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ORIGINAL ARTICLE

Economic and social impact of upper extremity fragility fractures in elderly patients

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Abstract

Background Fragility fractures of the proximal humerus and distal radius can have a significant impact on the elderly population, both economically and physically. Limited data are available to demonstrate the functional and economic impact of upper extremity fragility fractures.
Aims To investigate the economic and social impact that proximal humerus fragility fractures may have on an older population.
Methods A retrospective chart review for patients ≥50 years old treated as an inpatient at a local hospital between 2006 and 2012 for a proximal humerus or a distal radius fracture was done. Patients were divided into two groups to show age impact; Group 1 = 50–79 years old and Group 2 = 80 years and older. Eighty-six charts were reviewed, 38 for Group 1 and 48 for Group 2. Demographic, admission, inpatient, and discharge data were compared between groups.
Results A third of patients in each group had a previous fragility fracture. Inpatient length of stay was comparable between groups. Surgical treatment was used at a higher rate in the younger cohort ($p = 0.06$). Approximate average hospital charges for an inpatient surgical treatment were about twice those of the non-surgically treated patients.
Discussion Our results illustrate the significant burden of upper extremity fractures in terms of loss of independence, inpatient hospitalizations and prolonged nursing home or rehabilitation needs, which account for considerable health care costs.
Conclusion Fractures of the humerus, forearm and wrist account for one-third of the total incidence of fractures and can be a significant burden to individuals and the community.

Keywords Osteoporosis · Fragility fracture · Proximal humerus · Epidemiology · Treatment costs

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Introduction

Fragility fractures have become nearly epidemic in the United States among elderly adults with over 2 million fractures occurring each year—more than heart attacks, strokes, and breast cancer combined [1]. Forty-four million Americans are now affected by osteoporosis or low-bone density, with one of the most devastating complications of osteoporosis being fragility fracture. According to the National Osteoporosis Foundation, up to one-half of all women and up to one quarter of all men will suffer a fragility fracture in their lifetime. The economic impact of fragility fractures is staggering; the direct cost of care for these fractures on the United States health care system is estimated at 13–20 billion dollars annually, with costs projected to rise by almost 50 percent by 2025 [2–7]. The number of upper extremity fragility fractures will continue to increase as the US population continues to age, and the impact these fractures have on our health care system and patient quality of life will become a greater burden. Distal radius and proximal humerus fractures (PHF) are common among the elderly population as they are the second and third most common fractures in adults over the age of 65 [8]. It is estimated that proximal humerus fractures account for 20 % of all osteoporotic fractures, and it has been reported that more than 70 % of proximal humeral fractures occur in patients over 60 years old [9–11].

Several European countries have been able to use national claims databases from their single payer systems to evaluate the economic impact that upper extremity fragility fractures have on their aging population [12–14]. The lack of a national unified database in the US makes these studies more difficult. Additionally, while there has been extensive literature published in the US that focuses on social and financial consequences resulting from suffering a hip fracture, literature focused on functional and economic impact resulting from upper extremity fractures is limited [15–17]. These fractures account for one-third of the total incidence of fractures in the elderly, yet we do not fully understand the impact these fractures have on patient's independence, quality of life, or families. In particular, as age increases so do the number of medical co-morbidities, leading to more complicated and costly hospital stays, poorer outcomes, and increased mortality [18–21]. We examined the relationship between age and treatment type for upper extremity fragility fractures. We also looked at the early social and economic impact that upper extremity fragility fractures have based on increased age at injury.

Methods

This was an Institutional Review Board approved retrospective review. The authors have no conflicts of interest for this study.

Patients who had an inpatient treatment at Bronson Methodist hospital with a diagnosis (ICD-9 codes) for a proximal humerus or a distal radius fracture from 2006 to 2012 were included in the study. A retrospective chart review was performed and patients were excluded if their fracture resulted from a high energy or traumatic injury such as motor vehicle accident or crush injury. Eighty-six patients who met all the criteria were included in this study. To better delineate effect of age on patients with these types of upper extremity fragility fractures, patients were divided into two groups; group 1 consisted of patients aged 50–79 years old and group 2 included patient's ≥80 years old. The institutional EMR was used to collect relevant clinical, demographic, and discharge data for each participant ("Appendix").

Demographic data included age, gender, race, height, weight, smoking status, alcohol consumption, menopause status, history of fracture and location, and mechanism of injury for current fracture. The co-morbid conditions collected for both cohorts included histories of osteoporosis, osteopenia, diabetes mellitus, dementia, rheumatoid arthritis, and cancer. Medication history and discharge medication list were reviewed and data collected for oral steroids, Vitamin D, Calcium, and osteoporosis drugs including bisphosphonates.

Pre-fracture mobility levels were collected from patient charts. These were based on reported ambulatory status and pre-fracture place of residence [lived at home, in an assisted living facility (AL), or in a skilled nursing facility (SNF)]. Discharge levels of independence (residence status) were categorized into four groups: home, assisted living facility, skilled nursing or rehabilitation facility (Rehab), and hospice care or unknown. Additionally, inpatient data on treatment type: surgical or non-surgical and type of surgery, length of stay (LOS), complications or readmission were collected for each patient. Surgical treatments included open reduction and internal fixation (ORIF) of the humerus or distal radius or shoulder arthroplasty. Major complications included implant failure, loss of reduction, permanent neuropathy, deep infection, malunion, nonunion, while minor complications included delayed union, superficial infection, stiffness, symptomatic implant, transient neuropathy, or continued pain.

Total direct costs related to upper extremity fractures were computed for each group using standard charges from the admitting hospital for a general per diem inpatient stay and using CPT codes for fracture repair. Fixed standard charges for CPT codes were: CPT23470 hemiarthroplasty of the shoulder at $27,876.00, CPT23615 ORIF of the humerus at $29,523.00, CPT25607 for ORIF distal radius $19,195. The per diem inpatient charge for non-surgically treated patients was $2,428/day. Cost for non-operative treatment was calculated as inpatient days times standard daily charge, and the average was calculated by dividing by the total number of patients in each corresponding subset of a cohort (38 for cohort 1, and 48 for cohort 2). Total cost per group for treatment was calculated by combining total surgery costs and total non-operative treatment costs; the average was calculated using the total number of patients in each corresponding subset of a cohort.

Statistical analysis

The data were summarized using descriptive statistics. The R 3.01 (R Foundation for Statistical Computing, Vienna Austria) software was used for all statistical analyses. Comparisons between G1 and G2 were performed for each of the independent variables collected. The Chi-squared test was used to evaluate the association between 2 categorical variables including previous history of fracture, co-morbidities, comparison of patient living status or level of independence pre and post fracture, and pre- to post-fracture mobility. A Chi-squared test was also used to compare non-surgical and surgical treatments as they relate to age and co-morbidities. A student *t* test comparison was used to compare LOS between G1 and G2 and for non-operative and surgically treated patients. A p value ≤ 0.05 was considered statistically significant.

Results

Of the eighty-six patients who met our inclusion criteria; G1 consisted of 38 patients and G2 had 48 patients. The average ages for the groups were 66 years for G1 and 87 years for G2. The majority of our cohort was Caucasian (94 %) and over 70 % of patients had no prior diagnosis of osteoporosis. No difference was seen in the rate of previous fracture between G1 and G2 (34 and 35 %, respectively) ($p = 0.13$). There was a significantly higher rate of smoking among G1 patients compared to G2 ($p < 0.0001$). There were no other significant differences between group demographics (Table 1). Results of Chi-square analysis demonstrated no relationship between increased age and increased number of co-morbidities ($p = 0.59$).

Mobility and independence

The majority of both groups had a high level of independent pre-fracture mobility (Fig. 1). As expected, our younger cohort showed a higher level of baseline independent mobility with 76 % being ambulatory with no assisted devices and 24 % using a walker compared to 58.3 % of patients in the older cohort who were ambulatory with no assisted devices, 27 % using a walker, 8.3 % were in a wheelchair, and 6.3 % were considered immobile. Patients from both groups were discharged to either a skilled nursing facility or rehab at equal rates, 44.7 % for G1 compared to 45.8 % from G2 ($p = 0.98$). A similar trend was seen in the discharge of patients to assisted living facilities, 28.9 % for G1 compared to 31.3 % for G2 ($p = 0.99$). G2 patients were discharged home at a slightly higher rate 16.7 %, than their G1 counterparts 7.9 % but this was not statistically significant ($p = 0.48$). There was no significant difference in pre to post fracture independence between groups ($p = 0.32$) (Fig. 2).

Length of stay

The average LOS for all patients was not significantly different between the cohorts ($p = 0.074$). The overall average inpatient stay for the younger was 5.29 days compared to the average stay for the older cohort of 4.15 days ($p = 0.074$). Surgically treated patients within a group trended toward a shorter average LOS than the non-operative patients in that group. There was also no significant difference when comparing LOS for the surgically treated patients from G1 (4.93 days) to G2 (5.52 days), ($p = 0.201$) and LOS for non-operatively treated patients in G1 (3.6 days) to G2 (4.29 days) ($p = 0.137$). Chi-square analysis demonstrated no correlation between increased number of comorbidities and LOS ($p = 0.159$).

Table 1 Summary of demographics and co-morbidities for G1 and G2

Cohort	50–79	80+
Total no.	38	48
Male	12 (32)	9 (19)
Female	26 (68)	39 (81)
Race		
White	35 (92)	46 (96)
Black	2 (5)	1 (2)
Hispanic	1 (3)	0
Other	0	1 (2)
Smoker		
Yes	15 (39)	1 (2)
No	22 (58)	46 (96)
Diagnosed osteoporosis		
Yes	8 (21)	13 (27)
No	30 (79)	35 (73)
History of fracture		
Yes	13 (34)	17 (35)
No	25 (66)	31 (65)

Demographics and history summary with (%)

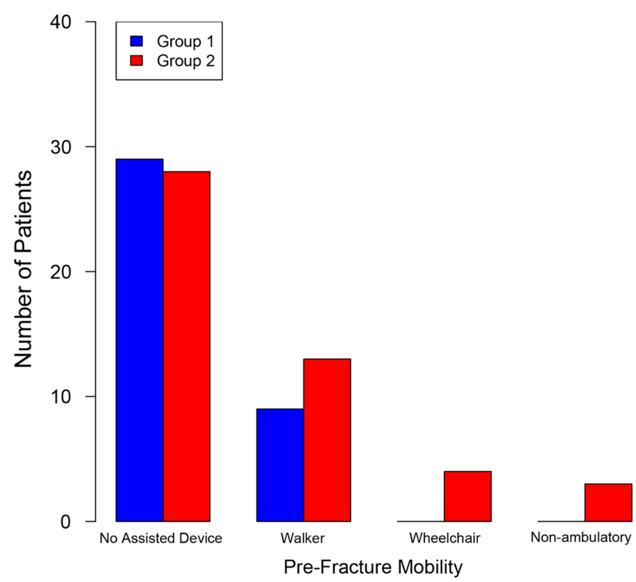

Fig. 1 Pre-fracture mobility status of patients in G1 and G2

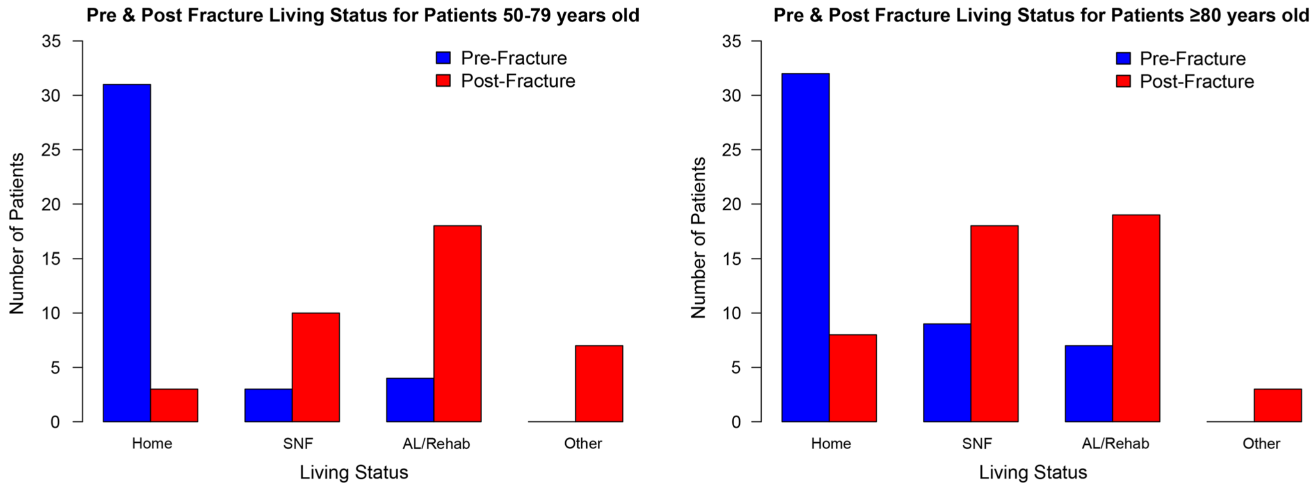

Fig. 2 Pre- and post-fracture living status for patients in G1 (*left*) and G2 (*right*)

Treatment

Our study showed that patients in the older cohort (G2) were less likely to undergo elective surgical treatment for their fracture, 21 % compared to 39 % of patients in G1 ($p = 0.06$). In the younger cohort, 15 patients received surgical treatment for their fracture. Seven patients had an ORIF for a distal radius fracture, and eight patients had an ORIF for a proximal humerus fracture. Ten patients in G2 received surgical treatment for their fragility fracture; 4 patients were treated with ORIF for a proximal humerus fracture, 5 with ORIF for a distal radius fracture and 1 patient was treated with a hemiarthroplasty for their proximal humerus fracture. Chi-square analysis results showed no relationship between increased co-morbidities and selection for surgical treatment (>1 Co-morbidity $p = 0.46$ and >2 co-morbidities $p = 0.96$). Specifically, smokers did not have an increased rate of surgical treatment based on Chi-square analysis ($p = 0.29$) even though there was an uneven distribution of smokers in the younger cohort.

Post-fracture complications

The complication rate was similar for both groups, with 9 % of patients in G2 (4/43) and 5.5 % percent (2/36) of patients in G1 having post-fracture complications ($p = 0.99$). There were 2 major complications in G1 (1 loss of reduction and 1 deep infection). The minor complications in G1 included 3 patients with continuous pain and 1 patient with a superficial infection. There were 2 major complications in G2 (1 deep infection and 1 loss of reduction) and 2 minor complications: 1 delayed union and 1 patient with painful implant.

Table 2 Cost analysis of upper extremity fragility fractures

	# tx	Std cost	Total cost
Group 1 (50–79)			
Non-sx	23	$2,428/day	$308,356
Hemi-arthroplasty	–	–	–
ORIF humerus	8	$29,523	$236,184
ORIF distal radius	7	$19,195	$134,365
Total cost G1			$678,905
Group 2 (80+)			
Non-sx	38	$2,428/day	$395,764
Hemi-arthroplasty	1	$27,876	$27,876
ORIF humerus	4	$29,523	$118,092
ORIF distal radius	5	$19,195	$95,975
Total cost G2			$637,707

Cost by age and procedure (%)

Cost

The average charge, based on per diem hospitalization charges, for non-operative treatment for patients in G1 was calculated to be $13,407 and $10,415 for G2. The average charges for surgically treating patients in G1 were $24,703 and $24,194 for patients in G2. The average cost for patients in G1 (combining both non-operative and operative treatment) was $17,866 compared with $13,286 per patient for G2 ($p = 0.02$) (Table 2).

Discussion

In an aging population, upper extremity fragility fractures will continue to be a common and significant problem, particularly in osteoporotic patients. Controversy persists on whether non-operative or operative treatment is indicated in older individuals. There have been many studies that have analyzed patient quality of life following a specified treatment option for a PHF and distal radius fracture [22–26]. Olerud et al. [25] described the increase in functional outcome and quality of life following surgical intervention compared to non-operative treatment for PHF. Overall, operative treatment had earlier return to function, increased independence, and improved patient satisfaction/quality of life. Non-operative treatment however, has been reported equally beneficial, as there have been many authors that have found no significant benefits for operative treatment especially in the elderly population. Non-surgical treatment has less initial costs per patient and good functional outcomes.

Our results demonstrated age as the primary driver in selection for surgical treatment regardless of increased number of co-morbidities. In addition in our population increased number of co-morbidities was not associated with increased age or longer LOS [23]. These results illustrate the significant burden of upper extremity fractures in terms of loss of independence, inpatient hospitalizations, and prolonged nursing home or rehabilitation needs, accounting for considerable health care costs. The significant increased cost during the acute period for surgically treated patients did not produce more benefits than the non-operative group in terms of returning them home or allowing them to live independently. Non-elderly patients had surgery more often than elderly patients, increasing the overall cost in that group without a significant difference in independence post operatively (at the time of discharge). Although, not statistically significant, there was a trend to increase surgical treatment in the younger patients compared to the older cohort. This could be attributed to a selection bias by surgeons for more aggressive treatment in younger patients, in addition young patients being lower surgical risk and more better candidates for surgery based on higher functional requirements and expectations. Neither age nor treatment type had a statistically significant effect on LOS or discharge locations in these patients.

While hip fractures represent the most dramatic consequence of osteoporosis, fractures of the humerus, forearm and wrist account for one-third of the total incidence of fractures and can be a significant burden to individuals and the community [23]. The impact of these upper extremity fragility fractures may be more than predicted, and significant in terms of healthcare resources, social impact and loss of independence. Our results showed that all ages have decreased independence following these upper extremity fractures and this loss of independence can have a greater impact on older patients. Furthermore, regardless of treatment option, upper extremity fracture patients have problems with mobility, personal care, and are unable to perform their usual activities [26]. More research needs to be done regarding optimizing who we select for surgical versus non-surgical management and how treatment selection impacts not only patient satisfaction and function but also socio-economic impact.

More resources need to be dedicated to prevention of fragility fractures. These prevention programs could have a significant impact on patient-related outcomes, as well as healthcare costs. With 34.9 % of our patients having a history of previous fracture, prevention efforts can reduce the amount of fragility fractures, and thus improve patient quality of life. More focus on prevention of these types of injuries especially in the setting of a fragility fracture as a point of intervention which could reduce post-operative and post-fracture rehabilitation expenses.

In summary our results illustrate the significant impact upper extremity fragility fractures with inpatient hospitalizations, loss of independence and long-term rehabilitation needs. Increased age was not correlated with increased co-morbidities or LOS but did affect treatment selection. The need for better prevention efforts with a first time fragility fracture could clearly decrease incidence of repeated fragility fractures for this population. There is a large need for increased awareness and more studies specific to treatment of these upper extremity fractures, to optimize patient outcomes, function and reduced rehabilitation or long-term healthcare needs. In addition, more studies that focused on optimal treatment as it related to costs and healthcare impact, as has been done for lower extremity hip fractures, could prove to be beneficial in reducing the burden on the healthcare system with recurrent fractures and costly surgeries.

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Conflict of interest The authors have no conflicts of interest related to this study work.

Appendix: Data collection tool

Patient ID #: ___

Demographics/History

1. Gender M F Age: _______ Menopause status Pre Post

2. Current WEIGHT? Pounds _______ Current HEIGHT? _______Feet /Inches

3. Race: □ Af.Am □ Am Indian/Alask. □Asian □ Cauc. □Hisp □ Indian(subcontinent)
□ Other _____________

4. Currently smoking cigarettes? ☐Yes ☐No Past smoker quit date:_____________

5. Drink 3 or more glasses of alcohol a day? ☐ Yes ☐ No

6. **Diagnosed osteoporosis □ Y □ N** Diagnosed osteopenia □ Y □ N
Diagnosis of Diabetis Mellitus □ Y □ N **Diagnosed Rheumatoid Arthritis □ Y □ N**
Diagnosis of Dementia □ Y □ N

7. Currently take oral steroids (Glucocorticoids) or took oral steroids longer than 3 months? □ Y □ N Length______

8. Current Fx location: _____________________ Mechanism of injury: __________________

9. History of Previous Fractures after 50y/o? □ Y □ N Location: ____________________

10. Family history of Fx or osteoporosis? □ Y □ N Parent had hip fx? _________

11. Pre fx ambulatory status □ walker □ wheelchair □ not mobile □ fully mobile

12. Pre fx living situation □home □SNF □family □assisted living

Hospitalization

13. Inpatient? □ Y □ N LOS: _______
Reason for admission: ________________________

14. Surgical Tx for fracture? □ Y □ N

15. Have any post-fx complication? □ Y □ N

If yes: Major complications: □ hardware failure □ deep infection
□ loss of reduction □ malunion
□ permanent neuropathy □ non-union

Minor complications: □ delayed union □ symptomatic hardware
□ superficial infections □ transient neuropathy
□ stiffness (dec ROM) □ continued pain

16. Readmission for fx related issue? □ Y □ N LOS: _________

17. Revision surgery? □ Y □ N Date: ____________

18. Patient expired? □ Y □ N

19. Discharge plan: □ SNF □ Asst. living □ Rehab □Home LOS: _________

Xrays

20. Initial injury xrays available? □Y □ N Date:_________________
Fracture classification: □ 2part □3part □4part □simple □comminuted
Details: ___________________________

21. Post op xrays? □Y □ N Date:_________________

Pre Fx osteoporosis medications

☐ Vitamin D ______Length of Tx
☐ Calcium ______Length of Tx
☐ Bisphos ______Length of Tx
Circle: Fosamax Didronel Boniva Aredia Actonal Reclast Forteo
Other: ________________

Post-Fx osteoporosis medications

☐ Vitamin D Date started: ______ Length of Tx: ______
☐ Calcium Date started: ______ Length of Tx: ______
☐ Bisphos Date started: ______ Length of Tx: ______
Circle: Fosamax Didronel Boniva Aredia Actonal Reclast Forteo
Other: ________________

DEXA

Date: ___________ Scores: **FemNeck**_____ Hip ______ Spine ______

Date: ___________ Scores: FemNeck_____ Hip ______ Spine ______

Date: ___________ Scores: FemNeck_____ Hip ______ Spine ______

FRAX calculation: __________

References

1. National Osteoporosis Foundation Research Agenda. Available at: http://nof.org/hcp/research/research-agendaAccessed 17 Sep 2013
2. American Orthopaedic Association—Own the Bone (2011) Osteoporosis epidemic. Retrieved 17 Sept 2013 from http://www.ownthebone.org/about-own-the-bone/osteoporosis-epidemic.aspx
3. Chrischilles E, Shireman T, Wallace R (1994) Costs and health effects of osteoporotic fractures. Bone 15(4):377–386
4. Hoerger TJ, Downs KE, Lakshmanan MC et al (1999) Healthcare use among US women aged 45 and older: total costs and costs for selected postmenopausal health risks. J Womens Health Gend Based Med 8(8):1077–1089
5. Holbrook TL, Grazier KL, AAOS (1984) The frequency of occurrence, impact, and cost of selected musculoskeletal conditions in the United States. American Academy of Orthopaedic Surgeons, Chicago, IL
6. Phillips S, Fox N, Jacobs J, Wright WE (1988) The direct medical costs of osteoporosis for American women aged 45 and older, 1986. Bone 9(5):271–279
7. Ray NF, Chan JK, Thamer M, Melton LJ (1997) Medical expenditures for the treatment of osteoporotic fractures in the United States in 1995: report from the National Osteoporosis Foundation. J Bone Miner Res 12(1):24–35
8. Launonen AP, Lepola V, Flinkkilä T et al (2012) Conservative treatment, plate fixation, or prosthesis for proximal humeral fracture. A prospective randomized study. BMC Musculoskelet Disord 13:167
9. Calvo E, de Miguel I, de la Cruz JJ, López-Martín N (2007) Percutaneous fixation of displaced proximal humeral fractures: indications based on the correlation between clinical and radiographic results. J Shoulder Elbow Surg 16(6):774–781
10. Südkamp N, Bayer J, Hepp P et al (2009) Open reduction and internal fixation of proximal humeral fractures with use of the locking proximal humerus plate. Results of a prospective, multicenter, observational study. J Bone Jt Surg Am 91(6):1320–1328
11. Thanasas C, Kontakis G, Angoules A, Limb D, Giannoudis P (2009) Treatment of proximal humerus fractures with locking plates: a systematic review. J Shoulder Elbow Surg 18(6):837–844
12. Svedbom A, Ivergård M, Hernlund E, Rizzoli R, Kanis JA (2014) Epidemiology and economic burden of osteoporosis in Switzerland. Arch Osteoporos 9:187
13. Hernlund E, Svedbom A, Ivergård M et al (2013) Osteoporosis in the European Union: medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). Arch Osteoporos 8(1–2):136
14. Bleibler F, Rapp K, Jaensch A, Becker C, König HH (2014) Expected lifetime numbers and costs of fractures in postmenopausal women with and without osteoporosis in Germany: a discrete event simulation model. BMC Health Serv Res 14:284
15. Lee SH, Dargent-Molina P, Bréart G (2002) Study EGEdlO. Risk factors for fractures of the proximal humerus: results from the EPIDOS prospective study. J Bone Miner Res 17(5):817–825
16. Nguyen TV, Center JR, Sambrook PN, Eisman JA (2001) Risk factors for proximal humerus, forearm, and wrist fractures in elderly men and women: the Dubbo Osteoporosis Epidemiology Study. Am J Epidemiol 153(6):587–595
17. Seeley DG, Browner WS, Nevitt MC, Genant HK, Scott JC, Cummings SR (1991) Which fractures are associated with low appendicular bone mass in elderly women? The Study of Osteoporotic Fractures Research Group. Ann Intern Med 115(11):837–842
18. Johnell O, Kanis J (2005) Epidemiology of osteoporotic fractures. Osteoporos Int 16(Suppl 2):S3–S7
19. Johnell O, Kanis JA, Odén A et al (2004) Mortality after osteoporotic fractures. Osteoporos Int 15(1):38–42
20. Kanis JA, Oden A, Johnell O, De Laet C, Jonsson B, Oglesby AK (2003) The components of excess mortality after hip fracture. Bone 32(5):468–473
21. Sernbo I, Johnell O (1993) Consequences of a hip fracture: a prospective study over 1 year. Osteoporos Int 3(3):148–153

22. Court-Brown CM, McQueen MM (2004) The impacted varus (A2.2) proximal humeral fracture: prediction of outcome and results of nonoperative treatment in 99 patients. Acta Orthop Scand 75(6):736–740
23. Fjalestad T, Hole M, Jørgensen JJ, Strømsøe K, Kristiansen IS (2010) Health and cost consequences of surgical versus conservative treatment for a comminuted proximal humeral fracture in elderly patients. Injury 41(6):599–605
24. Grönhagen CM, Abbaszadegan H, Révay SA, Adolphson PY (2007) Medium-term results after primary hemiarthroplasty for comminute proximal humerus fractures: a study of 46 patients followed up for an average of 4.4 years. J Shoulder Elbow Surg 16(6):766–773
25. Olerud P, Ahrengart L, Söderqvist A, Saving J, Tidermark J (2010) Quality of life and functional outcome after a 2-part proximal humeral fracture: a prospective cohort study on 50 patients treated with a locking plate. J Shoulder Elbow Surg 19(6):814–822
26. Sanders RJ, Thissen LG, Teepen JC, van Kampen A, Jaarsma RL (2011) Locking plate versus nonsurgical treatment for proximal humeral fractures: better midterm outcome with nonsurgical treatment. J Shoulder Elbow Surg 20(7):1118–1124