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Human Kinetics
CASE STUDY

Hip Fracture in the Sportive Adult: Case Report of Complete Functional Recovery After Removal of Hardware

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Context: Pertrochanteric hip fractures in sportive young adults are mainly caused by a high-energy trauma and treated in the same way as in the older population, using an osteosynthesis immediately followed by a rehabilitation program for several months. The current standard is not to remove osteosynthesis material, similar to the case of older patients. ***Case Presentation:*** A 45-year-old male cyclist experienced a right pertrochanteric femoral fracture, treated with cephalomedullary nails. After 9 months of adequate rehabilitation, weakness of the quadriceps musculature and functional complaints persisted, objectified through an isokinetic strength test and a significantly reduced score on the Hip Disability and Osteoarthritis Outcome Score questionnaire. The patient was unable to return to his previous level of cycling performance. ***Management and Outcome:*** After exclusion of structural bone complications, nerve injury, and central sensitization, the functional complaints and strength deficiency were hypothesized to be related to the osteosynthesis material. Therefore, the hardware was removed 9 months after the first surgery, and the rehabilitation was continued for another 20 weeks. Very soon after the removal of the hardware, the functional complaints disappeared with a remarkable improvement of the Hip Disability and Osteoarthritis Outcome Score. The isokinetic strength test showed complete recovery of muscle strength 20 weeks after osteosynthesis removal, and preinjury cycling performance values were obtained 9 months posthardware removal. ***Conclusion:*** Despite an adequate rehabilitation following a hip fracture, sporty young adults may fail to reach their previous level of functioning. Osteosynthesis removal may be indicated in this sportive population to reach complete muscle strength and functional recovery. The management of hip fractures in the sportive young adult and the identification of patients who may benefit from removal of the hardware require more research.

Keywords: isokinetic strength test, osteosynthesis, cyclist

Key Points

- Despite an adequate rehabilitation following a pertrochanteric fracture, muscle weakness and functional complaints may persist in young active adults.
- All possible causes of incomplete functional recovery and persistent muscle strength deficits following a pertrochanteric fracture should be excluded before hardware removal.
- Removal of the hardware may be indicated in sporty adults to reach preinjury level of functioning.

Hip fractures in the young adult are far less common than in people older than 60 years of age and mostly occur due to a high-energy mechanism of injury.[1] Literature data on the management, postoperative rehabilitation, and long-term functional outcome of hip fractures in young athletic adults are scarce, in contrast to the older population.[1,2] Consequently, hip fractures and their rehabilitation in the young active adult are managed in the same way as in older patients. Current guidelines do not support the routine removal of osteosynthesis material, similar to the case of older patients.[3] Although pain relief and functional improvement have been reported following material removal, the indication remains a topic of debate.[4] This case report describes a young cyclist who, despite adequate rehabilitation, was unable to return to his previous level of performance. Rationale is provided regarding clinical decision making throughout the entire process until the decision is made to remove the osteosynthesis material.

Case Report

A 45-year-old male cyclist had a crash during a training ride for the Etape du Tour 2021. He experienced a severe fall onto his right side while descending a slippery road. He was diagnosed with a right pertrochanteric femoral fracture and an avulsion of the greater trochanter (Figure 1A). There were no concomitant injuries and no relevant history to report.

During the last year before his trauma, he accumulated 344 hours and 38 minutes of cycling training (6–7 h/wk). The latest exercise test, performed on a Cylus2® (General Electric GmbH, Bitz) 7 months before the crash, demonstrated the following cycling performance data: VO_2max of 57 mL/kg/min for a body mass index

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of 22.1 kg/m^2, an anaerobic threshold of 310 W at 161 beats per minute, and a maximal power of 4.7 W/kg.

An osteosynthesis using cephalomedullary nails was performed within 12 hours (Figure 1B) of the injury. According to the latest guidelines, rehabilitation started immediately postoperative and consisted of early mobilization (within 48 h) during hospitalization and physical therapy to increase muscle strength (especially gluteal and quadriceps muscles).[5] Full weight bearing was allowed from the first day onward.

After discharge, rehabilitation focused on physical therapy with supervised home-based exercises as described in Table 1. The patient rehabilitated for 2 hours per day during the first 6 weeks, during which the aforementioned exercises were progressively built up. In the following months, he continued rehabilitation, attending sessions 5 times per week for 1 hour each session. For the first 3 months, this occurred 3 times a week under the supervision of a physiotherapist.

During the initial 7 weeks, the patient used crutches for walking, employing 2 crutches for the initial 4 weeks and transitioning to 1 crutch for the remaining 3 weeks. He was able to discontinue pain medication after 3 weeks.

Cycling was introduced on a stationary bike after 7 days as a mobilization exercise (on average, 50 W for 15 min). Following 1 month postsurgery, the intensity and duration of cycling on his stationary bike was progressively increased, starting with 20 km with an average of 85 W thrice weekly. Cycling trainings were meticulously built up, culminating in training sessions encompassing 100 km at an average of 148 W 4 months thereafter. Further progression was prevented due to discomfort during and after cycling training, and cycling performance remained notably lower compared with his preoperative values. Other daily complaints after 4 months were a limping gait and an instability to stand on the affected leg (eg, during dressing).

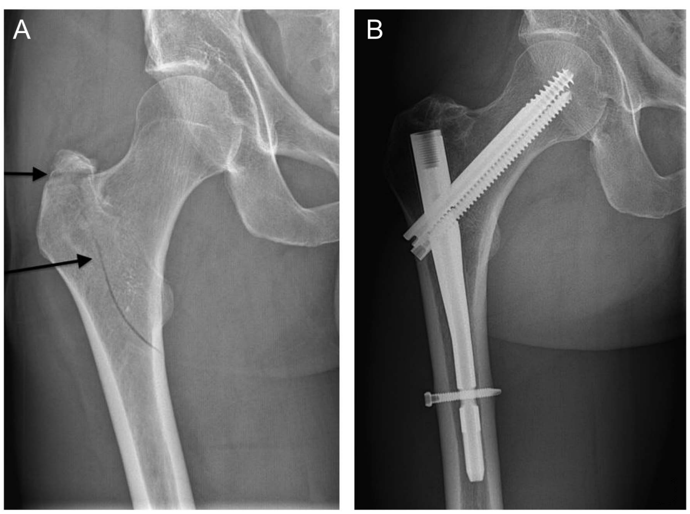

Figure 1 — X-Ray of pertrochanteric hip fracture with impaction of the greater trochanter (black arrows in [A] and after osteosynthesis using cephalomedullary nails [B]).

Management and Outcome

At that time, 4 months postoperative, the patient presented for the first time at the sports and rehabilitation department with the aforementioned complaints. Clinical examination showed weakness of the quadriceps, hip flexors, and gluteal musculature (MRC 4/5), with a positive Trendelenburg sign and a reduction in range of motion of passive hip abduction in comparison with the unaffected leg. Functional exercises, for example squats, single-leg stance, and lunges, showed significant left–right discrepancies with excessive valgus motion of the right knee. An isokinetic strength test was performed to objectify this strength deficit. This showed a significant difference to the detriment of the affected right side for all performed tests: concentric slow (60°/s) and fast (240°/s) movement by the quadriceps and the hamstrings and eccentric slow movement (30°/s) by the hamstrings (Table 2). A significant discrepancy between both sides was defined as >10%. Because of weakness of the lower limb musculature, rehabilitation was adjusted and intensified while focusing more on strength training of the affected leg with more dynamic and functional exercise therapy.

Even after training for another 13 weeks, 3 to 4 times a week, 1 to 2 hours per session, the same complaints persisted. A second isokinetic strength test of the quadriceps showed an even increased asymmetry during concentric slow (60°/s) and fast (240°/s) movement. Conversely, the left–right discrepancy on the isokinetic strength tests of the hamstrings during concentric slow (60°/s) and fast (240°/s) movement was eliminated (Table 2). An electromyographic test excluded a femoral nerve lesion as a possible cause of this persistent loss of strength in the quadriceps musculature, and an X-ray excluded structural bone causes. Furthermore, we used the Central Sensitization Inventory and the International Association for the Study of Pain criteria for nociplastic pain affecting the musculoskeletal system to exclude central sensitization as a cause of these persisting complaints.[6]

Table 1 Exercise Therapy Under Supervision of the Physiotherapist, Gradually Built up After Osteosynthesis

- Angular passive mobilizations + active automobilization in hip, knee, and ankle joints
- Circulation exercises in acute postoperative setting (lower limb)
- Weight transfers, weight shifts
- Walking rehabilitation exercises
- Aquatic therapy
- Isometric, eccentric, and concentric active rehabilitation exercises focusing on regaining strength and neuromuscular activation: (single-leg) heel raises, lunges, squats, sit–stand–sit, clams (side-lying top leg turn out), glute bridges, deadlifts, unilateral stance, Bulgarian split squats, sumo squats, and lunge squats
- Mobility and stretching (rectus femoris, iliopsoas, long and short adductors)
- Proprioception training (progression from stable to unstable surfaces)
- Core stability training
- Kinetic chain stretching, functional training
- Cardio training: cycling and walking

Table 2 Results of Isokinetic Strength Tests Performed at 4 Months After Osteosynthesis Using Cephalomedullary Nails, at 8 Months Postoperative, and at 4 Months After Removal of the Hardware

	Right	Left
Quadriceps muscle strength		
Concentric 60°/s	130/**137**/*201*	145/**188**/*202*
Concentric 240°/s	85/**91**/*114*	117/**126**/*129*
Hamstring muscle strength		
Concentric 60°/s	80/**94**/*110*	100/**102**/*110*
Concentric 240°/s	57/**65**/*65*	69/**64**/*69*
Eccentric 30°/s	75/**118**/*172*	115/**138**/*164*
H/Q ratio		
Concentric 60°/s	0.62/**0.69**/*0.55*	0.69/**0.54**/*0.54*
Concentric 240°/s	0.67/**0.71**/*0.57*	0.59/**0.51**/*0.53*
H-eccentric (30°/s)/ Q-concentric (240°/s)	0.88/**1.29**/*1.50*	0.98/**1.1**/*1.27*
Relative strength N·m/kg: Q-concentric (60°/s)/body weight	1.7/**1.8**/*2.6*	1.9/**2.4**/*2.6*

Roman font indicates 4 months after osteosynthesis using cephalomedullary nails, bold indicates 8 months postoperative, and italics indicates 4 months after removal of hardware. Abbreviations: H, hamstrings; Q, quadriceps. Note: Values are expressed in Newton-meter.

Therefore, after 9 months of rehabilitation, weakness of the quadriceps musculature on the affected side and functional complaints persisted. The patient was still unable to reach his previous cycling level (current maximum average of 188 W on 27 km), experienced an accentuated limping gait after his training sessions (Trendelenburg gait), and had difficulty walking downhill. No new exercise test was conducted at this time as the patient did not feel sufficiently fit. To assess the patient's disability more objectively, the Hip Disability and Osteoarthritis Outcome Score (HOOS) questionnaire was administered.[7] At this point in his rehabilitation, he scored 42/100, with 0 meaning the highest possible disability.

After exclusion of bone complications on X-ray, nerve lesions through electromyography testing, and central sensitization, it was hypothesized that the lingering complaints were related to the hardware. Consequently, following consultation with the patient, removal of the hardware was performed 9 months after the initial surgery. After the removal, he continued his rehabilitation 3 to 5 times a week, 1 to 2 hours per session, for another 20 weeks. Rehabilitation exercises were included in his training program as described in Table 3.

In the initial weeks following the removal of the hardware, it was expected that the patient would experience some setback. But, after several weeks, the patient experienced significant functional improvements: he was able to engage in exercise therapy and strength training more effectively without residual burden and felt more capable of gradually increasing his strength training regimen. This functional improvement was objectified in a remarkable increase of the HOOS score (97/100 at 3 mo after material removal versus 42/100 at 9 mo postsurgery). In addition, the isokinetic strength test was repeated 20 weeks after hardware removal, showing a significant improvement of the strength tests of both quadriceps and hamstrings muscles, with the disappearance of any left–right discrepancy (Table 2).

Cycling training was also resumed 2 weeks after hardware removal. In combination with the exercise program, both the duration and intensity of his training sessions were successfully increased. The patient managed to perform his training rides as he did before, completing rides of 111 km with an average of 206 W. A new exercise test was performed 3 months posthardware removal and demonstrated the following cycling performance data: VO_2max of 56 mL/kg/min for a body mass index of 22.1 kg/m^2, an anaerobic threshold of 275 W at 157 beats per minute, and a maximal power of 4.2 W/kg. After an additional 6 months of cycling training, his values further improved, reaching preinjury levels with a VO_2max of 61 mL/kg/min for a body mass index of 22.1 kg/m^2, an anaerobic threshold of 300 W at 163 beats per minute, and a maximal power of 4.9 w/kg.

Table 3 Exercise Therapy Under Supervision of the Physiotherapist, Gradually Built up After Removal of the Hardware

- Isometric, eccentric, and concentric active rehabilitation exercises focusing on regaining strength and neuromuscular activation: (single-leg) heel raises, lunges, squats, sit–stand–sit, clams (side-lying top leg turn out), glute bridges, deadlifts, unilateral stance, Bulgarian split squats, sumo squats, and lunge squats
- Mobility and stretching (rectus femoris, iliopsoas, and long/short adductors)
- Proprioception training (progression from stable to unstable surfaces)
- Core stability training
- Kinetic chain stretching, functional training
- Cardio training: cycling and walking

Discussion

Pertrochanteric fractures in the sportive young adult and their rehabilitation are generally managed in the same way as in the older patient. The therapeutic mainstay is internal fixation shortly posttraumatic, using a sliding hip screw or a cephalomedullary device to preserve the femoral head.[8] According to the latest guidelines, rehabilitation of active young adults consists of mobilization immediately postoperative and physical therapy, as described in the case report. These rehabilitation guidelines have been extensively reported on and are generally sufficient for the older patient, whereas literature concerning long-term functional outcome following a hip fracture in the sportive population is scarce.[2]

In the case of incomplete functional recovery in young sportive adults with high-level tasks (such as bike racing), despite adequate rehabilitation, it is important to objectively assess the clinical situation together with the patient according to the international classification of functioning, disability, and heath (ICF).[9] This was objectified in our patient through the HOOS questionnaire, cycling performance data, and isokinetic strength testing.[7] The HOOS questionnaire is useful for the evaluation of patient-relevant outcomes and has proved to be valid for persons with hip disability, with or without hip osteoarthritis, and with high demands of physical functioning. HOOS scores serve to monitor alterations in the patient's functionality and quality of life over time as well as to assess the efficacy of interventions.[7]

All potential causes that may be responsible for insufficient functional outcome have to be excluded before hardware removal. First, because of the high-energy mechanism of injury in the young adult and, consequently, the higher rate of complication, it is crucial to rule out any bone complications with imaging (avascular necrosis, varus collapse, nonunion or delayed union, periprosthetic fractures, and failure of osteosynthesis).[2,10,11] Second, a nerve lesion needs to be eliminated through electromyography testing. Third, it is important to exclude central sensitization using the Central Sensitization Inventory and the International Association for the Study of Pain criteria for nociplastic pain affecting the musculoskeletal system.[12,13]

Similar to disturbances in proprioception and balance observed after hip arthroplasty, the osteosynthesis material used in cephalomedullary nailing for treating pertrochanteric hip fractures may adversely affect proprioception in young, active athletes, potentially leading to persistent functional complaints.[14] Currently, there is no consensus regarding the indication, risks, and benefits of hardware removal, despite it being a frequently performed procedure.[4,15] Current literature reports improvement in pain or discomfort ranging from 53% to 96% of patients.[16,17] However, limited prospective data are available to support decision making.[3,4]

According to the guidelines of the Association for the Study of Internal Fixation, implant removal of a pertrochanteric hip fracture is possible 12 months postsurgery.[18] However, exact timing of osteosynthesis removal depends on different factors, including timing of bone healing, fracture localization, fracture type and severity, type of implant, and patient characteristics.[19] Due to the patient's young age, male gender, absence of osteoporosis, and complete bone healing of a nondisplaced pertrochanteric fracture, the decision was made to remove the hardware 9 months after the initial surgery in our patient.[20]

Conclusion

Sporty young adults may continue to experience quadriceps muscle weakness and functional complaints, despite appropriate rehabilitation, following a pertrochanteric femoral fracture treated with cephalomedullary nails. After exclusion of all other possible causes of incomplete muscle strength and functional recovery, removal of the hardware may be indicated to reach a preinjury level of functioning, as observed in our cyclist. The management of hip fractures in the sportive young adult and the identification of patients who may benefit from removal of the hardware require more research.

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A patient informed consent statement was obtained.

References

1. Chien-Fu Lin J, Wu CC, Lo C, et al. Mortality and complications of hip fracture in young adults: a nationwide population-based cohort study. *BMC Musculoskelet Disord*. 2014;15:362. doi:10.1186/1471-2474-15-362
2. Amini MH, Feldman JJ, Weinlein JC. High complication rate in young patients with high-energy intertrochanteric femoral fractures. *Orthopedics*. 2017;40(2):e293–e299. doi:10.3928/01477447-20161128-04
3. Busam ML, Esther RJ, Obremskey WT. Hardware removal: indications and expectations. *J Am Acad Orthop Surg*. 2006;14(2):113–120. doi:10.5435/00124635-200602000-00006
4. Vos DI, Verhofstad MHJ. Indications for implant removal after fracture healing: a review of the literature. *Eur J Trauma Emerg Surg*. 2013; 39(4):327–337. doi:10.1007/S00068-013-0283-5/METRICS
5. Lee KJ, Um SH, Kim YH. Postoperative rehabilitation after hip fracture: a literature review. *Hip Pelvis*. 2020;32(3):125. doi:10.5371/HP.2020.32.3.125
6. Nijs J, Lahousse A, Kapreli E, et al. Nociplastic pain criteria or recognition of central sensitization? Pain phenotyping in the past, present and future. *J Clin Med*. 2021;10(15):3203. doi:10.3390/JCM10153203
7. de Groot IB, Reijman M, Terwee CB, et al. Validation of the Dutch version of the hip disability and osteoarthritis outcome score. *Osteoarthritis Cartilage*. 2007;15(1):104–109. doi:10.1016/J.JOCA.2006.06.014
8. Mäkinen TJ, Gunton M, Fichman SG, Kashigar A, Safir O, Kuzyk PRT. Arthroplasty for pertrochanteric hip fractures. *Orthop Clin North Am*. 2015;46(4):433–444. doi:10.1016/J.OCL.2015.06.001
9. Lin CL, Liao CD, Lee YH, Escorpizo R, Liou TH, Huang SW. Delphi-based consensus to determine core aspects of post-hip-fracture surgery rehabilitation based on the international classification of functioning, disability, and health. *Int J Environ Res Public Health*. 2022;19(23):988. doi:10.3390/IJERPH192315988
10. Carpintero P, Caeiro JR, Carpintero R, Morales A, Silva S, Mesa M. Complications of hip fractures: a review. *World J Orthop*. 2014;5(4): 402. doi:10.5312/WJO.V5.I4.402
11. Istianah U, Nurjannah I, Magetsari R. Post-discharge complications in postoperative patients with hip fracture. *J Clin Orthop Trauma*. 2021;14:45. doi:10.1016/J.JCOT.2020.10.045
12. Yuen EC, So YT. Sciatic neuropathy. *Neurol Clin*. 1999;17(3): 617–631. doi:10.1016/S0733-8619(05)70155-9
13. Hida M, Deguchi Y, Miyaguchi K, et al. Association between acute postoperative pain and recovery of independent walking ability after surgical treatment of hip fracture. *Prog Rehabil Med*. 2018;3:12. doi:10.2490/PRM.20180012
14. Frattura GDL, Bordoni V, Feltri P, Fusco A, Candrian C, Filardo G. Balance remains impaired after hip arthroplasty: a systematic review and best evidence synthesis. *Diagnostics*. 2022;12(3):684. doi:10.3390/DIAGNOSTICS12030684/S1
15. Williams BR, McCreary DL, Parikh HR, Albersheim MS, Cunningham BP. Improvement in functional outcomes after elective symptomatic orthopaedic implant removal. *J Am Acad Orthop Surg Glob Res Rev*. 2020;4(9):137. doi:10.5435/JAAOSGLOBAL-D-20-00137
16. Minkowitz RB, Bhadsavle S, Walsh M, Egol KA. Removal of painful orthopaedic implants after fracture union. *J Bone Joint Surg Am*. 2007;89(9):1906–1912. doi:10.2106/JBJS.F.01536
17. Reith G, Schmitz-Greven V, Hensel KO, et al. Metal implant removal: benefits and drawbacks—a patient survey. *BMC Surg*. 2015; 15(1):96. doi:10.1186/S12893-015-0081-6
18. Canale T, Beaty JH. *Campbell's Operative Orthopaedics*. Elsevier Health Sciences.
19. Prediger B, Mathes T, Probst C, Pieper D. Elective removal vs. retaining of hardware after osteosynthesis in asymptomatic patients—a scoping review. *Syst Rev*. 2020;9(1):488. doi:10.1186/S13643-020-01488-2/FIGURES/2
20. Barquet A, Giannoudis PV, Gelink A. Femoral neck fractures after removal of hardware in healed trochanteric fractures. *Injury*. 2017; 48(12):2619–2624. doi:10.1016/J.INJURY.2017.11.031