Injury, Int. J. Care Injured 50 (2019) 1324–1328

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Weight bearing in patients with femoral neck fractures compared to pertrochanteric fractures: A postoperative gait analysis

Daniel Pfeufer[a,b], Chiara Grabmann[b], Stefan Mehaffey[b], Alexander Keppler[b], Wolfgang Böcker[b], Christian Kammerlander[b,*], Carl Neuerburg[b]

[a] University of Utah, Department of Orthopaedics, 590 Wakara Way, 84108, Salt Lake City, Utah, United States
[b] Munich University Hospital LMU, Department of General, Trauma and Reconstructive Surgery, Marchioninistraße 15, 81337, Munich, Germany

ARTICLE INFO

Article history:
Accepted 17 May 2019

Keywords:
Hip fracture
Mobility
Hip replacement
Fracture fixation
Gait analysis
Orthogeriatrics

ABSTRACT

Early mobilization following hip fracture surgery is of superior importance especially in elderly hip fracture patients. Reduced mobilization can result in complications and increased mortality. In this study a gait analysis was performed using force-measuring insoles. We hypothesized, that patients with femoral neck fractures treated with hip replacement surgery load the affected limb more compared to patients with pertrochanteric fractures treated with fracture fixation.

All patients (> 65 years) treated for a femoral neck fracture with hip replacement or a pertrochanteric fracture, respectively using fracture fixation with intramedullary nailing, were consecutively included in this study. For gait analysis, specific insole forcesensors (Loadsol®) were inserted into the footwear. Five days after surgery gait analysis was performed with a defined walking distance and all patients were instructed to transpose full weight.

20 patients following hip replacement surgery and 27 patients following intramedullary nailing were included. The hip replacement group loaded the affected limb with an average of 74.01% (SD 13.6) of bodyweight, while the fracture fixation group loaded a significantly reduced average of 62.70% (SD 8.3; p = 0.002).

The results of the present study indicate that patients suffering from pertrochanteric fractures following fracture fixation are struggling to fully load the affected leg compared to patients suffering from femoral neck fractures treated with hip replacement surgery. The focus of further studies should concentrate on alternative analgesia and verify the cause of the observed difference in order to facilitate early full weight bearing especially in hip fracture patients following fracture fixation. The results indicate that in elderly patients, the fracture pattern and thus the surgical approach lead to a different weight bearing pattern. The primary therapeutic goal for elderly patients must be early mobilization at full weight bearing.

© 2019 Elsevier Ltd. All rights reserved.

Introduction

Elderly hip fracture patients with reduced activity benefit from early mobilization as weight bearing restrictions can cause irreversible immobilization [1]. The worldwide burden of an ageing population is associated with an increase in the total number of hip fracture patients from 1.7 million per year in 1990 towards 6.3 million per year in 2050 and an increase of the socio-economic costs [2]. On the other side, one-year mortality in elderly hip fracture patients is still as high as 30% and the limited mobility is linked with severe reductions in quality of life and reduced functional long term results [3]. Therefore, the goal of treatment for these patients is the preservation of function, independence and activities of daily living.

Immobilization triggers postoperative complications like pneumonia, urinary tract infections, pressure ulcers and venous thromboembolism [1,4]. Prolonged bedrest in hip fracture patients is associated with poor function after two months and decreased survival at six months [5]. Consequently, the inability to stand up, sit down or walk within two weeks after surgery is known to be a significant indicator of mortality in patients undergoing hip fracture surgery [6]. Comparative analysis of periprosthetic femur fracture patients showed that those treated with hip replacement surgery and immediate full weight bearing postoperatively had significant decreased total mortality compared to patients

* Corresponding author.
E-mail address: Christian.Kammerlander@med.uni-muenchen.de (C. Kammerlander).

https://doi.org/10.1016/j.injury.2019.05.008
0020-1383/© 2019 Elsevier Ltd. All rights reserved.

Downloaded for Anonymous User (n/a) at Northwestern University from ClinicalKey.com by Elsevier on August 19, 2020.
For personal use only. No other uses without permission. Copyright ©2020. Elsevier Inc. All rights reserved.

undergoing fracture fixation with subsequent weight bearing restrictions [7]. Sale et al. showed that pain and fracture related-limitations persist up to 6 month in fragility fractures [8]. Long-term pain which affected mobility, functional activity and independence was described by Gheorghita et al. [9].

In the present study we therefore questioned if hip fracture patients undergoing fracture fixation might have a different weight bearing pattern compared to patients undergoing hip replacement surgery. Micro movements within the fracture zone are likely to cause increased pain, different biomechanical forces [10] and a different surgical approach could be associated with a prolonged rehabilitation process and affect transposition of weight on the affected leg. In this comparative study we therefore hypothesized that hip fracture patients treated with fracture fixation surgery transpose less weight on the affected leg compared to patients treated with hip replacement surgery.

Materials and methods

Study design and participants

Prospective cohort study, Level of Evidence 2

All patients meeting the inclusion criteria (age >65 years presenting with a hip fracture of either the femoral neck or the trochanteric area) were enrolled in the study between October 2017 and April 2018 and performed the gait analysis consecutively. Fig. 1 shows the attrition of study enrolment. Patients with the following conditions were excluded from the study: cognitive disorders (i.e. delirium, Mini-Mental State Examination Test < 26), immobility prior to surgery (bed ridden patients, musculoskeletal disorders), language barrier and other severe medical illnesses (chronic obstructive pulmonary disease (COPD)), coronary heart disease (CHD) and comorbidities such as patients suffering from additional fractures.

Gait analysis was performed using insole force sensors (Loadsol ® by Novel, Munich, Germany) fitted to the individuals foot size, which were then placed in the shoe of each individual. Following the manufacturers instructions, the Loadsol® has matchbox sized electronics and communicates via Bluetooth with a tablet computer. Data is transmitted in real-time and can be stored on the tablet for analysis. The sensors are able to record maximum load on both feet separately, average maximum load, average loading rate and biofeedback analysis.

Hip fracture patients suffering from pertrochanteric fractures underwent surgery with intramedullary nail fixation (Co. DePuy/Synthes; PFNA, Umkirch, Germany). The group of patients suffering from medial femoral neck fractures were treated with hip replacement surgery (Co. DePuy/Synthes, Umkirch, Germany; Pinnacle acetapular cup, Biolox femoral head and Corail stem in case of total hip replacement and Bipolar hemiarthroplasty of the hip with cemented Corail stem respectively).

A standardized questionnaire was used to assess cognitive impairment, patients' mobility and activity and comorbidities. The Mini- Mental State Examination (MMSE) was performed to evaluated cognitive impairment. The Parker mobility score (PMS) and the Barthel-Index (BI) were used to assess the patients' prefracture mobility and activities of daily living. We verified by explicit inquiry that these questions were answered correctly.

All patients were treated following the WHO treatment guidelines according to a standardized pain regime. None of the patients were treated with a local pain catheter at the day of gait analysis. Pain assessment was performed with a 11 point visual analogue scale with 0 = no pain to 10 = worst pain.

Following the approval by our ethical review committee (Ref.-No.: 214-16) all patients were enrolled prospectively, additional online registry of the study was referenced under DRKS00012800.

All included patients were trained by the same physiotherapy staff from the first day following surgery onwards, with immediate full weight bearing and no other mobility restrictions. There was no difference in post-operative procedure between the patients receiving hip replacement surgery compared to those undergoing fracture fixation with nailing. On the fifth post-operative day the study participants were mobilized for gait analysis with a walking device of their choice. They walked a fixed distance of 40 m by starting from a chair, level walking, turning and returning to the chair. The total load on both feet was measured in newton, steps were counted and the gait speed and duration were determined. The insoles measured the plantar force in static and dynamic situations and scan the foot with up to 200 Hz. The capacitive sensors covered the complete plantar surface of the foot.

Statistical analysis

A power analysis was performed prior to this study to estimate the needed number of patients. Powerandsamplesize.com 2013–2018 (HyLown Consulting LLC • Atlanta, USA) was used. Data from a pilot study showed that patients treated for a femoral neck fracture loaded the affected limb about 73.80% (SD 16.96) of the total body weight following hip replacement surgery, while patients treated for a pertrochanteric fracture with fracture fixation had a significantly lower load of 62.19% (SD 8.84). Aiming

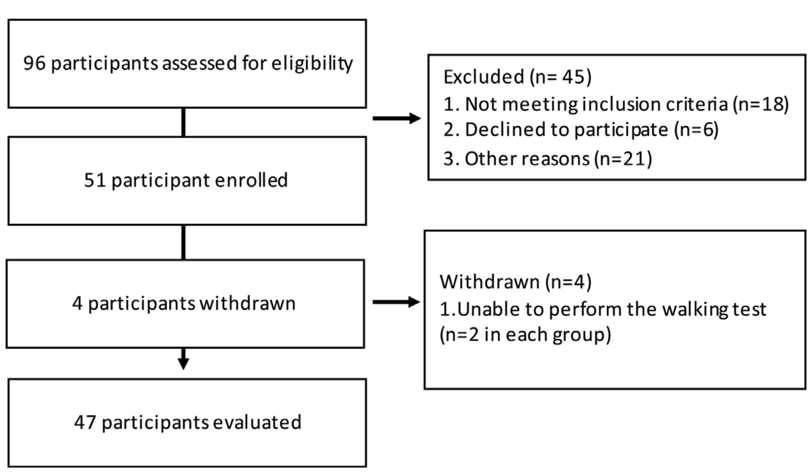

Fig. 1. shows the attrition flow chart depicting application of inclusion and exclusion criteria and withdraw.

Downloaded for Anonymous User (n/a) at Northwestern University from ClinicalKey.com by Elsevier on August 19, 2020.
For personal use only. No other uses without permission. Copyright ©2020. Elsevier Inc. All rights reserved.

for a Power of 80% and a level of significance set at $p < 0.05$, the number of patients was estimated to be 25 in the femoral neck fracture group and 27 in the pertrochanteric fracture group.

Within the main study the actual number of patients was 20 in the hip replacement and 27 in the fracture fixation group. The results were analysed by a rank sum test. Considering the small sample size and missing normal distribution in one of the groups, a nonparametric test, the Mann-Whitney-U-Test, was performed to identify significant differences between groups. Thereafter the Maximum peakforce and Average peakforce were analysed. The level of significance was set at $p < 0.05$.

Graphs and statistical analysis were calculated with IBM SPSS Statistics Version 24 (IBM Germany GmbH, Ehningen, Germany).

Results

In total 47 patients met the inclusion criteria, of those, 20 hip fracture patients were treated with hip replacement surgery due to a femoral neck fracture and 27 patients presented with a pertrochanteric fracture following fracture fixation with proximal femoral nailing. Patients in the femoral neck fracture group presented with a mean age of 78.95 years (SD ± 7.810) (13 male/ 7 female, 11 hemiprostheses and 9 total hip replacements). A subanalysis showed no difference concerning the load bearing between the hemiprotheses group and total hip replacement group, therefore these groups were pooled together for further analysis. The fracture fixation group included 27 pertrochanteric fractures following fracture fixation with an intramedullary nail. The mean age in that group was 80.63 years (SD ± 8.404) (8 male/ 19 female). The mean ASA score was 2.85 (SD ± 0.587) in the femoral neck fracture group and 2.74 (SD ± 0.656) in the pertrochanteric fracture group. In all cases good implant positioning and fracture reduction in the group of pertrochanteric fractures was radiographically proofed. No cases with wound healing disorders or other events prohibiting early mobilization were observed.

Comparative analysis of the group presenting with a femoral neck fracture and the group of patients with a trochanteric fracture revealed no statistical differences with regards to age, ASA score, pre fracture Barthel index and Parker Mobility Score (Table 1).

Main outcome parameters

Gait analysis showed that the femoral neck fracture group loaded a significantly higher percentage of their total body weight on the affected limb following hip replacement than the group of patients treated for a pertrochanteric fracture with fracture fixation (Figs. 2 and 3). Therefore, the **Maximum Peakforce (Max. Pf)** which is the maximum force value of each step taken and the **Average Peakforce (Avg. Pf)** which is the average of maximum force values over the entire gait analysis in each step was recorded.

Table 1
shows comorbidities, Parker Mobility Score (PMS), Barthel index (BI) and Minimental State examination (MMSE) in between the two groups.

Score	Femoral neck fracture group (mean)	SD	Pertrochanteric Fracture group (mean)	SD	p-value (between the groups)
Charlson-Index	2.0	2.68	1.07	1.59	0.444
PMS pre op	8.50	1.24	8.33	1.49	0.718
PMS post op	5.10	1.59	5.07	1.33	0.546
BI pre op	96.50	7.96	96.85	5.74	0.785
BI post op	65.25	13.42	66.48	13.72	0.854
MMSE	28.65	3.53	28.44	3.51	0.765

The femoral neck fracture group loaded the affected limb with 74.01% (SD ± 13.604) regarding Max. Pf, while the pertrochanteric fracture group had a significantly lower load of 62.70% (SD ± 8.281) Max.Pf. There was a significant difference between the two groups concerning the Maximum Peakforce on the affected limb ($p = 0.002$). Concerning the Average Peakforce there is also a significant difference between both groups. The femoral neck fracture group loaded the affected limb with an Avg. Pf of 61.64% (SD 14.596) of the total body weight and pertrochanteric fracture group with 53.17% (SD 9.307) of the total body weight following surgery ($p = 0.045$).

The VAS pain assessment during walking showed a difference between the two groups as well. The pertrochanteric fracture group reported a higher pain score (mean = 3.22, SD ± 1.592) than the femoral neck fracture group (mean = 2.2, SD ± 2.741) although there was no statistical significance $p = 0.160$.

Discussion

Improvements in hip fracture treatment and aftercare will become of superior importance, as a hip fracture is a life-threatening event, especially in orthogeriatric patients [11–13]. Early mobilization in these patients is crucial, as it has a major impact on a successful rehabilitation in order to maintain mobility and independency. A delay in getting hip fracture patients out of bed is associated with a reduced physical function at 2 months and a worse survival rate at 6 months [5]. Reduced mobility is often caused by an underlying gait problem, which might lead to falls and is often compounded by a fear of falling, which further immobilises patients [14].

Balanced weight bearing of both legs is a basic requirement of normal gait. Gait analysis using an insole device has proven to be a feasible approach to detect patients who are at risk for not following their physical therapy adequately, subsequently it can be useful to evaluate the rehabilitation process of hip fracture patients [15]. In a recent study it was shown that none of the investigated older adult hip fracture patients, who were instructed to maintain weight bearing restrictions, were able to transpose these recommendations, while an insole force sensor (Loadsol) recorded load reliably [16].

In the present study we then questioned, if there are differences in load bearing depending on the type of hip fracture (pertrochanteric vs. femoral neck fracture). Therefore, we investigated loading of the lower extremity in a comparative prospective study of hip fracture patients being treated with nailing for fracture fixation, compared to a group of patients undergoing hip replacement surgery. While all patients were instructed to transpose full weight, our findings show that loading of the affected hip was significantly higher in patients treated with hip replacement, while the pain regime was the same for both groups. These findings are supported by an older investigation published by Koval et al. in which the authors used a similar approach for gait analysis and also observed a reduced transposition of weight in patients undergoing fracture fixation of the hip [17]. Contradictory to our findings, no significant difference was observed in pain level recorded via VAS, while patients treated with intramedullary nailing reported only a slightly higher VAS. The difference observed might be attributed to the surgical approach used in the present study. Thus patients undergoing fracture fixation were treated with minimal invasive surgery, while patients in the hip replacement group were operated, using an anterolateral approach to the hip. Reduced postoperative pain, earlier discharge and less use of assistive devices due to minimal invasive approaches are well known in primary total hip replacement [18,19]. Thus, it is interesting why femoral neck fracture patients undergoing hip replacement surgery showed a higher loading of the affected limb

Downloaded for Anonymous User (n/a) at Northwestern University from ClinicalKey.com by Elsevier on August 19, 2020.
For personal use only. No other uses without permission. Copyright ©2020. Elsevier Inc. All rights reserved.

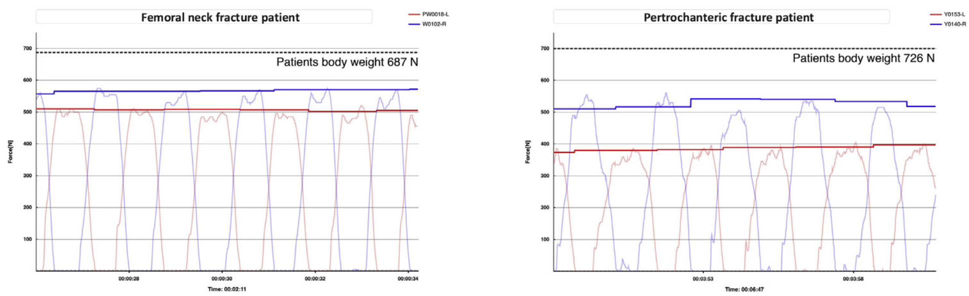

Fig. 2. shows the load in newton of the operated (red graph) and healthy (blue graph) lower extremity during gait analysis. An average difference between 5 exemplary gait cycles in a femoral neck fracture patient (left) and a pertrochanteric fracture patient (right) are displayed. X-axis is time in seconds, y-axis force in newton. The blue (upper) and red (lower) lines show the Average Peakforces, these two patients have a similar total bodyweight (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

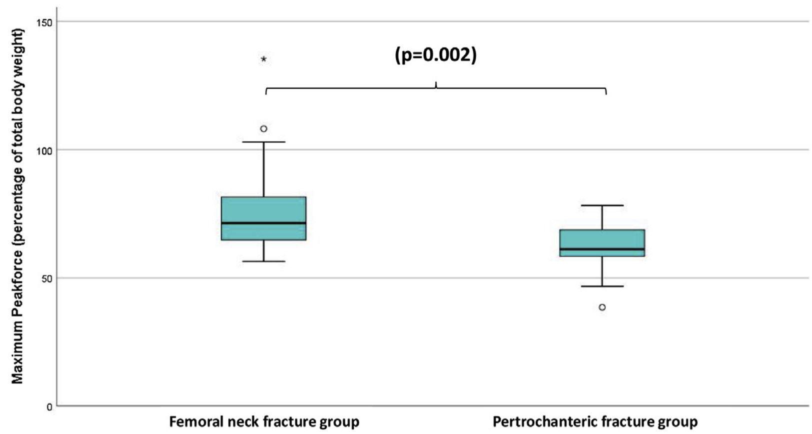

Fig. 3. shows the box-plot of the Maximum Peakforce as a percentage of the total body weight. The femoral neck fracture group at the left loads a significant (p = 0.002) higher percentage of the total body weight than the pertrochanteric fracture group on the right.

in the present study than patients treated with minimal invasive nailing of a pertrochanteric fracture. Micromovement within the fracture-zone following fracture fixation might also be associated with reduced loading compared to patients undergoing hip replacement. Disregarding the cause of reduced load bearing in pertrochanteric hip fracture patients, it is well known that muscle disuse caused by reduced mobilization is associated with accelerated loss of muscle strength, which is difficult to recover from thereafter. Further, deficits in physical function predict short term falls in older adults, which might cause further fractures and immobilization [20]. Even a long-term experience of pain following fragility fractures has been reported by Gheorghita et al. [9]. The insole device used in the present study could easily detect patients at risk for postoperative immobility caused by decreased weight bearing. In case a gait analysis is performed within the first days after surgery and decreased weight bearing is detected, the pain regime and physical therapy should be adapted to this finding. Insole force sensors can be used to address an improved rehabilitation including i.e. individualized analgesia, and physiotherapy.

One option to address pain within the fracture zone is i.e. local infiltration therapy, as it is widely used in hip replacement surgery [21]. This might also be a feasible approach in trauma surgery to reduce postoperative pain. Easypump C-block RA by B.Braun®, Melsungen, Germany is another established system that continuously provides patients with locally applied pain relieving drugs [22]. Improvements in pain management will play a key role in future care in orthogeriatrics, as it is well known that pain is causing delirium and might prevent patients from early mobilization [23,24]. However, according to the current literature, there is an ongoing controversial discussion about the merits and demerits of local infiltration therapies, femoral nerve blocks and systemic analgesia in orthogeriatric patients [25–27].

Reduced mobility and poor functional long-term outcome are only one negative effect of a hip fracture and its treatment [3]. Declined functional outcomes, decreased patient satisfaction, nausea and delirium in post anaesthesia period are other negative effects [28,29].

To determinate the impact on activities of daily living the Parker mobility score and the Barthel -Index were obtained for the time prior to trauma and after surgical treatment of the fracture. Both analysis indicated no difference concerning the fracture type and surgical treatment on the postoperative mobility in the fracture fixation group compared to the hip replacement group. Similar pre- and postoperative scores were shown in both groups, while there were also no cognitive differences according to the MMSE in between the groups. This is of high relevance as the PMS has a high predictive value for elderly hip fracture patients concerning the one year mortality [12]. Yet, taking into account that the PMS is based on ordinal data it is understandable that it is not capable to detect differences in gait analysis within the first 5 postoperative days.

Although the present study clearly showed distinct differences in load bearing in hip fracture patients, the study contains some limitations which have to be taken into account. Thus, two different entities of fractures (pertrochanteric and femoral neck fractures) were investigated, while the biomechanic forces acting on these areas and the surgical therapy differ from each other. The short observational time must also be considered, thus only the early postoperative stage was investigated as immediate

Downloaded for Anonymous User (n/a) at Northwestern University from ClinicalKey.com by Elsevier on August 19, 2020.
For personal use only. No other uses without permission. Copyright ©2020. Elsevier Inc. All rights reserved.

remobilization is most important within the current literature. There have been investigations showing an increase in loadbearing of hip fracture patients throughout the postoperative time course, while it remains unclear if the difference in loadbearing observed in the present study persists [17]. Future studies should analyze how long this difference in weight bearing persists and therefore include follow up gait analysis at 2 weeks and 6 weeks post surgery or ideally a continuously measurement in the first 6 postoperative weeks.

Conclusion

In the present study on hip fracture patients, gait analysis with an insole force sensor clearly showed that patients with pertrochanteric fractures who underwent nailing apply significantly less load to the affected leg compared to patients with femoral neck fractures following hip replacement, while no significant differences in the level of pain were observed. Reduced weight-bearing is known to be associated with various complications such as reduced mobility and increased mortality. Therefore, future studies should focus on the patient's ability to transpose as much weight as early as possible to facilitate immediate mobilisation.

Authors contribution

DP: Study design, analysis and interpretation of data; drafting paper; approval of final version

CG: Acquisition and analysis of data; approval of final version

AK: Interpretation of data, revising first draft, approval of final version

WB, CK: Study design, Revising first draft and approval of the final version

CN: Study design and interpretation of data; revising first draft, approval of final version

Acknowledgments

Friedrich-Baur-Foundation, (Reg.No. 29/16)

Deutsche Forschungsgemeinschaft/ Max Kade Foundation, Postdoctoral Research Fellowship (PF 939/1-0)

We want to thank the nursing staff on our ortho-geriatric ward and all involved physiotherapists for their continuous support during the study period. Thanks to Marissa Stagg for proofreading and language corrections. Thanks to the Department of Medical Informatics, Biometry, and Epidemiology at LMU Munich which helped with the statistical analysis and supported our power analysis and final analysis of all data.

References

[1] Schwachmeyer V, Damm P, Bender A, Dymke J, Graichen F, Bergmann G. In vivo hip joint loading during post-operative physiotherapeutic exercises. PloS One Bd 2013;8(10)e77807.
[2] Friedman SM, Mendelson DA. Epidemiology of fragility fractures. Clin Geriatr Med Bd 2014;30(Mai 2):175–81.
[3] Kammerlander C, Gosch M, Kammerlander-Knauer U, Luger TJ, Blauth M, Roth T. Long-term functional outcome in geriatric hip fracture patients. Arch Orthop Trauma Surg Bd 2011;131(Okt.10):1435–44.
[4] Kamel HK, Iqbal MA, Mogallapu R, Maas D, Hoffmann RG. Time to ambulation after hip fracture surgery: relation to hospitalization outcomes. J Gerontol A Biol Sci Med Sci Bd 2003;58(November (11)):1042–5.
[5] Siu AL, Penrod JD, Boockvar KS, Koval K, Strauss E, Morrison RS. Early ambulation after hip fracture: effects on function and mortality. Arch Intern Med Bd 2006;166(April (7)):766–71.
[6] Heinonen M, Karppi P, Huusko T, Kautiainen H, Sulkava R. Post-operative degree of mobilization at two weeks predicts one-year mortality after hip fracture. Aging Clin Exp Res Bd 2004;16(Dez. 6):476–80.
[7] Langenhan R, Trobisch P, Ricart P, Probst A. Aggressive surgical treatment of periprosthetic femur fractures can reduce mortality: comparison of open reduction and internal fixation versus a modular prosthesis nail. J Orthop Trauma Bd 2012;26(February (2)):80–5.
[8] Sale JEM, Frankel L, Thielke S, Funnell L. Pain and fracture-related limitations persist 6 months after a fragility fracture. Rheumatol Int Bd 2017;37(August (8)):1317–22.
[9] Gheorghita A, Webster F, Thielke S, Sale JEM. Long-term experiences of pain after a fragility fracture. Osteoporos Int 2018;(February):1–12.
[10] Ehrnthaller C, Olivier AC, Gebhard F, Dürselen L. The role of lesser trochanter fragment in unstable pertrochanteric A2 proximal femur fractures - is refixation of the lesser trochanter worth the effort? Clin Biomech Bristol Avon Bd 2017;42(February):31–7.
[11] Morris AH, Zuckerman JD, AAOS Council of Health Policy and Practice, USA, American Academy of Orthopaedic Surgeons. National Consensus Conference on Improving the Continuum of Care for Patients with Hip Fracture. J Bone Joint Surg Am Bd 2002;84-A(April (4)):670–4.
[12] Schnell S, Friedman SM, Mendelson DA, Bingham KW, Kates SL. The 1-year mortality of patients treated in a hip fracture program for elders. Geriatr Orthop Surg Rehabil Bd 2010;1(September (1)):6–14.
[13] Magaziner J, Simonsick EM, Kashner TM, Hebel JR, Kenzora JE. Survival experience of aged hip fracture patients. Am J Public Health Bd 1989;79(März (3)):274–8.
[14] Lauretani F, Meschi T, Ticinesi A, Maggio M. Brain-muscle loop 'in the fragility of older persons: from pathophysiology to new organizing models. Aging Clin Exp Res Bd 2017;29(Dez (6)):1305–11.
[15] Braun BJ. A novel tool for continuous fracture aftercare - Clinical feasibility and first results of a new telemetric gait analysis insole. Injury Bd 2016;47 (February (2)):490–4.
[16] Kammerlander C, Pfeufer D, Lisitano LA, Mehaffey S, Böcker W, Neuerburg C. Inability of Older Adult Patients with Hip Fracture to Maintain Postoperative Weight-Bearing Restrictions. J Bone Joint Surg Am Bd 2018;100(Juni (11)):936–41.
[17] Koval KJ, Sala DA, Kummer FJ, Zuckerman JD. Postoperative weight-bearing after a fracture of the femoral neck or an intertrochanteric fracture. J Bone Joint Surg Am Bd 1998;80(März (3)):352–6.
[18] Goebel S, u. a. Reduced postoperative pain in total hip arthroplasty after minimal-invasive anterior approach. Int Orthop Bd 2012;36(März (3)):491–8.
[19] Dorr LD, Maheshwari AV, Long WT, Wan Z, Sirianni LE. Early pain relief and function after posterior minimally invasive and conventional total hip arthroplasty. A prospective, randomized, blinded study. J Bone Joint Surg Am Bd 2007;89(Juni (6)):1153–60.
[20] Welmer A-K, Rizzuto D, Laukka EJ, Johnell K, Fratiglioni L. Cognitive and physical function in relation to the risk of injurious falls in older adults: a population-based study. J Gerontol A Biol Sci Med Sci Bd 2017;72(Mai (5)):669–75.
[21] Tziona D, Papaioannou M, Mela A, Potamianou S, Makris A. Local infiltration analgesia combined with a standardized multimodal approach including an adductor canal block in total knee arthroplasty: a prospective randomized, placebo-controlled, double-blinded clinical trial. J Anesth 2018(März).
[22] Remerand F, u. a. Elastomeric pump reliability in postoperative regional anesthesia: a survey of 430 consecutive devices. Anesth Analg Bd 2008;107 (Dez (6)):2079–84.
[23] Lundstrom M, u. a. Postoperative delirium in old patients with femoral neck fracture: a randomized intervention study. Aging Clin Exp Res Bd 2007;19(Juni (3)):178–86.
[24] Greer N. Delirium: Screening, prevention, and diagnosis - a systematic review of the evidence. Washington (DC): Department of Veterans Affairs (US); 2011.
[25] Andersen LJ, Poulsen T, Krogh B, Nielsen T. Postoperative analgesia in total hip arthroplasty: a randomized double-blinded, placebo-controlled study on peroperative and postoperative ropivacaine, ketorolac, and adrenaline wound infiltration. Acta Orthop Bd 2007;78(January 2):187–92.
[26] Rowlands M, u. a. Femoral nerve block intervention in neck of femur fracture (FINOF): a randomised controlled trial. BMJ Open Bd 2018;8(April 4)e019650.
[27] Andersen LØ, Kehlet H. Analgesic efficacy of local infiltration analgesia in hip and knee arthroplasty: a systematic review. Br J Anaesth Bd 2014;113 (September (3)):360–74.
[28] Guenther U, Radtke FM. Delirium in the postanaesthesia period. Curr Opin Anaesthesiol Bd 2011;24(Dez (6)):670–5.
[29] Hansson S, Rolfson O, Åkesson K, Nemes S, Leonardsson O, Rogmark C. Complications and patient-reported outcome after hip fracture. A consecutive annual cohort study of 664 patients. Injury Bd 2015;46(November (11)):2206–11.

Downloaded for Anonymous User (n/a) at Northwestern University from ClinicalKey.com by Elsevier on August 19, 2020.
For personal use only. No other uses without permission. Copyright ©2020. Elsevier Inc. All rights reserved.