RESEARCH ARTICLE

Trends in Orthopaedic Surgery on Patients 90 Years Old and Older 2014-2023

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Abstract

Objectives: The United States (US) population is aging with an increasing number of older adults over 90 years old. The primary purpose of this study is to evaluate trends in orthopaedic surgeries in patients 90 years old and greater over the past decade from 2014-2023.

Methods: Patients ≥90 years old at the time of surgery at a single orthopaedic specialty practice from 2014 through 2023 were identified. All patients that underwent nonsurgical treatment were excluded. Surgeries were categorized by musculoskeletal area and procedure type by CPT codes. Musculoskeletal areas include Shoulder, Humerus/Elbow, Forearm/Wrist, Hand/Fingers, Pelvis/Hip, Femur/Knee, Leg/Ankle, Foot/Toes, Spine, Integumentary, Nervous System, and Other.

Results: Over the last decade, 5,291 orthopaedic surgeries were performed on 4,807 patients 90 years old and older (age range 90-107 years old; 75% female). Of these patients, 91% underwent only one surgery while ≥90 years old, while the remaining underwent between two to five surgeries. The number of surgeries each year ranged from 180 to 680 with a positive correlation between year and number of surgeries and a greater than threefold increase in surgeries 2014-2023. The Pelvis and Hip were the primary musculoskeletal areas of surgery, accounting for 69% of surgeries overall, followed by femur and knee (11%) and nervous system (which includes carpal tunnel release, 5.2%). Most surgeries (69%) were for a fracture or dislocation.

Conclusion: There is an increase in volume of orthopaedic surgery on patients ≥90 years old over the last decade between 2014-2023, the majority of which were performed on the hip and pelvis and for fractures or dislocations. As older adults ≥90 years old continue to increase in the population, we project the surgical volume will continue to grow and place a large financial burden on the US healthcare system.

Level of evidence: IV

Keywords: Centenarians, Fractures, Frail elderly, Nonagenarian, Orthopedics

Introduction

The United States (US) population is aging and the number of older adults is expected to continue to rise.[1,2] A 2023 estimate of the US population projected that individuals 85 years and older will increase from 2.0% of the total population in 2022 to 7.7% of the total population in 2100.[2] The increased population age, in combination with the increase in disease management complexity and healthcare costs, is associated with an increased financial burden of healthcare in the US.[3,4] In 2021, Medicare covered nearly 65 million people, primarily older adults 65 years and older, but this is projected to increase to over 90 million in 2030. This increase in Medicare-eligible individuals is projected to result in an increase in total expenditure from $829 billion in 2021 to over $1.5 trillion in 2030.[3,4]

The aging US population has a disproportionate need for orthopaedic surgery. Older patients have a higher risk of fall and a higher risk of injury from low-energy falls.[5-7] The incidence of associated fragility fractures has been increasing and is projected to continue to do so.[6,8] Furthermore, the incidence of femoral shaft fracture and periprosthetic fractures in patients over 65 years old have

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been shown to increase with age, disproportionately affecting the older elderly.[9,10] There is a high cost of care for injuries from these falls and fragility fractures. A recent database study found that the annual average cost for Emergency Department and inpatient admissions for fall injuries in older adults ≥65 years old exceeded $20. billion annually. Within this cohort, patients ≥85 years old accounted for 39% of inpatient fall admissions and 30% of Emergency Department visits.[11] A recent European study projected the cost from fragility fractures to increase by 27% between just 2017 and 2030.[8] Beyond fracture care, older adults can also benefit from elective orthopaedic surgery.

There is limited literature looking specifically at this elderly population in orthopaedic surgery.[1] The primary purpose of this study is to evaluate trends in orthopaedic surgeries in patients 90 years old and older over the past decade from 2014-2023.

Materials and Methods

With institutional review board approval, billing records were queried to identify all patients 90 years old and over at the time of surgery at a large multi-state orthopaedic specialty practice spanning across the Northeast Unted States and Florida from 2014 through 2023. All patients that underwent nonsurgical treatment, as identified by Current Procedural Terminology (CPT) code for injections or closed fracture treatment, were excluded. Multiple CPT codes were identified for the same patient on the same date of service for 635 patients (12%). For these patients, all CPT for the same patient on the same date of service were compiled and treated as a single surgery occurrence for that patient. The number of CPT codes ranged from one to eight and the primary code was determined to be the code without a 51 modifier.

Surgeries were categorized by musculoskeletal area and procedure type as defined by the Accreditation Council for Graduate Medical Education (ACGME) list of CPT codes relevant to orthopaedic surgery. Musculoskeletal areas include Shoulder, Humerus/Elbow, Forearm/Wrist, Hand/Fingers, Pelvis/Hip, Femur/Knee, Leg/Ankle, Foot/Toes, Spine, Integumentary, Nervous System, and Other. Procedure type include Fracture/Dislocation, Intro/Removal (including injections and foreign body or prosthesis removal), Manipulation, Repair/Revision/Reconstruction, Incision/Excision, Amputation, Arthrodesis, Arthroscopy, Decompression, Exploration, Instrumentation, Osteotomy, Flaps, Skin Grafts, Carpal Tunnel, Neuroplasty, Neurorrhaphy, Transection/Avulsion, and Other. All surgery codes associated with the procedure were analyzed to determine if any code was for a fracture/dislocation treatment. For surgeries without a fracture/dislocation treatment code, only the primary code was used to categorize the procedure type.

Continuous data is presented as a mean and standard deviation (SD). Categorical data is presented as count and percentage. A linear line of best fit and an associated R^2 value was calculated to represent the trend in surgery volume as a function of time.

Results

Over the last decade, 5,291 orthopaedic surgeries were performed on 4,807 patients 90 years and older. Of these patients, 91% underwent only one surgery during the study period, while the remaining underwent between two to five surgeries [Table 1]. The average patient age was 93 years old (SD 2.7 years; range 90 to 107 years old). Female patients accounted for 3,966 surgeries (75%) compared to 1,326 male patients (25%).

Over the study period, there is a positive correlation between the year and number of surgeries with a greater than threefold increase in surgeries over the last decade [Figure 1]. The total number of surgeries each year ranged from a minimum of 180 in 2014 to a maximum of 680 in 2022.

Figure 2 shows the number of surgeries per year when stratified by musculoskeletal area. Pelvis/Hip was the primary musculoskeletal area of surgery, accounting for 69.0% of surgeries overall [Figure 2]. Figure 3 shows the number of surgeries per year when stratified by musculoskeletal area after exclusion of the Pelvis/Hip category to better visualize the distribution of the remaining 31.0% of surgeries. Femur/Knee represents 11% of surgeries and Nervous System (which includes carpal tunnel release) represents 5.2% of surgeries, while all other musculoskeletal areas together (including Shoulder, Humerus/Elbow, Forearm/Wrist, Hand/Fingers, Leg/Ankle, Foot/Toes, Spine, Integumentary, and Other) account for the remaining 15% of surgeries [Figure 3].

Most surgeries (3,625 surgeries; 69%) included a fracture/dislocation CPT code as at least one of the procedure codes. For the surgeries (1,666 surgeries; 31%) that did not include a fracture or dislocation code, the next three most common procedures were categorized as "Repair, Revision, or Reconstruction," "Carpal Tunnel," or "Incision or Excision." All other procedures represented on average 1% or less of all surgeries [Figure 4].

Table 1: Number of patients undergoing multiple surgeries while 90 years old and older during the study period

Number of surgeries per patient	1	2	3	4	5
Number of patients with multiple surgeries	4385	368	47	5	2
Percentage of All Patients	91.2%	7.7%	1.0%	0.1%	0.0%

Discussion

The number of surgeries performed on patients 90 years old and greater has increased over the last decade by over three-fold. To our knowledge this is the first study evaluating trends in volumes of surgery in patients 90 years and older undergoing both elective and trauma orthopaedic surgery. Other studies, inclusive of all elderly patients over 65 years

old, have shown mixed results for trends in specific orthopaedic surgery procedure volume over the past 15 years. A study of operatively treated elderly proximal humerus fractures 2015-2020 found a 40.8% decrease in rate of operative treatment between the 1st and 2nd half of the study.[12] One study of femoral shaft fractures in elderly patients between 2009 and 2019 showed no significant change with time.[9] In contrast, a study of periprosthetic fractures in elderly patients from 2010 to 2019 reported a significant increased incidence of periprosthetic fractures with age.[10] Direct comparison of our study to these previous reports are limited by variation in inclusion criteria.

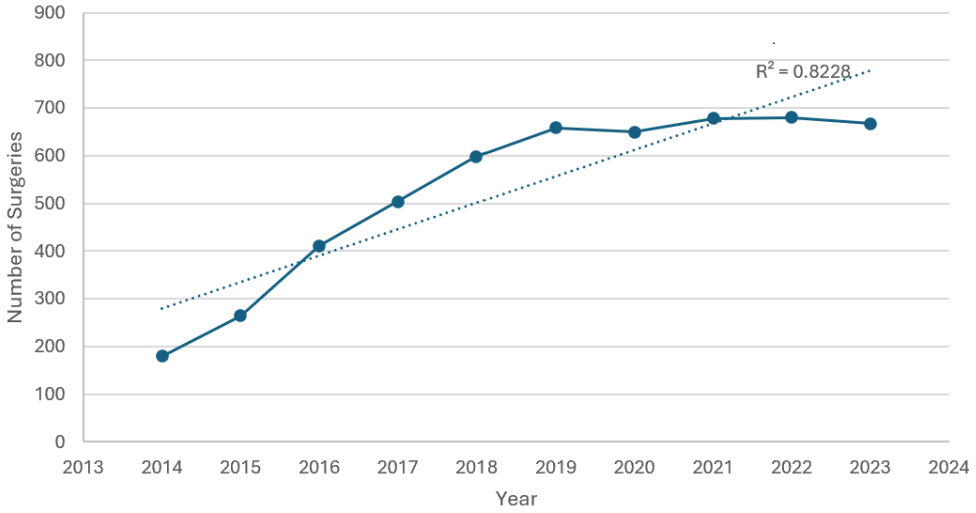

Figure 1. Number of surgeries performed per year on patients ≥90 years between 2014 to 2023. The dotted line represents the linear line of best fit with the corresponding R2 value

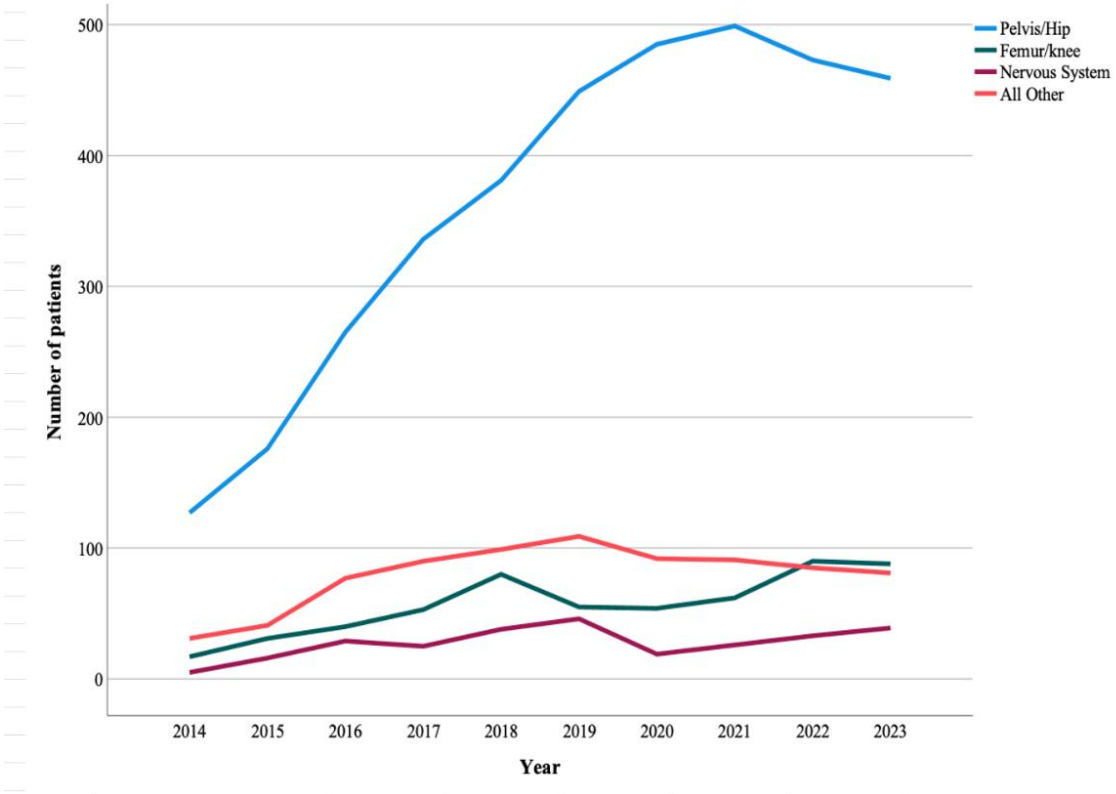

Figure 2 Number of surgeries performed per year on patients ≥90 years between 2014 to 2023 stratified by musculoskeletal area

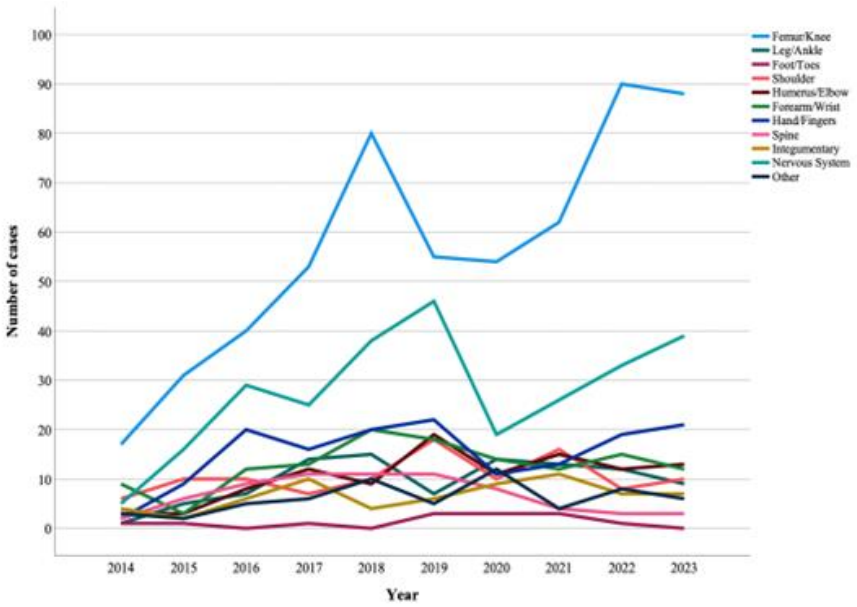

Figure 3. Number of surgeries performed per year on patients ≥90 years between 2014 to 2023 stratified by musculoskeletal area after exclusion of pelvis and hip procedures

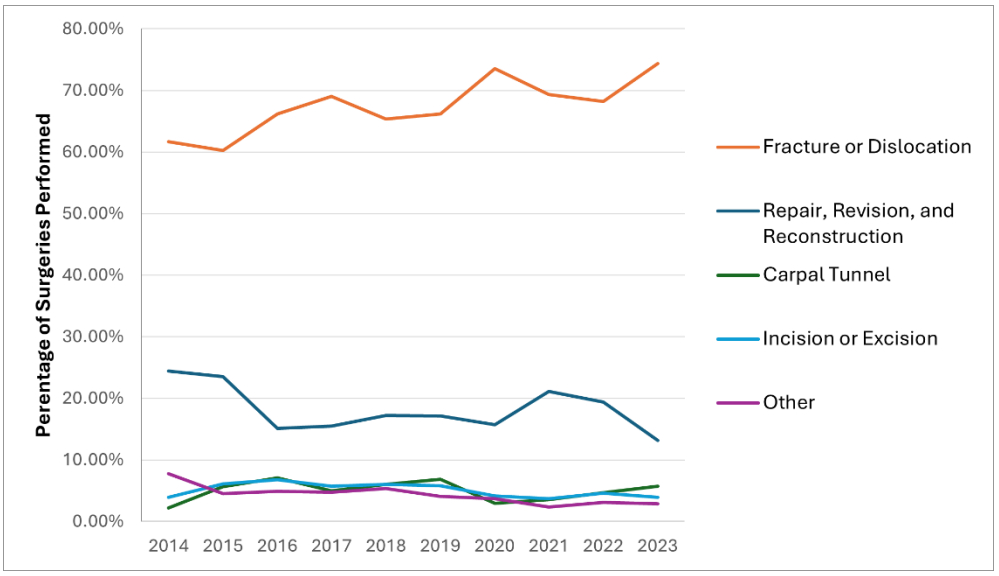

Figure 4. The type of procedure performed as a percentage of total surgeries on patients ≥90 years between 2014 to 2023. Other includes procedures categorized as Intro/Removal, Manipulation, Amputation, Arthrodesis, Arthroscopy, Decompression, Exploration, Instrumentation, Osteotomy, Flaps, Skin Grafts, Neuroplasty, Neurorrhaphy, Transection/Avulsion, and Other

Most surgeries were performed on the pelvis or hip followed second by the femur and knee. This aligns with a study on geriatric trauma in elderly patients in New York City, which found that older patients in their cohort ranging from 55 years old to ≥95 years old had a greater number of hip and pelvic injuries with a decrease in upper and lower extremity injuries. Further their cohort of patients 86-94 years old and ≥95 years old hip fractures represented 45.9% and 50.7% of fractures, respectively.[13] Furthermore, over two-thirds of surgeries performed on patients 90 years and older were for fracture care. Given the significant burden of fractures in the elderly population, many have advocated for mechanisms to decrease fall and fracture risk in elderly patients through appropriate osteoporosis screening, medical management of osteoporosis, and fall prevention programs.[5,8,14-16] Though not currently standard of care, literature has also recently proposed novel prophylactic surgical intervention for hip fractures. A recent cost-

effectiveness analysis investigated prophylactic pertrochanteric hip fracture fixation both as secondary prevention during contralateral hip fracture surgery and as primary prevention via prophylactic bilateral fixation for patients with risk factors. With an assumed 10% reduction in fracture risk, they reported prophylactic fixation to be cost effective, but the degree of benefit decreased with increasing patient age.[17] Alternatively, biomechanical cadaveric studies have advocated for development of a femoroplasty procedure involving injection of polymethyl methacrylate of the proximal femur as a prophylactic mechanism to decrease the likelihood of geriatric hip fractures.[18,19] While the benefit of these interventions to decrease fracture and fall risk in the elderly is thought to decrease as a patient ages, the significant number of annual orthopaedic surgeries performed on patients 90 years and older demonstrated here suggests that continuing preventative measures in even older patients over 90 years old may be of benefit.

Interesting, 5% of procedures were categorized as Nervous System, which includes primarily carpal tunnel release procedures. The large representation in patients 90 years old and greater is likely a reflection of the ability to perform this procedure with the wide-awake local anesthesia technique, avoiding the anesthetic risk.

In our cohort, 8.8% of patients underwent greater than one surgery during the study period. This is multifaceted with patients undergoing staged procedures, complications requiring return to the operating room, and patients treated for multiple operative fractures during the study period. The history of a fracture in elderly patients is a well-documented risk factor for subsequent fracture beyond that which can be explained by other fracture risk factors.[20-25] Specifically, Ratnasamy *et al* reported the risk of contralateral hip fracture in patients over 65 years old with a hip fracture within 10 years is 6.9%, 68.4% of which occurred in the first 2 post-operative years.[24] The first osteoporotic fracture is a time period that patients could be identified for osteoporosis intervention, as highlighted by the American Orthopaedic Association "Own the Bone" initiative.[26-30] The high incidence of multiple orthopaedic surgeries for patients 90 years old and greater here highlights the need for appropriate referral to geriatrics to ensure appropriate medical optimization and patient patient-specific fall prevention strategies.

The total number of surgeries in 2020 during the height of the COVID-19 pandemic was 650 relatives to 659 in 2019 and 678 in 2021. Of these, 74.6% were performed on the pelvis and hip and 73.5% were for fracture or dislocation. At the same time, the number of Nervous System procedures, which included carpal tunnel surgery, dropped from 6.98% of surgeries in 2019 to 2.92% in 2020. Together this suggests that though the trend of increased surgery on patients 90 years old and greater was not reproduced during the pandemic, these elderly patients continued to have falls resulting in hip fractures requiring surgical intervention. At the same time, elective surgeries such as carpal tunnel release decreased during 2020 corresponding to the COVID-19 pandemic.

There are several shortcomings to this study. First, we report that two thirds of procedures were performed for fracture care, but this may underestimate fracture surgeries. We determined fracture care by including a CPT code categorized as "fracture or dislocation." While this identified many patients treated for fracture, it may not have correctly identified all arthroplasty procedures performed for fracture if they did not include both the fracture care and arthroplasty CPT codes. Second, there is a large cohort retrospective study dependent on accurate CPT code billing documentation. Lastly, the specific number of surgeons in the practice may fluctuate from year to year which could skew the number of surgeries in one year compared to the next.

Conclusion

Surgery for these elderly patients has additional risks due to comorbidities and frailty, as well as an increased mortality risk seen in both elective and nonelective otolaryngology, general surgery, and spine surgery.[31-33] Given this, some have advocated to limit surgery on these older adults, while others advocate for continued treatment in the optimized patients.[31,32,34] Here we demonstrate an increase in volume of orthopaedic surgery on patients 90 years old and greater between 2014-2023, the majority of which were performed on the hip and pelvis and for fractures or dislocations. As older adults ≥90 years old continue to increase in the population, we project this volume will continue to increase and place a large financial burden on the US healthcare system.

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