MUSCULOSKELETAL SURGERY (2021) 105:167–172
https://doi.org/10.1007/s12306-020-00642-2

ORIGINAL ARTICLE

Proximal humeral fracture in patients with high Charlson comorbidity index: mortality rate according to treatment choice

Ana Belén Fernández-Cortiñas[1,2] · Jesús Vidal Campos[3] · Fernando Marco Martínez[1,4]

Received: 22 October 2019 / Accepted: 23 January 2020 / Published online: 1 February 2020

Abstract

Background The purpose of this study was to evaluate the relevance of a commonly used morbidity prognostic tool, the Charlson comorbidity index (CCI), in determining the survival rate of patients with isolated proximal humeral fractures (PHFs) and to determine the impact of surgical treatment according to previous comorbidities (measured with CCI).

Materials and methods All patients who were treated for a single PHF in our institution for 29 consecutive months were included in this retrospective study, with a minimum follow-up of 24 months (mean 52.8 months). Two groups were established according to the type of treatment received (surgical versus non-surgical). Preinjury comorbidities were identified, and the age-adapted CCI was calculated. All complications and mortality rates were prospectively recorded over the complete follow-up period.

Results Patients with elevated preinjury comorbidities (CCI > 5) demonstrated a significant increase in mortality (HR = 4.64) compared to those with CCI ≤ 5. In addition, patients with high comorbidities (CCI > 5) who underwent surgical treatment demonstrated a statistically significant increase in mortality (HR = 6.92) compared to patients with similarly high comorbidities (CCI > 5) who underwent non-surgical treatment.

Conclusions Patients with high preinjury comorbidities (CCI > 5) experienced an increased mortality risk if they underwent surgical treatment for isolated PHFs. The use of a morbidity prognostic tool, such as the CCI, can help predict the outcome (particularly mortality) in these patients and may aid in making decisions in terms of operative versus non-operative treatment to minimize patient mortality.

Level of evidence Level III; Retrospective Comparative Study; Treatment Study.

Keywords Proximal humeral fracture · Comorbidity · Charlson comorbidity index · Mortality · Surgical treatment

Introduction

Proximal humeral fractures (PHFs) are the third most common fracture type in patients older than 65 years, behind only the proximal femur and distal radius [1–3].

Many papers have studied how comorbidities influence the final state of health in patients suffering from hip and pelvic fractures and how the choice of treatment influences the development of adverse effects and mortality [4]. Therefore, in hip and pelvic fractures, there is high homogeneity in treatment choice (surgical versus non-surgical) and little variability in the type of surgical technique that is performed. Although PHFs are often due to fragility, the situation is completely different because there is no consensus on which determining factors should be considered when choosing the treatment (surgical versus non-surgical) [5]. Therefore,

✉ Ana Belén Fernández-Cortiñas
anabelen6k@gmail.com

1 Complutense University of Madrid, Madrid, Spain

2 Department of Orthopaedic Surgery, Cosaga Hospital, Complexo Hospitalario Universitario de Ourense, Ourense, Spain

3 Department of Orthopaedic Surgery, El Carmen Hospital, Complexo Hospitalario Universitario de Ourense, Ourense, Spain

4 Shoulder and Elbow Unit, Department of Traumatology and Orthopaedic Surgery, Clínico San Carlos Hospital, Complutense University, Madrid, Spain

PHF treatment continues to be the subject of investigation and controversy.

In the last few years, the incidence of PHFs has increased, and the rate of surgical treatment has increased, which has led to an increase in postoperative complications and a higher rate of re-operation [6–8]. This trend has been enhanced by the widespread use of locking plates and the success of total reversed arthroplasty in elderly patients [9, 10]. There is a marked regional variation in the rates of surgical treatment, which highlights the need for a consensus regarding optimal treatment of PHF [11].

Many fractures in the proximal humerus are osteoporotic and mostly affect elderly patients, who usually have higher comorbidities. Several publications show that osteoporotic fractures increase mortality, with the exception of distal radius fractures [12]. Fracture in osteoporotic patients imparts a stress that could precipitate this outcome. Additionally, the surgical procedure, which also involves a greater risk, may increase mortality and complications according to the patient's previous comorbidities.

Several comorbidity indices have been described in the literature to assess how chronic diseases influence mortality. Among them, the Charlson comorbidity index (CCI) [13] is one of the most commonly used [4, 14, 15]. The CCI is a predictive method for mortality that takes into account 19 comorbid conditions, in which each condition receives a score of 1–6 based on an adjusted risk of mortality associated with each comorbidity (Table 1). The higher the CCI is, the more likely it is that the result is predictive of a patient's mortality. This study aims to evaluate the relevance of a commonly used morbidity prognostic tool, the CCI, in determining the survival rate of patients with isolated PHFs and the impact of surgical treatment according to the previous comorbidities in those patients.

Table 1 Charlson comorbidity index: the total score is obtained by adding the relative weight of each comorbidity [13]

	Relative weight assignment
Diabetes	1
Mild liver disease	1
Ulcer disease	1
Connective tissue disease	1
Chronic pulmonary disease	1
Dementia	1
Cerebrovascular disease	1
Peripheral vascular disease	1
Congestive heart failure	1
Myocardial infarct	1
Leukaemia	2
Lymphoma	2
Neoplasia (any tumour)	2
Diabetes with end organ damage	2
Moderate to severe renal failure	2
Hemiplegia	2
Moderate to severe liver disease	3
AIDS	6
Metastatic solid tumour	6

Materials and methods

A retrospective study was conducted with the prospectively collected data considering all patients who were treated for an isolated fracture between January 1, 2013, and December 31, 2016, in our institution. Our hospital is the reference hospital for trauma patients in the region, with a population of almost 315,000 habitants.

Inclusion criteria Patients aged 18 years and older who were seen in our emergency department with an acute and isolated PHF were treated and who had a minimum follow-up of 24 months in our hospital were candidates for inclusion.

Exclusion criteria Patients who had a concomitant fracture, underage patients, pregnant women, polytrauma patients and those who did not have follow-up at our hospital were excluded from the study.

All patients received surgical or conservative treatment in accordance with the decision made based on the protocol and criteria adopted by the shoulder unit. Surgical treatment was indicated when fractures were displaced by more than 50% or when the difference between the normal physiological head–shaft angle of 130° and the fracture angle varied by more than 20°–45°. All patients who underwent surgery were admitted to the hospital and were operated on under general anaesthesia and regional block. This treatment included open reduction and internal fixation (ORIF) with an osteosuture, a locking plate or an intramedullary locking nail and shoulder arthroplasty (hemiarthroplasty and reverse total shoulder arthroplasty [RTSA]). Non-surgical treatment consisted of sling immobilization for 3 weeks and a progressive physiotherapy programme, with most of these patients treated as outpatients. Both groups (surgical and conservative) were followed by a rehabilitation treatment programme.

Prefracture comorbidities that were collected included diabetes, cardiopathy, neurologic disease, neoplasia, dementia, and history of alcohol and/or drug abuse, and age-adapted CCI values were calculated. We also included sex, affected side, anteroposterior and axial radiographs, laboratory analysis and medical evaluations.

Mortality rate and all complications (systemic and local complications) were recorded. During follow-up, mortality and complications were documented in a digitized history that registers all health events that occur in any hospital or primary care centre in our region.

PHFs were rated according to the Neer classification [16]. A single researcher was in charge of classifying the fractures, determining CCI scores and data collection and analysis. This researcher did not participate in therapeutic decision-making or in clinical follow-up.

A descriptive analysis was performed in which the qualitative variables were expressed as frequencies and percentages, and the continuous variables were expressed as the means ± standard deviations. Parametric or nonparametric tests were performed to determine the potential associations among the variables of the study (Chi-square test, Fisher's exact test and Student's *t* test). Global and specific survival studies were performed and are expressed as hazard ratios (HRs) and 95% confidence intervals (CIs). Finally, Cox regression models were executed. We considered statistically significant differences as those with $p < 0.05$, and all analyses were performed using SPSS 22.0.

Results

A total of 354 patients met the inclusion criteria. The mean age was 71.4 (± 14.8) years, and most of the patients were female (279, 78.8%). One hundred eighty-one patients (51.1%) had fractures of the left shoulder. A total of 232 (65.5%) patients had a fracture in 3 or more fragments, with 37 fractures (10.5%) associated with dislocation. Surgical treatment was performed on 114 patients (32.2%), 81 of them with ORIF (48 locking plates, 24 intramedullary locking nails and 9 osteosutures) and 33 of them with shoulder arthroplasty (2 hemiarthroplasty and 31 reverse total shoulder arthroplasty).

The most frequent comorbidities were heart disease in 82 patients (23.2%), diabetes mellitus in 63 (17.8%), a history of neoplasia in 52 (14.7%) and a history of neurologic disease in 47 (13.3%), of whom 39 (11%) had dementia. In addition, 22 patients (6.2%) were chronic alcoholics, 2 of them also had a history of drug addiction.

Comparing the baseline characteristics of patients at the beginning, the non-surgical group was older and had more comorbidities (heart disease and dementia). In addition, the CCI score was significantly higher ($p = 0.030$) in the non-surgical group (Table 2).

The mean follow-up was 4.4 years (95% CI [4.3–4.5]).

Compared to 10% of those in the non-surgical group, 35 patients in the surgical group (30.7%) developed complications that required hospital readmission ($p < 0.001$). Mortality was also higher in the surgical group (14%, mean survival time 4.3 years, 95% CI [4.1–4.6], compared to 10% in the non-surgical group (median survival time: 4.5 years, 95% CI [4.3–4.6], $p = 0.262$)).

Patients with CCI > 5 had a greater mortality risk (HR = 4.6, 95% CI [2.4–9.0]) than patients with CCI ≤ 5; the risk was even higher if the high-CCI patients also belonged to the surgical group (HR = 6.9, 95% CI [2.5–19.1], $p < 0.001$) compared to those in the non-surgical group (HR = 4.1, 95% CI [1.7–9.9], $p = 0.002$) (Fig. 1). That is, patients with high comorbidities before the injury (CCI > 5) experienced an increase in mortality rate if they underwent surgical treatment.

Discussion

Several papers have shown that surgical treatment has good functional results, but also a percentage of complications, both local and systemic, which, according to the literature,

Table 2 Descriptive analysis at the beginning of the study according to the study group

Variable	Global N = 354	Non-surgical N = 240	Surgical N = 114	*p* value
Sex (female)	279 (78.8%)	189 (78.8%)	90 (78.9%)	0.966
Age	71.4 (± 14.8)	73.4 (± 14.8)	67.1 (± 13.8)	< 0.001^{+}
Laterality (left)	181 (51.1%)	125 (52.1%)	56 (49.1%)	0.603
Alcoholism	22 (6.2%)	10 (4.2%)	12 (10.5%)	0.021
Diabetes mellitus	63 (17.8%)	43 (17.9%)	20 (17.5%)	0.932
Dementia	39 (11.0%)	36 (15.0%)	3 (2.6%)	< 0.001*
Neoplasia	52 (14.7%)	40 (16.7%)	12 (10.5%)	0.127
Neurologic disease	47 (13.3%)	35 (14.6%)	12 (10.5%)	0.293
Heart disease	82 (23.2%)	63 (26.3%)	19 (16.7%)	0.046
CCI	4.4 (± 2.6)	4.62 (± 2.5)	3.9 (± 2.8)	0.030^{+}
CCI > 5	117 (33.1%)	93 (38.8%)	24 (21.1%)	0.001
Haemoglobin	13.1 (± 1.5)	13.3 (± 1.5)	13.5 (± 1.4)	0.363^{+}

p value: Chi-square test. *Fisher's exact test + Student's *t* test for independent samples

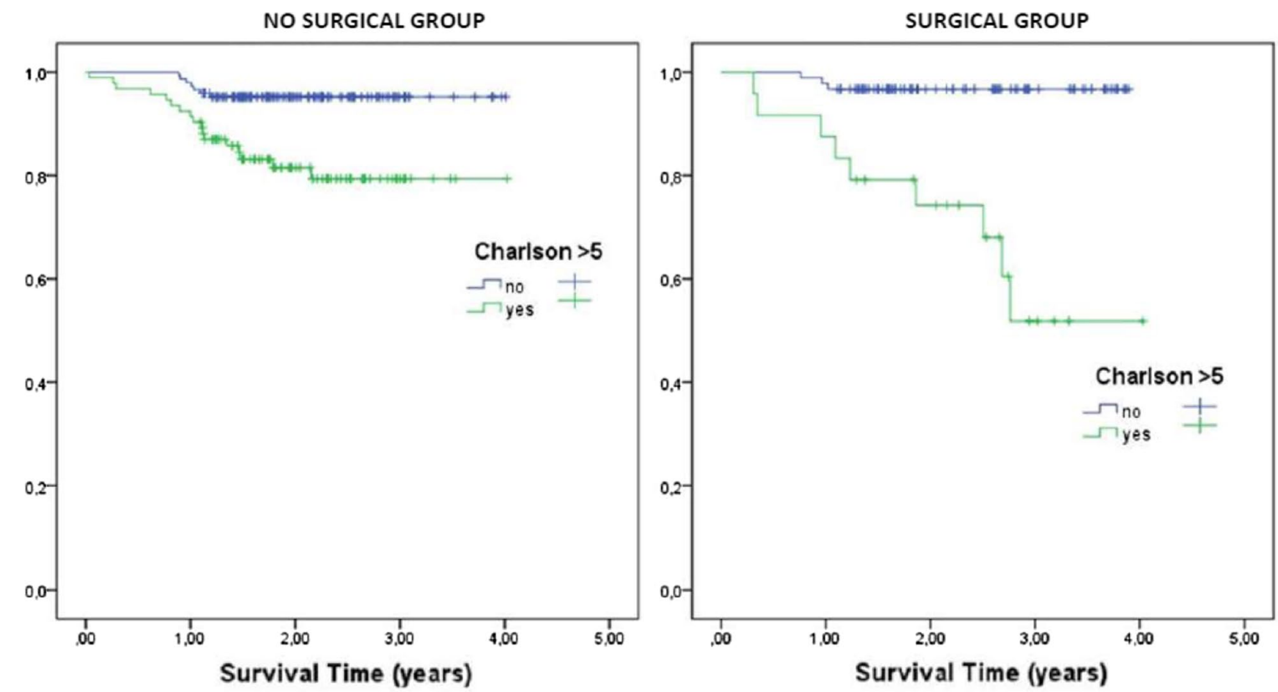

Fig. 1 Kaplan-Meier plot of survival as a function of the two strata of the Charlson Comorbiduty Index, ≤ 5 and > 5, and the treatment choice (surgical versus non-surgical)

varies from 20% to close to 40% [10, 17]. However, other studies question whether surgical treatment obtains better functional results. The latest Cochrane review [18] states that there is high- or moderate-quality evidence suggesting that, compared with non-surgical treatment, surgery does not result in a better outcome at one and 2 years after injury and is likely to result in a greater need for subsequent surgery. The PROFHER trial [19] concluded that there are no differences in the functional results or in patient-related outcome measures between surgical and conservative treatments. A paper by Roberson et al. [20] compares the results of patients treated conservatively and those who underwent operation with reversed arthroplasty, concluding that there were no differences and questioning surgical indication. These authors consider that the functional benefit achieved by operative treatment is at least in doubt; therefore, the risk of the surgical procedure itself should be analysed.

In recent decades, a large number of publications on PHFs have studied and defined the different fracture patterns [21, 22] and functional results of the different surgical techniques and implants. These investigations have been very important, and their conclusions are very valuable for orthopaedic surgery to establish the current criteria of treatment for PHF. Different fixation methods, such as plates versus nails, and two types of arthroplasties, such as partial versus total reversed arthroplasty, have also been compared with conservative treatment [23, 24]. In these studies, treatment choice is monopolized by the type of fracture, and in some cases, age is also taken into account, but a patient's previous comorbidities are not taken into account. However, only a few authors have investigated how patients' prior comorbidities and treatment choice influence the rate of complications and mortality and what tools we could use to better treat patients according to their comorbidities and thus prevent aggressive treatment, which can further weaken the patient and may have fatal consequences.

Neuhaus et al. [25] show that operative treatment (ORIF in particular) is an independent risk factor for inpatient adverse events and mortality in older-aged patients admitted to the hospital with an isolated fracture of the proximal humerus and affirm that surgical treatment should perhaps be offered more cautiously.

Other studies have assessed complications and mortality in patients undergoing shoulder arthroplasty, showing that complications, functional results and mortality rates are worse in patients who undergo surgery (hemiarthroplasty or RTSA) for fracture compared to those who undergo primary shoulder replacement [26, 27].

Some systematic reviews of randomized controlled trials suggest no difference in outcomes between non-operative treatment and ORIF in older patients with 3- and 4-part fractures [28, 29].

In our study, patients who had a high comorbidity level prior to fracture, as measured by CCI (CCI > 5), also had a higher mortality risk and systemic complications, regardless of the treatment performed (conservative or surgical), according to the literature. The association of CCI with mortality after trauma agrees with prior studies in which higher in-hospital mortality was found in patients with higher CCI scores [14, 25]. However, the most important finding in our study was that if these patients with high comorbidity were also operated on, the mortality risk was much higher (HR = 6.9) than that for patients with the same comorbidity index who received conservative treatment (HR = 4.1).

This finding suggests that surgical treatment itself increases mortality and systemic complications in patients who, prior to fracture, had high comorbidity (CCI > 5). Therefore, we conclude that comorbidity should be taken into account and quantified in the same way that we classify fractures according to their pattern and assign a number based on comorbidity that corresponds to severity to help us in therapeutic decisions. In this way, we could include the degree of comorbidity of the patient as one more item to be taken into account when deciding whether the patient should be treated surgically or conservatively to avoid deaths due to aggressive treatment in patients with high comorbidity.

Our study included 239 patients, with a minimum follow-up of 24 months. The main strength is that the follow-up of every patient was exhaustive because any adverse health event suffered by the patient was recorded in a single, digitized medical history, regardless of the medical specialty of the staff recording the event, the hospital or primary care centre or the city in which a patient was treated. This level of recordkeeping has been possible because 100% of our reference population enjoys complete health coverage.

Other papers on this topic have a large sample size, but the data for each patient and the follow-up are very scarce in general, with most of these data being collected from state registries of admitted patients, so patients who are treated conservatively and in an outpatient setting are not taken into account, while they are the majority (up to 80% of PHFs), and the adverse effects and mortality of patients are not recorded once discharged [25, 30].

In our study, we considered this population of conservatively treated patients, and the medical follow-up of outpatients and admitted patients was equally exhaustive.

This study has limitations that must be considered. It is retrospective in design and has a limited sample size.

Conclusions

Comorbidities should be considered in the management of patients with PHFs.

Patients with high preinjury comorbidities (CCI > 5) experienced an increased mortality rate if they underwent surgical treatment for an isolated PHF.

The use of a morbidity prognostic tool such as the CCI can help us predict the outcome (particularly mortality) in patients suffering from an isolated PHF and may aid in making decisions in terms of surgical versus non-surgical treatment to minimize patient mortality.

Funding The authors, their immediate families and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

Compliance with ethical standards

Conflict of interest Ana-Belen Fernandez-Cortiñas, Jesus Vidal Campos and Fernando Marco Martinez confirm that neither they nor any member of their immediate family have received any financial payments or other benefits from any commercial entity related to the subject of this article. No outside funding or grants were used to assist with this study.

Ethical approval This study was conducted in accordance with Good Clinical Practice guidelines and the Declaration of Helsinki. Written consent was obtained from every patient.

Ethical statement This study has been carried out in accordance with national and European legislation on clinical research, following international ethical recommendations, the Declaration of Helsinki and the Council of Europe with regard to the Convention on Human Rights and Biomedicine. The study has complied at all times with the requirements established in the Spanish legislation in the field of biomedical research, personal data protection and bioethics. This study was approved by the Ethical Committee of Reference (Autonomous committee of research ethics in Galicia. No 2016/125).

References

1. Court-Brown CM, Garg A, McQueen MM (2001) The epidemiology of proximal humeral fractures. Acta Orthop Scand 72:365–371
2. Karl JW, Olson PR, Rosenwasser MP (2015) The epidemiology of upper extremity fractures in the United States, 2009. J Orthop Trauma 29:e242–e244
3. Launonen AP, Lepola V, Saranko A, Flinkkila T, Laitinen M, Mattila VM (2015) Epidemiology of proximal humerus fractures. Arch Osteoporos 10:209
4. Reyes C, Estrada P, Nogues X, Orozco P, Cooper C, Diez-Perez A, Formiga F, Gonzalez-Macias J, Prieto-Alhambra D (2014) The impact of common co-morbidities (as measured using the Charlson index) on hip fracture risk in elderly men: a population-based cohort study. Osteoporos Int 25:1751–1758
5. LaMartina J, Christmas KN, Simon P, Streit JJ, Allert JW, Clark J, Otto RJ, Abdelfattah A, Mighell MA, Frankle MA (2018) Difficulty in decision making in the treatment of displaced proximal humerus fractures: the effect of uncertainty on surgical outcomes. J Shoulder Elbow Surg 27:470–477
6. Hasty EK, Jernigan EW 3rd, Soo A, Varkey DT, Kamath GV (2017) Trends in surgical management and costs for operative treatment of proximal humerus fractures in the elderly. Orthopedics 40:e641–e647
7. Khatib O, Onyekwelu I, Zuckerman JD (2014) The incidence of proximal humeral fractures in New York state from 1990 through

2010 with an emphasis on operative management in patients aged 65 years or older. J Shoulder Elbow Surg 23:1356–1362
8. Maravic M, Briot K, Roux C, Maravic M, Briot K, Roux C, Collège Français des Médecins Rhumatologues (CFMR) (2014) Burden of proximal humerus fractures in the French National Hospital Database. Orthop Traumatol Surg Res 100(8):931–934
9. Anakwenze OA, Zoller S, Ahmad CS, Levine WN (2014) Reverse shoulder arthroplasty for acute proximal humerus fractures: a systematic review. J Shoulder Elbow Surg 23:e73–e80
10. Jost B, Spross C, Grehn H, Gerber C (2013) Locking plate fixation of fractures of the proximal humerus: analysis of complications, revision strategies and outcome. J Shoulder Elbow Surg 22:542–549
11. Bell JE, Leung BC, Spratt KF, Koval KJ, Weinstein JD, Goodman DC, Tosteson AN (2011) Trends and variation in incidence, surgical treatment, and repeat surgery of proximal humeral fractures in the elderly. J Bone Joint Surg Am 93:121–131
12. Johnell O, Kanis JA, Oden A, Sernbo I, Redlund-Johnell I, Petterson C, De Laet C, Jonsson B (2004) Mortality after osteoporotic fractures. Osteoporos Int 15:38–42
13. Charlson ME, Pompei P, Ales KL, MacKenzie CR (1987) A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 40:373–383
14. Voskuijl T, Hageman M, Ring D (2014) Higher Charlson comorbidity index scores are associated with readmission after orthopaedic surgery. Clin Orthop Relat Res 472:1638–1644
15. Fernandez-Cortiñas AB, Vidal CJ, Paredes-Carnero X, Marco F (2019) Is the Charlson comorbidity index a good predictor of mortality and adverse effects in proximal humerus fractures? Orthop Traumatol Surg Res 105(2):301–305
16. Neer CS (2006) Displaced proximal humeral fractures: part I. Classification and evaluation. 1970. Clin Orthop Relat Res 442:77–82
17. Clavert P, Adam P, Bevort A, Bonnomet F, Kempf JF (2010) Pitfalls and complications with locking plate for proximal humerus fracture. J Shoulder Elbow Surg 19:489–494
18. Handoll HH, Brorson S (2015) Interventions for treating proximal humeral fractures in adults. Cochrane Database Syst Rev CD000434
19. Rangan A, Handoll H, Brealey S, Jefferson L, Keding A, Martin BC, Goodchild L, Chuang LH, Hewitt C, Torgerson (2015) Surgical vs nonsurgical treatment of adults with displaced fractures of the proximal humerus: the PROFHER randomized clinical trial. JAMA 313:1037–1047
20. Roberson TA, Granade CM, Hunt Q, Griscom JT, Adams KJ, Momaya AM, Kwapisz A, Kissenberth MJ, Tolan SJ, Hawkins RJ, Tokish JM (2017) Nonoperative management versus reverse shoulder arthroplasty for treatment of 3- and 4-part proximal humeral fractures in older adults. J Shoulder Elbow Surg 26:1017–1022
21. Court-Brown CM, Cattermole H, McQueen MM (2002) Impacted valgus fractures (B1.1) of the proximal humerus. The results of non-operative treatment. J Bone Joint Surg Br 84:504–508
22. Foruria AM, de Gracia MM, Larson DR, Munuera L, Sanchez-Sotelo J (2011) The pattern of the fracture and displacement of the fragments predict the outcome in proximal humeral fractures. J Bone Joint Surg Br 93:378–386
23. Olerud P, Ahrengart L, Ponzer S, Saving J, Tidermark (2011) Hemiarthroplasty versus nonoperative treatment of displaced 4-part proximal humeral fractures in elderly patients: a randomized controlled trial. J Shoulder Elbow Surg 20:1025–1033
24. Shukla DR, McAnany S, Kim J, Overley S, Parsons BO (2016) Hemiarthroplasty versus reverse shoulder arthroplasty for treatment of proximal humeral fractures: a meta-analysis. J Shoulder Elbow Surg 25:330–340
25. Neuhaus V, Bot AG, Swellengrebel CH, Jain NB, Warner JJ, Ring DC (2014) Treatment choice affects inpatient adverse events and mortality in older aged inpatients with an isolated fracture of the proximal humerus. J Shoulder Elbow Surg 23:800–806
26. Amundsen A, Rasmussen JV, Olsen BS, Brorson S (2016) Mortality after shoulder arthroplasty: 30-day, 90-day, and 1-year mortality after shoulder replacement–5853 primary operations reported to the Danish Shoulder Arthroplasty Registry. J Shoulder Elbow Surg 25:756–762
27. Inacio MC, Dillon MT, Miric A, Anthony F, Navarro RA, Paxton EW (2014) Mortality after shoulder arthroplasty. J Arthroplasty 29:1823–1826
28. Beks RB, Ochen Y, Frima H, Smeeing DPJ, van der Meijden O, Timmers TK, van der Velde D, van Heijl M, Leenen LPH, Groenwold RHH, Houwert RM (2018) Operative versus nonoperative treatment of proximal humeral fractures: a systematic review, meta-analysis, and comparison of observational studies and randomized controlled trials. J Shoulder Elbow Surg 27:1526–1534
29. Launonen AP, Lepola V, Flinkkila T, Laitinen M, Paavola M, Malmivaara A (2015) Treatment of proximal humerus fractures in the elderly: a systemic review of 409 patients. Acta Orthop 86:280–285
30. Neuhaus V, Swellengrebel CH, Bossen JK, Ring D (2013) What are the factors influencing outcome among patients admitted to a hospital with a proximal humeral fracture? Clin Orthop Relat Res 471:1698–1706