Occupational Hazards and Injuries in Total Joint Arthroplasty: Identification and Prevention

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Joint replacements are demanding surgeries that take physical and mental tolls on arthroplasty surgeons. Occupational hazards of joint replacement surgery include musculoskeletal injuries, blood-borne diseases, radiation exposure, noxious chemical exposure, noise exposure, and emotional stress. This article is a review of the available literature surrounding occupational hazards that arthroplasty surgeons face and how they can be prevented. The goal is to address adult reconstruction occupational hazards in order to increase the longevity of arthroplasty surgeons. (Journal of Surgical Orthopaedic Advances 34(3):130-133, 2025)

Key words: arthroplasty, total knee, total hip, occupational hazards, work injury, mental health

The rate of total knee arthroplasty (TKA) and total hip arthroplasty (THA) is projected to increase 139% and 176% by 2040, respectively.[1] As the rate of total joint arthroplasty (TJA) increases, it is essential to focus on the health and longevity of joint replacement surgeons. TJA surgery is a physically taxing activity with nonergonomic movements that can result in musculoskeletal injuries. In a cross-sectional study of 66 practicing orthopaedic surgeons, there was a high rate of occupational hazards or their sequelae, with 82% of surveyed surgeons reporting either a musculoskeletal overuse disorder, cataracts, deafness, kidney stones, or a combination of the above, and more than half believed this was a direct result of their occupational exposures.[2] Other occupational hazards during TJA include infections due to blood-borne pathogens, radiation exposure, and chemical and noise exposure. Occupational hazards are not limited to physical ailments; emotional stress and burnout have increased in prevalence among orthopaedic surgeons.[3] The purpose of this article is to address the occupational hazards that TJA surgeons face and provide prevention strategies to help prolong their careers (Table 1).

Musculoskeletal Injuries

Musculoskeletal injuries are common among orthopaedic surgeons due to overuse and nonergonomic positions during surgery. A survey of orthopaedic surgeon occupational injuries revealed that 39.8% reported wrist/hand pain; 35.7% reported lower-back pain; 29.6% reported neck pain; and 18.4% reported shoulder pain.[4] In a similar study surveying practicing surgeons, 100% of respondents who had been in practice for 21 to 30 years reported musculoskeletal overuse disorder, with rotator cuff disease being the most common.[2] Repetitive movements, such as mallet swings, result in muscle fatigue, which can lead to associated neck, back, and arm pain. The average TJA surgeon performs 300 mallet swings per primary THA.[5] For surgeons performing 250 THAs per year, that equates to 75,000 mallet swings per year,[5] which can lead to overuse injuries of the upper extremities, such as the rotator cuff. Although both THA and TKA are physically demanding, in a prospective study, surgeons had higher heart rates, energy expenditure per minute, and minute ventilation during THA compared with TKA.[6]

Advances in technology surrounding TJA reduce the physical demand on surgeons. In THA, a reduction in muscle fatigue and brachioradialis muscle activation were observed with automated impactions compared with manual impactions.[7] Automated impaction devices, such as the KINCISE Surgical Automated System (DePuy Synthes, Raynham, MA) and the HAMMR automated impaction system (Zimmer Biomet, Warsaw, IN), were developed to decrease excessive mallet swings and overuse injuries. Robotic-assisted surgery during TKA has decreased surgeon total calorie expenditure, mean heart rate, and minute ventilation compared with manual TKA.[8]

TABLE 1. Orthopaedic surgery hazards and prevention options

Hazards	Prevention
Musculoskeletal injuries	Adjust OR table height, vibrational posture devices, automated impactors, robotic-assisted surgery
Infection	Universal precautions, double gloving, Kevlar gloves
Radiation	Lead apron, lead glasses, decreased radiation time, increased distance from radiation source
Noise exposure	Ear plugs, noise canceling headphones
Chemical exposure	Mixing cement in a closed vacuum system, allowing pregnant participants to leave the room, using press-fit components
Smoke exposure	Smoke evacuators, electrocautery with built-in suction, regular use of face masks
Emotional stress	Screening tools, meditation, mindfulness, social support, resilience training

OR, operating room

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Ergonomics in the operating room (OR) can also help alleviate these musculoskeletal injuries, and it is recommended to adjust the OR table to 70% to 80% of the resting elbow level height of the surgeon.[9] Robotic-assisted surgery has allowed for improved surgeon posture in the OR with significantly less time spent in a flexed position > 20° compared with manual TKA.[7] Ergonomically risky positions combined with wearable gear, such as exhaust suits, head lamps, loupes, lead aprons, and lead protective eyewear, increase the risk of musculoskeletal injuries.[10] In a survey of TJA surgeons, 68.2% thought that the use of protective lead contributed significantly to musculoskeletal pain, and 29.2% thought that exhaust suits also significantly contributed to higher musculoskeletal pain.[10] Wearable vibrational postural devices, such as the Upright Go 2 (Upright Technologies, Israel), allow for immediate feedback when there are postural lapses. A randomized controlled trial showed that vibrational intervention during surgery significantly reduced the time surgeons were in suboptimal posture.[11]

There is a bias of ergonomics in orthopaedic devices and equipment for taller male surgeons with large hands.[12] A survey by 204 orthopaedic surgeons showed that female surgeons thought it was difficult to use mallets, arthroscopic shavers, arthroscopes, power drivers, reduction clamps, and rongeurs.[12] This finding can be attributed to the fact that orthopaedic instrumentation is one-size-fits-all without regard for hand size or strength of the surgeon.[13] The average top and bottom glove size for female surgeons is 6.5, whereas the average top and bottom glove size for male surgeons is 8.0.[12] This emphasizes the need to develop and incorporate instruments that are accessible to female surgeons to lessen gender disparities specifically in TJA.

Infection

Occupational blood-borne diseases in surgery are well documented with risks of transmission of HIV, hepatitis B, and hepatitis C transmission through blood exposure. The risk of percutaneous needlestick transmission rates is 0.3% for HIV, 1.8% for hepatitis C, and 6% to 30% for hepatitis B.[9] Medical treatment, postexposure treatment, and vaccines have reduced the disease burden for these conditions.[14] However, blood-borne exposures are underreported by surgeons with only 38% of surgeons reporting the incident and following the recommended steps.[15] A survey of orthopaedic surgeons found that 93.8% had finger sticks from a needle at some point in their career.[4] Of those respondents, 66% experienced a finger stick from an orthopaedic instrument, and 61.8% had a finger stick from bone.[4] Personal protective equipment, such as double gloving, reinforced or thicker orthopaedic specific gloves, face shields, and sleeve reinforcements of the forearms of surgical gowns, decreases the risk of blood exposure.[16] Studies have shown that double gloving compared with single gloving reduces the risk of glove perforation and the risk of blood stains on skin.[17] Also, the use of one pair of fabric gloves over one pair of regular gloves reduced perforations compared with two pairs of normal gloves.[17] Although the risk of transmission is relatively low, exposures need to be reported appropriately to decrease morbidity to the surgeon.

Radiation Exposure

Radiation exposure is a well-known and documented occupational risk to the orthopaedic surgeon. Fluoroscopy remains an essential and useful tool for a number of orthopaedic procedures. With the rise of the Direct Anterior Approach, the potential for radiation exposure to arthroplasty surgeons is similarly on the rise. Although fluoroscopy is certainly useful for verification of implant positioning during THA, it has been demonstrated to result in increased radiation. In a study of three direct anterior approach surgeons utilizing helmet-mounted dosimeters, the mean total radiation dose was 2.00 mGy (± 1.31); dosimeter results were 8, 5, and < 1 mRem, respectively, for each surgeon.[18] A similar study demonstrated mean radiation dose of 0.716 Gy-cm^2 (range, 0.251 – 1.81) with a combined mean dosimeter result of 10 mRem.[19] There is no universal consensus on radiation safety standards, the International Commission on Radiological Protection, and U.S. National Council on Radiation Protection and Measurement set radiation standards of 20 mSv and 50 mSv per year, respectively. With regard to orthopaedics, 1 Gy of an absorbed dose is equal to 1 Sv of an effective dose.

The health risks of radiation vary based on exposure. The threshold for cataract risk is thought to be approximately 0.5 Sv in a single dose, where a cumulative dose of 5 Sv was previously thought to be the risk threshold. Solid cancer risk increases by 60% with a dose of 1.6 Sv. Offspring risk is thought to be > 100 mGy.[20] Using properly maintained and inspected radiation gowns and shields, decreasing the distance from the radiation source when applicable and limiting exposure times can reduce the risk of radiation-related risks to orthopaedic surgeons.

Chemical Exposure

Polymethylmethacrylate (PMMA) exposure presents a risk to arthroplasty surgeons and OR staff during cemented TJA procedures. It has been shown that exposure of neurocortical neurons to PMMA results in cell lysis and cell body atrophy.[21] In animal studies, pregnant rodents exposed to PMMA via inhalation have variably been shown to increase gross fetal abnormalities.[22] Although the absolute risks remain largely unknown in humans, a reassuring study by Speeckaert et al. demonstrated that the levels of PMMA peak exposure remain below the Occupational Safety and Health Administration limits of 100 ppm per 8 hours during mixing for both antibiotic beads and during simulated THA.[23] Regardless, efforts have been made to limit exposure to PMMA vapor, including closed system vacuum mixing as well as personal protective equipment. Activated carbon facemasks have been shown to effectively reduce PMMA vapor to an undetectable level for up to 40 minutes.[24] In general, pregnant surgeons and staff are asked to leave the OR from the time of PMMA mixing until the cement has hardened to decrease the risk of exposure.

Another chemical exposure that orthopaedic surgeons face is smoke in the OR. The smoke byproduct from electrocautery can contain toxic gases, including benzene, hydrogen cyanide, formaldehyde, bioaerosols, cellular material, and viruses.[25] Surgical masks have been shown to protect against > 90% of surgical smoke; however, particles that are smaller than 37 µm can pass through surgical masks.[26] Although there are concerns regarding the carcinogenic potential of surgical smoke inhalation, only a small number of case reports exist.[27] However, repeat and sustained inhalation of surgical smoke can be seen as equivalent to smoking several cigarettes, and it is recommended to use a smoke evacuator within 2 inches of the surgical site with a capture velocity of 100 to 150 feet per minute at the inlet nozzle.[25] Electrocautery systems with integrated suction are commercially available with increased costs compared with regular electrocautery.

Noise Exposure

Occupational noise exposure has long been a concern in orthopaedics and especially TJA due to the high usage of power-driven instruments and nature of the procedures. The generally accepted noise threshold for at-risk activities is 85 dBA per the National Institute for Occupational Safety and Health and Occupational Safety and Health Administration (OSHA). In a study of TKA, noise levels reached 90 to 100 dBA with a high of 104 dBA during surgical tool use, which is above the accepted noise threshold.[28] In a study of TJA, surgeons wore a sound dosimeter, and peak sound levels exceeding 140 dB multiple times during arthroplasty cases were reported.[29] Although surgical saw usage yields dangerous levels, it was found that a precision blade system produced an overall lower risk (81.6 dB) compared with a standard saw blade (88.9 dB, $p = 0.003$).[30] THA results in slightly improved risk profile with maximal sound levels approaching, but not routinely crossing, the 85-dB threshold.[31,32]

With the advent and increase in robotics and automated impaction devices, a new potential source of excessive and dangerous noise has been introduced. In one study, the MAKO robotic system (Stryker, Mahwah, NJ) had the highest average sound level (93.18 dB(A)) followed by CORI (Smith & Nephew, Memphis, TN; 89.38 dB(A)).[33] The peak sound level was higher using MAKO (128.98 dB(C)) compared with CORI (126.48 dB(C)).[33] Data regarding Velys (Depuy, Johnson & Johnson, Warsaw, IN), Rosa (Zimmer Biomet), and other platforms are lacking. Similarly, data regarding the exposure risk using modern automated impaction devices are limited.

To determine the long-term effects of noise exposure among TJA surgeons, arthroplasty and nonarthroplasty surgeons were given both a survey and a formal hearing screen. The prevalence of identifiable hearing loss among TJA surgeons was 3-fold higher (31% vs. 11%) when compared with nonsurgical clinicians.[34] The odds of frankly failing a formal hearing screening were nearly four times higher.[34] In order to mitigate these risks, it has been recommended that the orthopaedic surgeon don hearing protection while in the OR; however, many elect to forgo this recommendation in order to facilitate team communication. A study using commercially available noise-cancellation earphones showed improvement in identifying phrases, effectiveness, and clarity of communication.[35] The use of these devices continues to be under investigation, and no standard protocol has been established that adheres to health information protection policies.

Emotional Stress

Burnout has been described as emotional exhaustion, depersonalization, and low job satisfaction. Orthopaedic surgeons have reported the rate of emotional exhaustion from 28.4% up to 70%.[3] In a survey of orthopaedic surgeons, 55.8% of respondents reported feelings of psychological distress since beginning practice; 50.8% reported that those feelings adversely affected their social life, and 33.8% reported that those feelings affected their performance at work.[4] The impact of burnout and psychological distress cannot be understated, as the mean suicide rate among surgeons is 13.3%, which is double that of the general population.[36] Orthopaedic surgeons comprise the largest percentage of physician suicide at 28.2%.[37] Hospital systems and medical schools are combating the increase in burnout and suicide rates by educating physicians on screening tools, meditation, mindfulness, social support, and resilience training.[34] At the authors' institution, the support for physician mental wellness has been emphasized through a physician committee that focuses on physician professional fulfillment, ensuring access to well-being programs, and creating new ways to promote physician well-being.

Conclusion

Arthroplasty surgeons face occupational hazards daily while performing TJA. Newer advances in technologies, such as automated impaction devices, and robotics have helped diminish musculoskeletal injuries, radiation exposure, and emotional stress, while worsening noise exposure. Arthroplasty surgeons need to be aware of these occupational hazards and prevention strategies to maintain physical and mental wellness and to support career longevity.

References

1. Shichman I, Roof M, Askew N, et al. Projections and epidemiology of primary hip and knee arthroplasty in Medicare patients to 2040-2060. JBJS Open Access. 2023;8.
2. Vajapey SP, Li M, Glassman AH. Occupational hazards of orthopaedic surgery and adult reconstruction: a cross-sectional study. J Orthop. 2021;25:23-30.
3. Daniels AH, DePasse JM, Kamal RN. Orthopaedic surgeon burnout: diagnosis, treatment, and prevention. J Am Acad Orthop Surg. 2016;24:213-219.
4. Yakkanti RR, Sedani AB, Syros A, et al. Prevalence and spectrum of occupational injury among orthopaedic surgeons: a cross-sectional study. JBJS Open Access. 2023;8.
5. Canoles HG, Vigdorchik JM. Occupational hazards to the joint replacement surgeon: how can technology help prevent injury? J Arthroplasty. 2022;37:1478-1481.
6. Khan IA, Haffar A, Magnuson JA, et al. Surgeons experience greater cardiorespiratory strain and stress during total hip arthroplasty than total knee arthroplasty. J Arthroplasty. 2022;37:637-641.
7. Haffar A, Krueger CA, Goh GS, et al. Total knee arthroplasty with robotic surgical assistance results in less physician stress and strain than conventional methods. J Arthroplasty. 2022;37:S193-S200.
8. Ferrari E, Khan M, Mantel J, et al. The assessment of muscle fatigue in orthopedic surgeons, by comparing manual versus automated broaching in simulated total hip arthroplasty. Proc Inst Mech Eng H. 2021;235:1471-1478.
9. Patel K, Judd H, Harm RG, et al. Occupational hazards for the practicing orthopaedic surgeon: a standard review. J Am Acad Orthop Surg. 2022;30:E607-E616.
10. McQuivey KS, Christopher ZK, Deckey DG, et al. Surgical ergonomics and musculoskeletal pain in arthroplasty surgeons. J Arthroplasty. 2021;36:3781-3787.e7.
11. Soni S, Ritchie AMA, Liu S, et al. Using wearable technology for posture regulation to improve surgical ergonomics in the paediatric operating room: the UPRISE trial: a pilot study. Surg Endosc. 2024;38(8):4445-4456.
12. Fram B, Bishop ME, Beredjiklian P, et al. Female sex is associated with increased reported injury rates and difficulties with use of orthopedic surgical instruments. Cureus. 2021;13(5):e14952.
13. Chou L, Kha ST, Shapiro M. Health considerations for female orthopaedic surgeons. J Am Acad Orthop Surg. 2024;32(3):e125-e133.
14. Kugelman D, Weppler CG, Warren CF, et al. Occupational hazards of orthopedic surgery exposures: infection, smoke, and noise. J Arthroplasty. 2022;37:1470-1473.
15. Maniar HH, Tawari AA, Suk M, et al. Percutaneous and mucocutaneous exposure among orthopaedic surgeons: immediate management and compliance with CDC protocol. J Orthopaed Trauma. 2015;29:10.
16. Fry DE. Occupational blood-borne diseases in surgery. Am J Surg. 2005;190:249-254.
17. Mischke C, Verbeek JH, Saarto A, et al. Gloves, extra gloves or special types of gloves for preventing percutaneous exposure injuries in healthcare personnel. Cochrane Database Syst Rev. 2014;2014(3):CD009573.

18. Pomeroy CL, Mason JB, Fehring TK, et al. Radiation exposure during fluoro-assisted direct anterior total hip arthroplasty. J Arthroplasty. 2016;31:1742-1745.
19. McArthur BA, Schueler BA, Howe BM, et al. Radiation exposure during fluoroscopic guided direct anterior approach for total hip arthroplasty. J Arthroplasty. 2015;30:1565-1568.
20. Hayda RA, Hsu RY, DePasse JM, et al. Health risks for orthopaedic surgeons. J Am Acad Orthop Surg. 2018;26(8):268-277.
21. Lin JS, Townsend JA, Humbyrd C, et al. Is methylmethacrylate toxic during pregnancy and breastfeeding?—A systematic review. Arthroplasty. 2021;3:9.
22. McLaughlin RE, Reger SI, Barkalow JA, et al. Methylmethacrylate: a study of teratogenicity and fetal toxocity of the vapor in the mouse. J Bone Joint Surg Am. 1978;60(3):355-358.
23. Speeckaert AL, Brothers JG, Wingert NC, et al. Airborne exposure of methyl methacrylate during simulated total hip arthroplasty and fabrication of antibiotic beads. J Arthroplasty. 2015;30:1464-1469.
24. Compton J, Clinger J, Lawler E, et al. Masks for the reduction of methyl methacrylate vapor inhalation. Iowa Orthop J. 2020;1:191-193.
25. Control of smoke from laser/electric surgical procedures. National Institute for Occupational Safety and Health. Appl Occup Environ Hyg. 1999;14(2):71.
26. LeDuc R, Eikani C, Dickens B, et al. Surgical smoke and the orthopedic surgeon: a non-systematic review of the hazards and strategies for mitigating risk. Arch Orthop Trauma Surg. 2023;143(12):6975-6981.
27. Dixon K, Dasgupta P, Vasdev N. A systematic review of the harmful effects of surgical smoke inhalation on operating room personnel. Health Sci Rev. 2023;1;6:100077.
28. Siegel M. The risk of noise-induced hearing loss performing knee replacement surgery. Noise Health. 2019;21:183-188.
29. Love H. Noise exposure in the orthopaedic operating theatre: a significant health hazard. ANZ J Surg. 2003;73(10):836-838.
30. Sydney SE, Lepp AJ, Whitehouse SL, et al. Noise exposure due to orthopedic saws in simulated total knee arthroplasty surgery. J Arthroplasty. 2007;22(8):1193-1197.
31. Goffin J, MacRae E, Farrow L, et al. Study on impact of robotic-assisted orthopaedic industrial noise (SIREN). Arch Orthop Trauma Surg. 2024;144(5):2413-2420.
32. Slaven SE, Wheatley BM, Christensen DL, et al. Repeated noise exposure does not reach hazardous levels during total joint arthroplasty. Mil Med. 2020;185(9-10):e1551-e1555.
33. Hönecke T, Schwarze M, Wangenheim M, et al. Noise exposure during robot-assisted total knee arthroplasty. Arch Orthop Trauma Surg. 2023;143(6):2813-2819. Erratum in: Arch Orthop Trauma Surg. 2023;143(6):2821.
34. Palmer JS, Wilson C, Fraig H, et al. Hearing Evaluation of Arthroplasty Surgeons: results from the HEARS study. Ann R Coll Surg Engl. 2021;103(9):673-677.
35. Dunson BT, Cooper AM, Polascik BW, et al. Wireless in-ear communication for total joint arthroplasty: a simulated operating room evaluation. Arthrop Today. 2024;29:101481.
36. Travers V. Burnout in orthopedic surgeons. Orthop Traumatol: Surg Res. 2020;106:S7-S12.
37. Pearl A, Saleh K, Quick JC. Identifying and addressing burnout in the orthopaedic surgeon. J Am Acad Orthop Surg. 2023;31:229-238.