



# Why do female orthopaedic surgeons have a higher risk of breast cancer? – A narrative review

Dlaczego kobiety pracujące w ortopedii mają wyższe ryzyko zachorowania na raka piersi? – przegląd narracyjny

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## Abstract

**Introduction and Objective.** Breast cancer is a leading cause of mortality worldwide, and female orthopaedic surgeons have shown a higher prevalence of breast cancer due to occupational radiation exposure. The aim of the study is to explore the association between radiation exposure and breast cancer among female orthopaedic surgeons, while highlighting the challenges in minimizing exposure and emphasizing the importance of protective measures.

**Brief description of the state of knowledge.** Orthopaedic surgeons face increased radiation exposure during fluoroscopy-based procedures, which place them at risk. Studies have demonstrated their vulnerability, particularly in procedures like intramedullary nailing and pedicle screw insertion. Protective measures, such as lead aprons and positioning techniques, can help reduce exposure.

**Summary.** This study highlights the higher prevalence of breast cancer among female orthopaedic surgeons due to their occupational exposure to radiation. The close proximity to radiation sources during procedures increases the risk. Protective measures, such as lead aprons and proper positioning techniques, play a crucial role in reducing radiation exposure. However, there is a lack of knowledge and training in radiation safety among orthopaedic surgeons. To promote the health and safety of these surgeons, it is essential to raise awareness, implement appropriate precautions, and provide standardized training programmes. Further research is needed to better understand the underlying mechanisms and develop targeted interventions to mitigate the risks associated with radiation exposure in this population.

## Key words

breast cancer, protective measures, radiation exposure, orthopaedic surgeons

## Streszczenie

**Wprowadzenie i cel pracy.** Rak piersi jest istotnym problemem zdrowotnym o wysokiej śmiertelności na całym świecie. Kobiety pracujące jako ortopedzi, ze względu na zawodowe narażenie na promieniowanie rentgenowskie, wykazują wyższą częstość występowania tego nowotworu w porównaniu do ogólnej populacji. Celem tego przeglądu jest zbadanie związku między narażeniem na promieniowanie a rakiem piersi u kobiet ortopedów. Praca omawia wyzwania, z jakimi mierzą się ortopedzi, minimalizując narażenie na promieniowanie, a także podkreśla znaczenie środków ochrony i bezpieczeństwa pracy.

**Opis stanu wiedzy.** Wyniki przeglądanych badań wskazują na wyższą częstość występowania raka piersi u kobiet pracujących jako ortopedzi w porównaniu do ogólnej populacji. Badania jednoznacznie pokazują, że ortopedzi są szczególnie narażeni na promieniowanie podczas zabiegów wykorzystujących fluoroskopię, takich jak wprowadzanie gwoździ śródszpikowych czy śrub pedikularnych. Wynika to ze zwiększonej ekspozycji na promienie rentgenowskie podczas bezpośredniego kontaktu rąk chirurga z pacjentem lub źródłem promieniowania podczas wykonywania zabiegu. Niemniej jednak istnieją skuteczne strategie minimalizowania ryzyka narażenia na promieniowanie, takie jak stosowanie ołowianych kamizelek i odpowiednie zachowanie.

**Podsumowanie.** Wyższa częstość występowania raka piersi u kobiet ortopedów podkreśla potrzebę prowadzenia dalszych badań oraz działań prewencyjnych. Zrozumienie związku między narażeniem na promieniowanie rentgenowskie a rakiem piersi w tej populacji jest istotne dla promocji zdrowia i bezpieczeństwa kobiet ortopedów. Wzrost świadomości i wdrożenie odpowiednich środków ostrożności, takich jak stosowanie ochronnego sprzętu i przestrzeganie właściwych technik pozycjonowania, są niezbędne w celu minimalizacji ryzyka narażenia na promieniowanie i zapewnienia bezpiecznego środowiska pracy dla kobiet pracujących jako ortopedzi.

## Słowa kluczowe

rak piersi, środki ochrony, narażenie na promieniowanie, ortopeda, chirurg ortopeda

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## INTRODUCTION AND OBJECTIVE

Cancer is the second most common cause of death, while breast cancer is the leading cancer-related death among women [1] and has caused 684,996 deaths worldwide [95% UI, 675,493–694,633] at a rate of 13.6/100,000, adjusted for age. The increasing prevalence of breast cancer demonstrates its impact on society at large and the importance of taking urgent preventive and therapeutic measures.

A high percentage of breast cancer cases is linked to hormonal therapy, lifestyle factors, higher socio-economical status and hormonal therapy [2, 3]. About 10% of all breast cancer cases are related to hereditary gene mutations (such as BRCA 1/2), age, and family risks [1].

Exposure to radiation is a crucial risk factor to radiation-associated breast cancer [4, 5]. According to research, female orthopaedic surgeons have a greater incidence of breast cancer than the overall female population in the USA due to the exposure to radiation [6–9]

Among female surgeons specializing in orthopaedics, urology, and plastic surgery, it has been observed that orthopaedic surgeons specifically show a higher prevalence of breast cancer, compared to their counterparts in the other sub-specialties [8].

In large studies, it was discovered that female orthopaedic surgeons had an 85% higher prevalence of all-cause cancer compared to the general female population [6–8]. Additionally, the prevalence of breast cancer among female orthopaedic surgeons was found to be significantly higher, with a staggering 190% increase compared to the general female population.

## OBJECTIVE

The aim of the study is to investigate the association between radiation exposure and breast cancer among female orthopaedic surgeons. The reasons behind this higher prevalence of breast cancer among female orthopaedic surgeons remain unclear and require further investigation. It is important to note that these findings are specific to female surgeons in the orthopaedic field and do not apply to all female surgeons or individuals in other medical specialties.

## MATERIALS AND METHOD

A bibliographical search was performed in PubMed using terms related to key words ‘breast cancer’, ‘radiation exposure’ (i.e. fluoroscopy), ‘orthopaedic surgeons’ (i.e. orthopaedic surgery) and ‘protective measures’. The eligible criteria include studies in English language published between 2000–2023. The review included studies referring to breast cancer, radiation, and orthopaedic surgeons. Special attention was paid to the available cohort and case-control studies, randomized control trials, large epidemiological studies, available meta-analyses and systematic reviews.

## DISCUSSION

Radiation exposure has been established as a risk factor for the development of breast cancer [1, 5, 10]. This increased risk

can be attributed to both direct and indirect effects on cellular and molecular processes [11]. Directly, ionizing radiation has the potential to cause DNA damage, including single-strand breaks, double-strand breaks, and chromosomal rearrangements. These genetic alterations can disrupt normal cellular function and lead to the development of cancer. Radiation exposure can also indirectly influence breast cancer development. Ionizing radiation has been shown to affect the endocrine system, including hormone receptors and signaling pathways. Hormones, such as estrogen, play a significant role in breast cancer development, and alterations in their levels or signalling can contribute to tumour growth. Radiation exposure may modify the ability of hormones or other chemical substances to interact with breast tissue, potentially enhancing the risk of breast cancer [10].

Orthopaedic surgeons face unique challenges in their profession that may contribute to their higher prevalence of breast cancer. One significant factor is their increased reliance on intra-operative imaging, particularly fluoroscopy [12]. Orthopaedic surgeons face unique challenges in minimizing radiation exposure compared to other surgical specialties [6–9]. Due to the nature of their procedures, orthopaedic surgeons must often work in close proximity to a fluoroscopy beam, which limits their ability to increase distance and reduce exposure.

The primary source of radiation exposure for orthopaedic surgeons, however, is scatter radiation, which occurs when the x-ray beam interacts with objects in its path, such as the patient and operating room table [13]. Only a small fraction of the emitted photons (approximately 2%) reach the image intensifier, while a portion (10–20%) is scattered and the remaining photons are absorbed in the operative field. However, if the surgeon’s hand or another body part is directly in the primary beam, the resulting radiation exposure is significantly higher.

It is important for orthopaedic surgeons to take precautions to minimize their exposure to radiation, such as using lead aprons and thyroid shields, as well as employing proper positioning techniques to reduce the risk to themselves and their patients. Regular monitoring and adherence to safety protocols are crucial to mitigate the potential long-term effects of radiation exposure.

In a study conducted by Doody et al., a cohort of 56,436 US female radiological technologists was examined to evaluate the incident breast cancer risks between 1983–1998, focusing on employment characteristics [14]. The findings of the study revealed a significant increase in breast cancer incidence among women who started working before 1940, and those who began working at ages younger than 17 years. The study highlights the potential impact of early employment and historical work practices on breast cancer risk among female radiological technologists. These findings suggest that factors such as prolonged exposure to radiation and older radiation technology during earlier periods, may contribute to the increased incidence of breast cancer in the occupational groups exposed to radiation.

The long-term effects of low-dose ionizing radiation are not fully understood, but it is believed that they may include a slight increase in the risk of cancer. There is also a possibility that exposure to radiation over a prolonged period could be associated with the development of hereditary and other chronic diseases, such as those affecting the circulatory and immune systems.

Fluoroscopy is an essential tool for orthopaedic surgeons as it allows real-time imaging guidance during procedures, such as fracture reductions, joint replacements, and spinal surgeries. Yu et al. conducted a study to investigate radiation exposure in spinal surgery, specifically comparing open spine procedures to less invasive spine procedures [15]. The researchers also examined the impact of the position of surgeons relative to the radiation source, compared to standard C-arm fluoroscopy with fluoroscopy assisted by computer navigation. The findings revealed that less invasive spine procedures, such as vertebroplasties and kyphoplasties, were associated with higher levels of radiation compared to other musculoskeletal procedures [16]. During pedicle screw insertion, the average radiation exposure to the surgeon's hand was approximately 58.2 mrem/min. Notably, radiation levels were highest on the side where the primary beam entered the surgical site. In the context of intramedullary nailing procedures for long bones, orthopaedic surgeons faced a heightened risk of significant radiation exposure due to the nature of the procedure, involving the insertion of metal rods into the bone and the use of fluoroscopy for precise guidance [17]. The close proximity of the surgeon's hands to either the patient or the radiation source during irradiation, made them particularly vulnerable to experiencing the highest levels of radiation exposure among the various body parts involved. However, for extremity surgeries where the hands can be kept out of the primary beam, the radiation exposure is generally lower [17]. By maintaining proper positioning and ensuring that their hands are shielded or kept away from the direct path of radiation, orthopaedic surgeons can reduce the risk of radiation exposure to their hands.

The prolonged and repeated exposure to radiation during orthopaedic procedures, coupled with the inherent sensitivity of breast tissue to radiation, may contribute to the higher prevalence of breast cancer among female orthopaedic surgeons [9]. The cumulative effect of radiation exposure over time could potentially increase the risk of developing cancer, including breast cancer.

A report from 2005 highlighted that orthopedic surgeons in particular experience higher average cumulative radiation doses (35.2 mSv) and cancer incidence (29%), compared to 4% in controls [18]. The study also revealed that orthopedic surgeons who utilize X-ray equipment during their procedures face a significantly higher risk of developing tumours, compared to medical workers who are not exposed to radiation. The observed risk difference was found to be statistically significant ( $P = 0.002$ ).

A cross-sectional study conducted at a major urban academic centre revealed that female orthopaedic surgeons had a significantly higher prevalence of cancer compared to the general population in the USA [6]. The study found that the prevalence of cancer among female orthopaedists was 85% higher than that of the general population. This suggests a potential occupational risk or exposure unique to the field of orthopaedic surgery.

Furthermore, a significantly higher risk of complications during pregnancy among female orthopaedic surgeons was identified compared to the general population in the USA [19]. The rate of pregnancy complications among female orthopaedists was found to be 31.2%, whereas the general population had a rate of 14.5%. These findings indicate that female orthopaedic surgeons may face additional challenges or health risks related to pregnancy and childbirth.

In a study from 2022, the researchers investigated the prevalence of cancer among female orthopaedic surgeons and compared it with the general population [9]. A total of 672 survey responses were collected from female orthopaedic surgeons who were members of national orthopaedic specialty societies. Among the 672 surveyed surgeons, 51 reported a diagnosis of invasive cancer, and of those, 20 reported breast cancer. The prevalence of breast cancer was found to be significantly higher among female orthopaedic surgeons compared to the general female population in the USA, with an SPR of 2.89 (95% CI: 2.16 to 3.81;  $P < 0.001$ ). Moreover, the prevalence of breast cancer was also higher among orthopaedic surgeons compared to the female population as a whole in the USA, with an SPR of 3.97 (95% CI: 2.43 to 6.14;  $P = 0.003$ ).

The prevalence of breast cancer was found to be significantly higher among female orthopaedic surgeons compared to the general US female population.

Researchers have observed that higher socio-economic status is associated with an increased prevalence of breast cancer [6, 9, 20]. This correlation may be attributed to certain factors commonly observed among individuals with higher socio-economic status, including lower parity and nulliparity, as well as older age at first childbirth. All these factors have been linked to a higher risk of developing breast cancer, and have been observed within the population of female orthopaedic surgeons [9].

The first nationwide survey conducted in the UK aimed to assess the level of understanding and knowledge of radiation practice, legislation, and risk among orthopaedic surgeons [21]. 406 surgeons participated in the nationwide online survey. The results showed that 92% of the respondents regularly used intra-operative ionising radiation, but 38% received no formal training on radiation safety. The knowledge of basic principles of radiation and legislation was limited, and there was poor uptake of radiation protection equipment. Only 19% of the respondents believed they had received adequate training in radiation safety. This knowledge gap could pose additional risks to patients and healthcare professionals. Other survey studies from Turkey, Brazil and South Africa presented similar results and emphasize the need for a standardized training programme on radiation safety for orthopaedic surgeons [22–24].

When considering fluoroscopy time, it is important to consider the X-ray lead protection of the surgical residents. They may have limited access to properly fitting personal lead protection garments due to logistical challenges and costs associated with covering multiple hospitals [25]. This is especially relevant for female residents, as they may be less likely to have access to hospital-owned lead protection garments that fit them adequately. Studies have shown that the use of lead sleeves and/or axillary supplements can reduce intra-operative lead exposure to breast tissue which is commonly affected by cancer [26]. These additional measures have demonstrated a potential decrease in the risk of cancer among surgeons exposed to radiation during procedures.

A recent study investigated the modification of lead protective vests and other lead attachments. The researchers aimed to determine if lead sleeves, wings, and/or axillary supplements could reduce intra-operative radiation exposure to the upper outer quadrant (UOQ) of the breast, which is the most common site for breast cancer [26]. Different configurations of protection (no lead, lead vest, vest with

sleeves, wings, and axillary supplements), position of the surgeon, and C-arm positions were tested. The results showed that lead sleeves and axillary supplements significantly reduced radiation exposure to the UOQ of the breast, compared to the standard lead vest alone. The addition of wings had a smaller effect and did not reach significance. The study concluded that standard lead vests alone or with wings do not adequately protect the UOQ of the breast, while axillary supplements and sleeves improved breast radiation protection. The findings suggest that modifying lead protective vests could enhance intra-operative breast radiation protection.

## CONCLUSION

Orthopaedic surgeons face unique challenges in minimizing radiation exposure during procedures. The positioning of surgeons relative to the radiation source and the use of fluoroscopy are crucial factors influencing radiation exposure levels. Protective measures and adherence to safety protocols are essential for mitigating the potential risks associated with radiation exposure. Potential factors contributing to the increased risk of breast cancer in this population include the prolonged and repeated exposure to radiation during orthopaedic procedures, as well as the inherent sensitivity of breast tissue to radiation. The cumulative effect of radiation exposure over time could potentially increase the risk of developing cancer, including breast cancer. Further research is required to better understand the relationship between radiation exposure and the prevalence of breast cancer among female orthopaedic surgeons. By raising awareness and implementing appropriate precautions, steps can be taken to ensure the health and well-being of orthopaedic surgeons and minimize their occupational risks.

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