REVIEW

acta orthopaedica belgica, 2025, 91, 401-409

doi.org/10.52628/91.4.15119

Vaping and Orthopaedic Surgery: A scoping review of the literature

T. B. PUGA[1], W. SCAMBLER[2], L. TACKETT[3], McK. W. BOX[1], M. POFFENBARGER[1], J. T. RIEHL[1,4]

[1]Department of Orthopaedics, Medical City Denton, Denton, TX, USA; [2]College of Medicine, Texas Christian University, Fort Worth, TX, USA; [3]College of Osteopathic Medicine, University of Pikeville, Pikeville, KY, USA; [4]Texas Bone and Joint, Fort Worth, TX, USA.

Correspondence at: Troy B. Puga, Medical City Denton, 3535 S I-35, Denton, TX 76210, USA. E-mail: Troy.puga@medicalcityhealth.com

Over the past decade, vaping has grown in popularity among adolescents and young adults. Much remains unknown regarding its effects on orthopaedic surgery. This scoping review expands upon previous reviews by evaluating updated literature from 2025 and including evaluation of orthopaedic injuries caused by vaping accidents. A search was conducted across seven databases. The search used a combination of keywords and Medical Subject Heading (MeSH) terms. Titles and abstracts were screened for eligibility for inclusion criteria. Full texts were screened and included if they met criteria. Demographics and results of the studies were extracted from the articles that met inclusion criteria. In clinical studies vaping led to increased complications and negative outcomes in patients undergoing total joint arthroplasty, anterior cervical discectomy and fusion, and total shoulder arthroplasty. Vaping was associated with increased self-reported rates of fragility fractures and decreased hand microcirculation. Studies highlighted the potential negative effects of vaping on bone and wound healing. Vaping trauma injuries led to patients experiencing burns, cervical spine injuries, bilateral hand sweet syndrome, and mangled hand injuries requiring complex reconstruction. Vaping may have a negative association on orthopaedic surgery outcomes in arthroplasty and spine surgery and may affect outcomes in other orthopaedic subspecialty surgeries as well. Vaping could potentially have negative effects on several organ systems, which may lead to surgical complications. Traumatic vaping injuries can cause serious orthopaedic injuries requiring operative management. Future studies can be conducted to evaluate the full effects of vaping on orthopaedic surgery.

Level of Evidence: **Level 4; Therapeutic**

Keywords: Vaping, electronic cigarettes, orthopaedic surgery, public health.

INTRODUCTION

E-cigarette use, better known as vaping, has rapidly gained popularity among adolescents and young adults[1-3]. E-cigarettes are devices that deliver aerosol nicotine and are oftentimes combined with flavorings and additional chemicals[4-6]. It is believed that roughly 30% of 16 to 18-year-olds are currently vaping, and it is believed that this may underestimate the current prevalence of vaping[7]. Over the past several years, vaping has quickly become a public health crisis[8-10]. Much remains unknown about the effects of vaping. However, vaping has been associated with a number of negative effects, such as lung injuries, blunted neurocognitive development in children, burn injuries, and choking[11-13]. Due to the new popularity of vaping, much remains unknown regarding its effects on orthopaedic surgery.

Few studies have begun to evaluate the effects of vaping on orthopaedic surgery outcomes. Literature regarding smoking and smokeless tobacco is abundant. Smoking and other forms of smokeless tobacco have shown strong associations with increased complications after orthopaedic surgery[14-18]. Smoking has been associated with increased wound complications, delays in bony union, and increased incidence of infection[14-18]. It is believed that nicotine, a component of tobacco, plays a role in these complications[14-20]. However, it is unknown how extensive that role is and if the nicotine in vaping products has any effects on orthopaedic surgery.

This scoping review aims to evaluate the current literature on the effects of vaping in orthopaedic surgery. This review expands upon previous reviews by evaluating updated literature from 2025 and including evaluation of orthopaedic injuries caused by vaping accidents. Much information remains unknown regarding the effects of vaping, and the hope is that this review will help to bridge this gap by providing a comprehensive review of the current available

literature. We hypothesize that vaping will lead to negative effects in orthopaedic surgery and that vaping accidents will cause serious orthopaedic injuries.

MATERIALS AND METHODS

Study Design

The study was exempt from institutional review board approval. This scoping review followed the Preferred Reporting Items for Systematic Review and Meta-Analysis for Scoping Reviews (PRISMA-ScR) statement standards[21].

Eligibility Criteria

Studies were eligible for inclusion if they were peer-reviewed articles and met one of the following criteria: 1.) Evaluated the effects of vaping on orthopaedic surgery in clinical studies, 2.) Evaluated the effects of vaping or vaping components in orthopaedic surgery in both human and animal studies, 3.) Evaluated the orthopaedic injuries from vaping accidents, 4.) Were grey literature studies with insights or theories regarding the effects of vaping on orthopaedic surgery. Studies were only included if completed in English. Any study not meeting one of the above criteria were excluded from inclusion.

Search Strategy

MEDLINE/Pubmed, Wiley, Cochrane CENTRAL, Clinicaltrials.gov, Google Scholar, Web of Science, and Embase databases were systematically searched for publications from database inception to January 20, 2025. Comprehensive search strategies were developed using keywords, Medical Subject Heading (MeSH) terms, and synonymous terms. The PubMed/Medline search was adapted to the other databases. See supplementary Table I for the complete search.

Screening and full text review were completed by two authors independently and any conflicts were resolved by a third author. One author (T.B.P.) performed the search. Two authors (L.T., W.S.) excluded irrelevant articles and duplicates based on title and abstract. The remaining articles underwent an independent full-text review by two authors (L.T., W.S.) and were assessed for eligibility based on established criteria. Any conflicts were resolved by discussion with a third author (T.B.P).

Data Extraction

Study demographic information and results were collected including the following: lead author and country of origin, study design and level of evidence, number of patients, outcomes, and complications.

Risk of Bias

No formal risk of bias assessment was completed on the included papers.

RESULTS

PRISMA Flow Diagram

A preliminary search of seven databases provided 807 studies. 223 duplicates were removed. 584 abstracts and titles were screened, and 544 were removed for lack of relevance. Twenty-nine reports were sought for retrieval. Twenty-three studies met the final inclusion criteria and were included in this study. See Figure 1.

Retrospective and Prospective Comparative Studies

Agoons et al. was a level 3 retrospective analysis of 5,569 patients that compared self-reported fragility fractures in e-cigarette users and non-users[22]. Subjects who had used e-cigarettes at any point in their lifetime ("ever e-cigarette users") and former e-cigarette users had an increased prevalence of self-reported fragility fractures in adjusted and unadjusted models when compared with never users[22]. Bieganowski was a Level 3 retrospective analysis that evaluated the trend of e-cigarette use in Total Joint Arthroplasty (TJA) patients and found that the vaping-only subgroup of patients undergoing TJA had increased length of stay, higher mean surgical time, and higher rates of readmission when compared with the no-exposure group, the concurrent tobacco and vaping group, and the tobacco-only group[23]. Lawland et al., 2025 was a Level 3 retrospective analysis of 89,910 Total Shoulder Arthroplasty (TSA) patients and compared outcomes at 90 days and 2 years for propensity score-matched cohorts of patients with and without nontobacco nicotine dependence (NTND)[24]. At 90 days, patients with NTND had higher rates of sepsis, surgical site infection, wound disruptions, average opioids prescribed, and readmission[24]. At 2 years NTND patients also exhibited higher rates of mechanical loosening and prosthetic joint infection, but not revision[24]. Lawland et al., 2024 was a level 3 retrospective analysis of 48,364 patients that compared 90 day and 2-year outcomes of propensity score-matched patients with and without NTND who underwent Anterior Cervical Discectomy and Fusion (ACDF)[25]. At 90 days, patients undergoing ACDF with NTND had a higher risk of opioid use, emergency department visits, opioid abuse, inpatient hospitalizations, and sepsis[25]. At the 2-year follow-up, patients undergoing ACDF with NTND had a higher risk of pseudarthrosis, revision surgery, adjacent segment

Table I. — Retrospective and Prospective Studies.

Retrospective and Prospective Comparative Studies					
Author and Origin	Study Design	Number of Patients	Orthopaedic Condition or Surgery Type	Follow-up and factors evaluated	Findings and Results
Agoons et al., 2021	Level 3 Retrospective Analysis	5,569	Fragility fractures (hip, spine, or wrist fractures)	Association of ever E-cigarette use and fragility fractures	● Ever e-cigarette users had 46% higher prevalence of self-reported fragility fracture (P=0.005) ● Higher prevalence of self-reported fragility fracture for former e-cigarette users in adjusted analysis (P=0.008)
Bieganowski et al., 2023	Level 3 Retrospective Analysis	1,082,239	Primary Total Joint Arthroplasty (TJA)	Trend of e-cigarette use in TJA patients and those undergoing routine physical exams (RPE). Surgical outcomes of subgroups in TJA patients by vaping and tobacco status.	● Both RPE and TJA patients exhibited an upward trend in e-cigarette use ● Vaping-only patients had increased length of stay (P=0.01), higher mean surgical time (P<0.001), and rates of readmission (P=0.001) when compared with other subgroups
Lawland et al., 2025	Level 3 Retrospective Analysis	89,910	Total Shoulder Arthroplasty (TSA)	90-day and 2-year outcomes of propensity score-matched cohorts of patients with NTND and without NTND	● At 90 days, patients with NTND had significantly higher rates of sepsis (P=0.012), surgical site infection (P=0.007), wound disruptions (P=0.048), average opioids prescribed (P<0.001), and readmission (P=0.001) when compared to patients without NTND. ● At 2 years, patients with NTND had significantly higher rates of mechanical loosening (P=0.001) and prosthetic joint infection (P=0.001) compared to patients without NTND.
Lawland et al., 2024	Level 3 Retrospective Analysis	48,364	Anterior Cervical Discectomy and Fusion (ACDF)	90-day and 2-year outcomes of propensity score-matched cohorts of patients with and without NTND.	● At 90 days, patients with NTND had significantly higher risk of opioid use (P<0.001), emergency department visits (P<0.001), opioid abuse (P<0.001), inpatient hospitalizations (P<0.001), and sepsis (P=0.01) when compared to patients without NTND. ● At 2 years, patients with NTND had significantly higher rates of pseudarthrosis (P<0.001), adjacent segment disease (P<0.001), dysphagia (P=0.001), and revision (P=0.02) when compared to patients without NTND
Pywell et al., 2018	Level 2 Prospective study	15	Hand microcirculation	Hand microcirculation flow after use of an e-cigarette in e-cigarette smokers and non-smokers	● E-cigarette smokers had a significant decrease in hand microcirculation during and up to 20 minutes after smoking a 24-mg e-cigarette (P<.05) ● E-cigarette smokers saw a 77% reduction in superficial flow and 29% in deep flow.

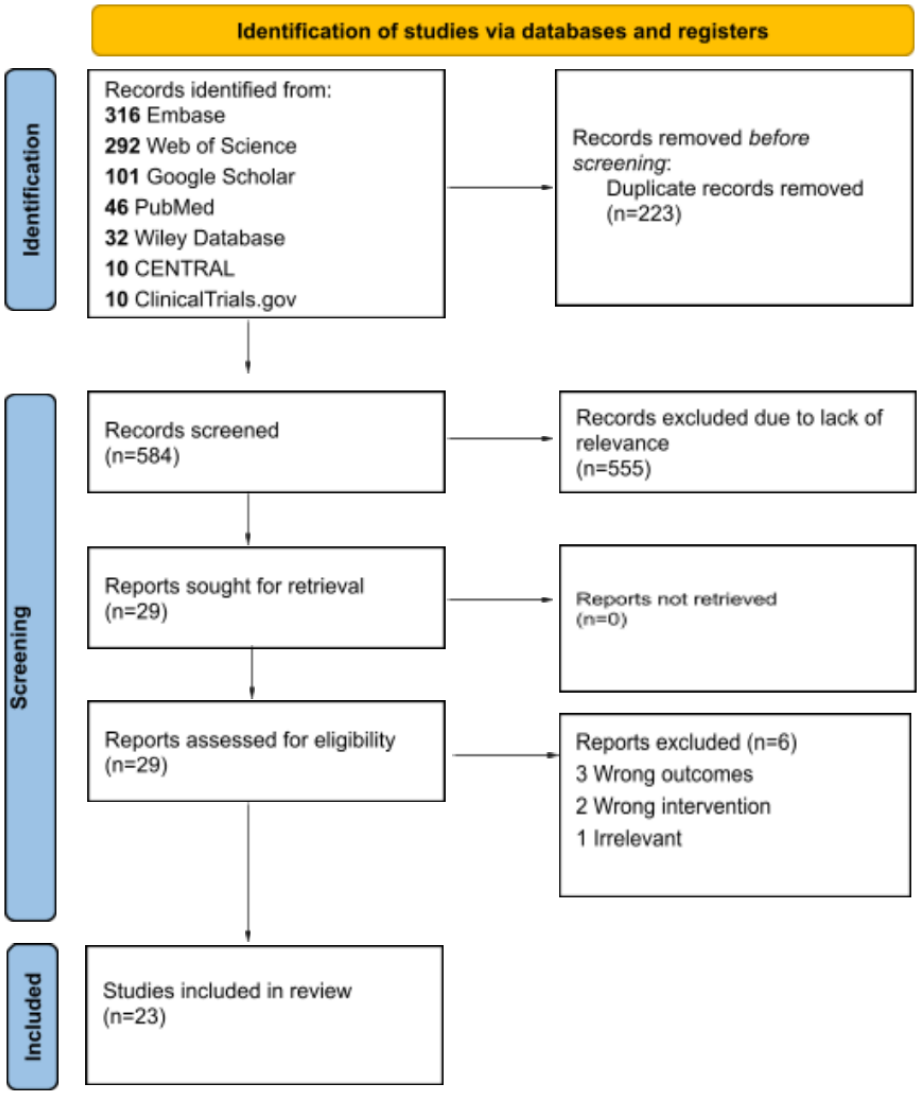

Fig. 1 — PRISMA Flowchart.

disease, and dysphagia[25]. Pywell et al. was a Level 2 prospective study that found e-cigarette smokers had a significant decrease in hand microcirculation during and up to 20 minutes after smoking a 24-mg e-cigarette[26]. See Table I.

Reviews, Basic Science, and Management

Amaro et al. was a Level 4 review that highlighted the rise in e-cigarette use among adolescents and former non-smokers, and found that e-cigarette vapor may have several negative effects such as infection, delayed healing and wound complications which may increase surgical risks[27]. Armstrong et al., was a Level 4 review that highlighted the negative effects of e-cigarettes on bone healing mechanisms[28]. Fiani et al., was a Level 4 review which found the products in e-cigarettes may lead to decreased bone mineral density, osteoporosis, and intervertebral disk degeneration[29]. Two studies found that e-cigarette vapor may lead to impaired function and viability of osteoblasts[30,31] Zaidi et al. was a level 4 review that highlighted that e-cigarettes may lead to wound complications, impairment of the immune system, and longer hospital stays[32].

Two studies were guideline studies for the management of e-cigarette use in orthopaedic surgery. Shore et al. and Wint et al., discussed that e-cigarettes may have negative effects on bone-healing and their use should be cautioned in patients with orthopaedic injuries[33,34]. See Table II.

Vaping Trauma Injuries

This study found 10 studies that reported traumatic vaping injuries[35-44]. All traumatic injuries except one were caused by e-cigarette battery explosions[35-37,39-44]. The one injury not caused by e-cigarette battery explosions was a case of bilateral hand sweet

Table II. — Reviews, basic science, and management studies.

Reviews, Basic Science, and Management Studies				
Author and Origin	Study Design	Study Purpose	Orthopaedic injuries or conditions	Recommendations or Findings
Amaro et al., 2019	Level 4 Review study	Current knowledge of vaping and orthopaedic surgery.	General Orthopaedics and Basic Science	● Found a rise in e-cigarette use among non-smokers and the adolescent population ● E-cigarette vapor is associated with cytotoxicity, pro-inflammatory effects, and decreased microbial defense, which may increase perioperative risks. ● Lack of current clinical studies evaluating outcomes and e-cigarette use
Armstrong et al., 2022	Level 4 Review study	Vaping on orthopaedic surgery Case series of 3 pediatric cases	Review: General Orthopaedics and Basic Science; Case Series: 1 pediatric ankle fracture and 2 pediatric forearm fractures	● Found a lack of literature regarding e-cigarette use effects on orthopaedic surgery in human models. ● Found evidence of a potential negative effect of e-cigarettes on human bone healing mechanisms in basic science models. ● Discovered delayed union in the 1 pediatric ankle fracture and 2 pediatric forearm fractures, all of which were e-cigarette users.
Fiani et al., 2020	Level 4 Review study	Impact e-cigarette use on spine health.	Spine	● E-cigarette carcinogens showed a toxic effect on osteoblasts, which may lead to decreased bone mineral density or osteoporosis. ● Nicotine e-liquids negatively impact intervertebral disk health and degenerate the intervertebral disk vasculature and cellular matrix. ● Animal models have shown negative impact of e-cigarette use in spinal fusion, but human literature is lacking.
Nicholson et al., 2022	Level 5 Basic science study	Evaluate the effects of e-cigarette vapor on osteoblast viability and function.	Basic Science; Bone properties	● E-cigarette vapor concentrate significantly reduces osteoblast viability and impairs osteoblast function at physiologically relevant doses.
Nicholson et al., 2021	Level 4 Review study	Evaluate the e-cigarette vapor constituents on bone health.	Basic Science; Bone properties	● Found evidence that human bone cells express nicotine receptors, and exposure to both nicotine on osteoblasts and osteoclasts may reduce their viability and impair their function. ● Aldehydes and flavoring chemicals may also impair osteoblast viability and function. ● It may be possible that e-cigarette vapor may affect mesenchymal stem cells.
Shore et al., 2021	Level 5 Guideline study	Management recommendations for teenagers undergoing orthopaedic surgery.	Pediatric Orthopaedic Surgery	● Highlighted the rise in adolescent e-cigarette use. ● Highlighted the negative effects of e-cigarettes in basic science models on bone healing mechanisms. ● Discussed the lack of current clinical literature in clinical studies, particularly for pediatric patients. ● Potential respiratory dangers from e-cigarette use. Recommendations from anesthesiologists to avoid usage of e-cigarettes on the day of surgery.
Wint et al., 2024	Level 5 Guideline study	Perioperative management recommendations for patients who vape and are undergoing orthopaedic surgery.	General Orthopaedic Surgery	● Discusses the potential harmful effects of e-cigarette use and risk for surgical site infections and wound complications. ● Discussed the potential effects of e-cigarettes on impairing bone healing. ● Highlighted the importance of orthopaedic surgeons understanding the potential risks, and communicating these with patients.
Zaidi et al., 2024	Level 4 Review study	Impact of e-cigarettes on the outcomes of total joint arthroplasty	Total Joint Arthroplasty	● E-cigarettes inconsistent nicotine release results in many negative effects on bone health. ● E-cigarettes may depress the immune system, may impair wound healing, and may lead to longer hospital stays.

Table III. — Vaping trauma injury studies.

Vaping Trauma Injuries					
Author and Origin	Study Design	Patients	Cause of Injury	Orthopaedic Injury/ Injuries	Treatment/Treatments
Boissiere et al., 2020	Level 4 Case Series	16	E-cigarette battery explosions in a pants pocket	Groin/Thigh Burns	● 6 Patients required split-thickness skin grafting. ● Conservative modalities treated the remainder.
Hagarty et al., 2020	Level 5 Case Report	1	E-cigarette battery explosion during use	C1 Fracture Additional non-orthopaedic injuries	● Conservative treatment with rigid C-collar
Kaltenborn et al., 2023	Level 4 Case Series	46	E-cigarette battery explosion	12 Hand injuries 32 waist/groin injuries 3 non-orthopaedic injuries	● All patients underwent wound debridement. ● 28 of the 46 patients were treated with split-thickness skin graft. ● 31 patients received synthetic skin substitute ● 18 cases had postoperative wound infection
Kelly et al., 2024	Level 5 Case Report	1	E-cigarette use	Bilateral Hand Sweet Syndrome	● Surgical debridement ● IV antibiotics ● Topical methylprednisolone
Kite et al., 2016	Level 5 Case Report	2	E-cigarette explosion	1 Hand injury 1 Non-orthopaedic injury	● Amputation of 3rd digit at the level of the metacarpophalangeal joint.
Kadhum et al., 2024	Level 5 Case Report	1	E-cigarette explosion	1 Pediatric hand injury	● Two surgical debridements Tetanus vaccination
Maraqa et al., 2018	Level 4 Case Series	8	E-cigarette explosion	7 patients with thigh burns 3 patients with hand burns Additional non-orthopaedic injuries	● Patients treated with surgical debridement, split-thickness skin grafting, or conservative treatment.
Norii et al, 2017	Level 5 Case Report	1	E-cigarette explosion	C1 and C2 fracture	● Foreign body removal ● Cervical collar treatment ● Antibiotics and pain control
Russell et al., 2022	Level 4 Case Series	15	E-cigarette explosion	5 thigh and groin burns 4 hand burns 1 radial nerve injury Additional non-orthopaedic injuries	● Conservative management ● 1 hand injury with I&D of the left hand, carpal tunnel release, and 5 additional surgeries for I&D and skin grafting. ● 3 burns to thigh requiring split-thickness skin grafting
Satteson et al., 2018	Level 5 Case Report	1	E-cigarette explosion	Thumb radial and ulnar proper and common digital nerve injuries Thumb radial proper digital artery injury FPL tendon injury Skin and soft tissue defect Acute carpal tunnel syndrome	● Foreign body removal ● Carpal tunnel release ● Groin flap ● FDS to FPL transfer ● Sural nerve grafting of thumb radial and ulnar proper and common digital nerves ● Scar contracture Z-plasty and flap debulking ● A2 and oblique pulley reconstruction ● Tenolysis of FPL ● Neurolysis of ulnar proper digital nerve of the thumb

(IV=Intravenous; I&D=Irrigation and Debridement; FPL= Flexor pollicis longus; FDS= Flexor digitorum superficialis).

syndrome, a neutrophilic dermatosis resulting in painful raised plaques. This was treated by debridement and topical steroids[38]. Four studies had e-cigarette battery explosions, which resulted in groin and thigh burns[35,37,41,43]. These injuries were treated with a range of modalities, including conservative modalities, debridements, and split-thickness skin grafting[35,37,41,43]. Two studies found cervical spine injuries caused by e-cigarette battery explosions, both of which were treated conservatively with a hard collar[36,42]. Six studies found additional hand injuries caused by e-cigarette battery explosions[37,39-41,43,44]. Treatments included conservative treatment, debridement, split-thickness skin grafting, or reconstructive hand procedures[37,39-41,43,44]. See Table III.

DISCUSSION

This study found that vaping may be associated with negative effects on orthopaedic surgery outcomes in several prior clinical studies. Laboratory studies in this review also highlighted the potential negative effects of vaping on orthopaedic surgery. This study also found that vaping accidents can cause serious orthopaedic injuries that require extensive reconstruction efforts. Overall the literature supports that vaping may present with negative associated outcomes in orthopaedic surgery.

It is well known that smoking has been associated with numerous negative outcomes in orthopaedic surgery[14-20]. These complications typically involve delayed wound healing, delayed bony union, and increased infections[14-20]. Nicotine likely plays a large role within these complications[14-20]. Nicotine has been shown to reduce blood flow to tissues through release of catecholamines, which leads to vasoconstriction of vessels[45,46]. Appropriate blood flow is essential for bone and wound healing[47,48]. Nicotine has been shown to have potentially negative effects on union in tibial shaft fractures, spinal fusions, and foot and ankle fusions[49]. Previous literature has highlighted that nicotine may be a significant driver of these potentially negative effects, likely in a dose-dependent matter[49]. Future studies can be completed to evaluate what dose relationship exists between nicotine and disruptions to the microvasculature to quantify measures of nicotine use.

Vaping is currently a public health crisis with high prevalence rates among adolescents and young adults[8-10]. Studies have shown that vaping cessation is difficult[50,51]. Vaping will likely continue to remain popular among this population for many years to come. In addition, vaping is becoming more popular particularly by early school aged children and the elderly population[7,52]. Currently, there have been many effective cessation protocols which have been described[53,54], and adoption of these protocols by orthopaedic surgeons to reduce patient vaping before surgical intervention may be of benefit to patient outcomes.

Although there is some literature evaluating the effects of vaping on orthopaedic surgery outcomes, the volume of literature remains scarce[22-44]. With the particularly high prevalence of vaping among adolescents and young adults[1-3,7-10], more studies on this subject would help to better understand and evaluate the effects of vaping on a variety of orthopaedic surgery procedures. Another consideration is that vaping is a relatively new substance of use, and the full spectrum of longitudinal effects remains unknown[55]. Researchers can begin the process of conducting longitudinal studies to better understand the full spectrum of effects of vaping on orthopaedic surgery.

Limitations

The results of this study should be evaluated within the context of the studies limitations. The most significant limitation of this study is the lack of multiple high-level evidence studies. There is a relatively low number of orthopaedic surgery vaping cessation clinical trials or prospective studies that evaluate outcomes. Future research can be done to conduct these higher-level evidence studies to assess if causal pathways exist. A second limitation is the potential for missed literature. Our search was comprehensive, and we evaluated seven major databases; however, there is always the possibility that literature exists outside of these databases or in another language. A third limitation is that some of the included database studies in this review use nontobacco nicotine dependence (NTND) codes, which may influence outcomes of the presented studies, as this may include other forms of non-combustible nicotine products outside of vaping. This could largely influence the associated outcomes in regards to vaping, and should be critically evaluated when making clinical practice recommendations.

CONCLUSION

Vaping may have an associated negative effect on orthopaedic surgery outcomes in arthroplasty and spine surgery. Vaping could possibly have a negative effect on several organ systems, such as the musculoskeletal, respiratory, integumentary, and immune systems, leading to surgical complications. Traumatic vaping

injuries can cause serious orthopaedic injuries that require extensive operative management. Future studies can be conducted to evaluate the full spectrum of the effects of vaping on orthopaedic surgery to bridge the gap of lacking clinical studies.

Ethical Approval: This study was determined to be exempt or excluded from Institutional Review Board (IRB) oversight in accordance with current regulations and institutional policy.

Funding: No funding was provided for this research.
HCA Healthcare Disclaimer: This research was supported (in whole or part) by HCA Healthcare and/ or an HCA Healthcare-affiliated entity. The views expressed in this publication represent those of the author(s) and do not necessarily represent the official views of HCA Healthcare or any affiliated entities.

Disclosures: The authors of this study have no conflicts of interest to disclose. One author receives royalties and consulting fees from Arthrex Inc.

REFERENCES

1. Bandi P, Star J, Minihan AK, Patel M, Nargis N, Jemal A. Changes in E-Cigarette Use Among U.S. Adults, 2019-2021. Am J Prev Med. 2023;65(2):322-326. doi:10.1016/j.amepre.2023.02.026
2. Erhabor J, Boakye E, Obisesan O, et al. E-Cigarette Use Among US Adults in the 2021 Behavioral Risk Factor Surveillance System Survey. JAMA Netw Open. 2023;6(11):e2340859. Published 2023 Nov 1. doi:10.1001/jamanetworkopen.2023.40859
3. Cullen KA, Gentzke AS, Sawdey MD, et al. e-Cigarette Use Among Youth in the United States, 2019. JAMA. 2019;322(21):2095-2103. doi:10.1001/jama.2019.18387
4. Kathuria H. Electronic Cigarette Use, Misuse, and Harm. Med Clin North Am. 2022;106(6):1081-1092. doi:10.1016/j.mcna.2022.07.009
5. Esteban-Lopez M, Perry MD, Garbinski LD, et al. Health effects and known pathology associated with the use of E-cigarettes. Toxicol Rep. 2022;9:1357-1368. Published 2022 Jun 16. doi:10.1016/j.toxrep.2022.06.006
6. Sachdeva J, Karunananthan A, Shi J, et al. Flavoring Agents in E-cigarette Liquids: A Comprehensive Analysis of Multiple Health Risks. Cureus. 2023;15(11):e48995. Published 2023 Nov 18. doi:10.7759/cureus.48995
7. Mattingly DT, Hart JL. Trends in Current Electronic Cigarette Use Among Youths by Age, Sex, and Race and Ethnicity. JAMA Netw Open. 2024;7(2):e2354872. Published 2024 Feb 5. doi:10.1001/jamanetworkopen.2023.54872
8. Walley SC, Wilson KM, Winickoff JP, Groner J. A Public Health Crisis: Electronic Cigarettes, Vape, and JUUL. Pediatrics. 2019;143(6):e20182741. doi:10.1542/peds.2018-2741
9. Besaratinia A, Tommasi S. Vaping: A growing global health concern. EClinicalMedicine. 2019;17:100208. Published 2019 Nov 16. doi:10.1016/j.eclinm.2019.10.019
10. Sun Y, Prabhu P, Li D, McIntosh S, Rahman I. Vaping: Public Health, Social Media, and Toxicity. Online J Public Health Inform. 2024;16:e53245. Published 2024 Apr 11. doi:10.2196/53245
11. Jonas A. Impact of vaping on respiratory health. BMJ. 2022;378:e065997. Published 2022 Jul 18. doi:10.1136/bmj-2021-065997
12. Dai HD, Doucet GE, Wang Y, et al. Longitudinal Assessments of Neurocognitive Performance and Brain Structure Associated With Initiation of Tobacco Use in Children, 2016 to 2021. JAMA Netw Open. 2022;5(8):e2225991. Published 2022 Aug 1. doi:10.1001/jamanetworkopen.2022.25991
13. Jones CD, Ho W, Gunn E, Widdowson D, Bahia H. E-cigarette burn injuries: Comprehensive review and management guidelines proposal. Burns. 2019;45(4):763-771. doi:10.1016/j.burns.2018.09.015
14. Rodriguez-Merchan EC. The importance of smoking in orthopedic surgery. Hosp Pract (1995). 2018;46(4):175-182. doi:10.1080/21548331.2018.1505406
15. Kwiatkowski TC, Hanley EN Jr, Ramp WK. Cigarette smoking and its orthopedic consequences. Am J Orthop (Belle Mead NJ). 1996;25(9):590-597.
16. Møller AM, Pedersen T, Villebro N, Munksgaard A. Effect of smoking on early complications after elective orthopaedic surgery. J Bone Joint Surg Br. 2003;85(2):178-181. doi:10.1302/0301-620x.85b2.13717
17. Argintar E, Triantafillou K, Delahay J, Wiesel B. The musculoskeletal effects of perioperative smoking. J Am Acad Orthop Surg. 2012;20(6):359-363. doi:10.5435/JAAOS-20-06-359
18. Beahrs TR, Reagan J, Bettin CC, Grear BJ, Murphy GA, Richardson DR. Smoking Effects in Foot and Ankle Surgery: An Evidence-Based Review. Foot Ankle Int. 2019;40(10):1226-1232. doi:10.1177/1071100719867942
19. Holle AM, Tummala SV, Pejic J, Van Schuyver PR, Chhabra A, Economopoulos KJ. Association of Smokeless Tobacco Use With Perioperative Complications and Revision Surgery After Anterior Cruciate Ligament Reconstruction. Am J Sports Med. 2025;53(2):308-314. doi:10.1177/03635465241303487
20. Starzer M, Smolle MA, Vielgut I, et al. Smokers have increased risk of soft-tissue complications following primary elective TKA. Arch Orthop Trauma Surg. 2023;143(8):4689-4695. doi:10.1007/s00402-023-04771-8
21. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. Published 2021 Mar 29. doi:10.1136/bmj.n71
22. Agoons DD, Agoons BB, Emmanuel KE, Matawalle FA, Cunningham JM. Association between electronic cigarette use and fragility fractures among US adults. Am J Med Open. 2021;1-6:100002. Published 2021 Sep 16. doi:10.1016/j.ajmo.2021.100002
23. Bieganowski T, Singh V, Kugelman DN, Rozell JC, Schwarzkopf R, Lajam CM. Vaping Trends and Outcomes in Primary Total Joint Arthroplasty Patients: An Analysis of 21,341 Patients. J Am Acad Orthop Surg Glob Res Rev. 2023;7(1):e22.00110. Published 2023 Jan 13. doi:10.5435/JAAOSGlobal-D-22-00110
24. Lawand J, Ghali A, Dajani AH, et al. Nontobacco Nicotine Dependence and Rates of Periprosthetic Joint Infection and Other Postoperative Complications in Shoulder Arthroplasty: A Retrospective Analysis. J Am Acad Orthop Surg. 2025;33(2):92-99. doi:10.5435/JAAOS-D-24-00706
25. Lawand J, Ghali A, Hauck J, Trejo Corona S, Gonzalez R, Deveza L. The Smokeless Paradox: Nontobacco Nicotine Use and Complications in Anterior Cervical Discectomy and Fusion. J Am Acad Orthop Surg. Published online December 18, 2024. doi:10.5435/JAAOS-D-24-00801
26. Pywell MJ, Wordsworth M, Kwasnicki RM, Chadha P, Hettiaratchy S, Halsey T. The Effect of Electronic Cigarettes on Hand Microcirculation. J Hand Surg Am. 2018;43(5):432-438. doi:10.1016/j.jhsa.2017.12.003

27. Amaro EJ, Shepard N, Moss L, Karamitopoulos M, Lajam C. Vaping and Orthopaedic Surgery: A Review of Current Knowledge. JBJS Rev. 2019;7(1):e5. doi:10.2106/JBJS.RVW.18.00015
28. Armstrong ML, Smith N, Tracey R, Jackman H. The Orthopedic Effects of Electronic Cigarettes: A Systematic Review and Pediatric Case Series. Children (Basel). 2022;9(1):62. Published 2022 Jan 4. doi:10.3390/children9010062
29. Fiani B, Noblett C, Nanney JM, et al. The Impact of "Vaping" Electronic Cigarettes on Spine Health. Cureus. 2020;12(6):e8907. Published 2020 Jun 29. doi:10.7759/cureus.8907
30. Nicholson T, Davis L, Davis ET, Newton Ede M, Scott A, Jones SW. e-Cigarette Vapour Condensate Reduces Viability and Impairs Function of Human Osteoblasts, in Part, via a Nicotine Dependent Mechanism. Toxics. 2022;10(9):506. Published 2022 Aug 28. doi:10.3390/toxics10090506
31. Nicholson T, Scott A, Newton Ede M, Jones SW. The impact of E-cigarette vaping and vapour constituents on bone health. J Inflamm (Lond). 2021;18(1):16. Published 2021 May 5. doi:10.1186/s12950-021-00283-7
32. Zaidi H, Stammers J, Hafez A, et al. The impact of electronic cigarettes on the outcomes of total joint arthroplasty. Arch Orthop Trauma Surg. 2024;144(11):4801-4808. doi:10.1007/s00402-024-05565-2
33. Shore BJ, Flaugh R, Shannon BA, Curran P, Hogue G. Preoperative Considerations for Teenagers Undergoing Orthopaedic Surgery: VTE Prevention, Mental Health Assessment, Vaping, and Drug Addiction. J Pediatr Orthop. 2021;41(Suppl 1):S64-S69. doi:10.1097/BPO.0000000000001764
34. Wint AB, Mangan JJ. Vaping and Orthopedic Surgery: Perioperative Management. SurgiColl. 2024;2(3). doi:10.58616/001c.90489
35. Boissiere F, Bekara F, Luca-Pozner V, et al. Thermal and chemical burns caused by e-cigarette battery explosions. Ann Chir Plast Esthet. 2020;65(1):24-30. doi:10.1016/j.anplas.2019.12.001
36. Hagarty S, Luo J. E-cigarette "Vape" Device Explosion Causing C Spine Fracture. Plast Reconstr Surg Glob Open. 2020;8(4):e2745. Published 2020 Apr 14. doi:10.1097/GOX.0000000000002745
37. Kaltenborn A, Dastagir K, Bingoel AS, Vogt PM, Krezdorn N. E-cigarette explosions: patient profiles, injury patterns, clinical management, and outcome. JPRAS Open. 2023;37:34-41. Published 2023 May 18. doi:10.1016/j.jpra.2023.05.001
38. Kelly T, McClure V, Loh I. Vaping—not such a sweet alternative: a case report of bilateral hand Sweet syndrome. AJOPS. 2024;8(1). doi:10.34239/ajops.94716
39. Kite AC, Le BQ, Cumpston KL, Hieger MA, Feldman MJ, Pozez AL. Blast Injuries Caused by Vape Devices: 2 Case Reports. Ann Plast Surg. 2016;77(6):620-622. doi:10.1097/SAP.0000000000000875
40. Kadhum M, El-Hilly A, O'Neill J. A Blast and Burn Hand Injury Caused by an Exploding Vaping Device in a Pediatric Patient: A Case Report. Plast Aesthet Nurs (Phila). 2024;44(3):180-182. doi:10.1097/PSN.0000000000000565
41. Maraqa T, Mohamed MAT, Salib M, Morris S, Mercer L, Sachwani-Daswani GR. Too Hot for Your Pocket! Burns From E-Cigarette Lithium Battery Explosions: A Case Series. J Burn Care Res. 2018;39(6):1043-1047. doi:10.1093/jbcr/irx015
42. Norii T, Plate A. Electronic Cigarette Explosion Resulting in a C1 and C2 Fracture: A Case Report. J Emerg Med. 2017;52(1):86-88. doi:10.1016/j.jemermed.2016.08.010
43. Russell KW, Katz MG, Phillips RC, et al. Adolescent Vaping-Associated Trauma in the Western United States. J Surg Res. 2022;276:251-255. doi:10.1016/j.jss.2022.02.026
44. Satteson ES, Walker NJ, Tuohy CJ, Molnar JA. Extensive Hand Thermal and Blast Injury From Electronic Cigarette Explosion: A Case Report. Hand (N Y). 2018;13(3):NP1-NP5. doi:10.1177/1558944717744333
45. Benowitz NL, Burbank AD. Cardiovascular toxicity of nicotine: Implications for electronic cigarette use. Trends Cardiovasc Med. 2016;26(6):515-523. doi:10.1016/j.tcm.2016.03.001
46. Whitehead AK, Erwin AP, Yue X. Nicotine and vascular dysfunction. Acta Physiol (Oxf). 2021;231(4):e13631. doi:10.1111/apha.13631
47. Tomlinson RE, Silva MJ. Skeletal Blood Flow in Bone Repair and Maintenance. Bone Res. 2013;1(4):311-322. Published 2013 Dec 31. doi:10.4248/BR201304002
48. Smollock W, Montenegro P, Czenis A, He Y. Hypoperfusion and Wound Healing: Another Dimension of Wound Assessment. Adv Skin Wound Care. 2018;31(2):72-77. doi:10.1097/01.ASW.0000527964.87741.a7
49. Al-Hadithy N, Sewell MD, Bhavikatti M, Gikas PD. The effect of smoking on fracture healing and on various orthopaedic procedures. Acta Orthop Belg. 2012;78(3):285-290.
50. Struik L, Yang Y. e-Cigarette Cessation: Content Analysis of a Quit Vaping Community on Reddit. J Med Internet Res. 2021;23(10):e28303. Published 2021 Oct 25. doi:10.2196/28303
51. Mayorga NA, Rogers AH, Smit T, Garey L, Zvolensky MJ. Evaluating the psychometric properties of the e-cigarette barriers to cessation scale. Cogn Behav Ther. 2021;50(6):492-508. doi:10.1080/16506073.2021.1901773
52. Bao W, Liu B, Du Y, Snetselaar LG, Wallace RB. Electronic Cigarette Use Among Young, Middle-aged, and Older Adults in the United States in 2017 and 2018. JAMA Intern Med. 2020;180(2):313-314. doi:10.1001/jamainternmed.2019.4957
53. Dai HD, Hanh P, Guenzel N, Morgan M, Kerns E, Winickoff JP. Adoption of Vaping Cessation Methods by US Adolescent E-Cigarette Users. Pediatrics. 2023;152(5):e2023062948. doi:10.1542/peds.2023-062948
54. Butler AR, Lindson N, Livingstone-Banks J, et al. Interventions for quitting vaping. Cochrane Database Syst Rev. 2024;5(5):CD016058. Published 2024 May 21. doi:10.1002/14651858.CD016058
55. Yammine L, Tovar M, Yammine NA, Becker C, Weaver MF. E-cigarettes and Youth: The Known, the Unknown, and Implications for Stakeholders. J Addict Med. 2024;18(4):360-365. doi:10.1097/ADM.0000000000001304

Appendix 1: Scan QR: https://qrco.de/bggRBe