alonso-Fernandez A, Toledo-Pons N, García-Río F. Obstructive sleep apnea and venous thromboembolism: overview of an emerging relationship. Sleep Med Rev 2020;50:101233.

25. Liak C, Fitzpatrick M. Coagulability in obstructive sleep apnea. Can Respir J 2011;18:338-48

26. Lyons MM, Bhatt NY, Kneeland-Szanto E, Keenan BT, Pechar J, Stearns B, Elkassabany NM, Memtsoudis SG, Pack AI, Gurubhagavatula I. Sleep apnea in total joint arthroplasty patients and the role for cardiac biomarkers for risk stratification: An exploration of feasibility. Biomarkers in Medicine. 2016;10(3):265–300. doi:10.2217/bmm.16.

27. Abuyassin B, Sharma K, Ayas NT, Laher I. Obstructive sleep apnea and kidney disease: A potential bidirectional relationship? J Clin Sleep Med 2015;11(8):915-924.

28. Hung, C.W., Zhang, T.S., Harrington, M.A. et al. Incidence and risk factors for acute kidney injury after total joint arthroplasty. Arthroplasty 4, 18 (2022). https://doi.org/10.1186/s42836-022-00120-z

29. Swanson CM, Shea SA, Stone KL, Cauley JA, Rosen CJ, Redline S, et al. Obstructive sleep apnea and metabolic bone disease: insights in to the relationship between bone and sleep. J Bone Miner Res 2015;30:199-211.

30. Chen YL, Weng SF, Shen YC, et al. Obstructive sleep apnea and risk of osteoporosis: a population-based cohort study in Taiwan. J Clin Endocrinol Metab. 2014;99(7):2441–7.

31. Cauley JA, Blackwell TL, Redline S, et al. Hypoxia during sleep and the risk of falls and fractures in older men: the osteoporotic fractures in men sleep study. J Am Geriatr Soc. 2014; 62(10):1853–9.

32. Tomiyama H, Okazaki R, Inoue D, et al. Link between obstructive sleep apnea and increased bone resorption in men. Osteoporos Int. 2008; 19(8):1185–92.

33. Flink BJ, Rivelli SK, Cox EA, White WD, Falcone G, Vail TP, et al. Obstructive sleep apnea and incidence of postoperative delirium after elective knee replacement in the nondemented elderly. Anesthesiology 2012;116:788-96.

34. Luyster FS, Strollo PJ Jr, Zee PC, Walsh JK; Boards of Directors of the American Academy of Sleep Medicine and the Sleep Research Society. Sleep: a health imperative. Sleep. 2012;35(6):727–34.

35. Maes C, Carmeliet G, Schipani E. Hypoxia-driven pathways in bone development, regeneration and disease. Nat Rev Rheumatol.2012;8(6):358–66.

36. Fan L, Li J, Yu Z, Dang X, Wang K. The hypoxia-inducible factor pathway, prolyl hydroxylase domain protein inhibitors, and their roles in bone repair and regeneration. Biomed Res Int. 2014;2014:239356.

37. Knowles HJ, Athanasou NA. Acute hypoxia and osteoclast activity: a balance between enhanced resorption and increased apoptosis. J Pathol. 2009;218(2):256–64.

38. Frey JL, Stonko DP, Faugere M-C, Riddle RC. Hypoxia-inducible factor-1a restricts the anabolic actions of parathyroid hormone. Bone Res. 2014;2: 14005. doi: 10.1038/boneres.2014.5

39. Watson NF. Health care savings: the economic value of diagnostic and therapeutic care for obstructive sleep apnea. J Clin Sleep Med 2016; 12(8):1075–1077

40. Cancienne JM, Dempsey IJ, Holzgrefe RE, Brockmeier SF, Werner BC. Is hepatitis C infection associated with a higher risk of complications after total shoulder arthroplasty? Clin Orthop Relat Res 2016;474: 2664-9.

41. Frey WC, Pilcher J. Obstructive sleep-related breathing disorders in patients evaluated for bariatric surgery. Obes Surg. 2003;13:676–683

42. O'Keeffe T, Patterson EJ. Evidence supporting routine polysomnography before bariatric surgery. Obes Surg. 2004; 14:23–26

43. Vasu TS, Doghramji K, Cavallazzi R, Grewal R, Hirani A, Leiby B, Markov D, Reiter D, Kraft WK, Witkowski T. Obstructive sleep apnea syndrome and postoperative complications: clinical use of the STOP-BANG questionnaire. Arch Otolaryngol Head Neck Surg 2010; 136:1020–1024