Functional outcomes more than 5 years following acetabulum fracture

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Abstract

Objectives: The purposes of this project were to evaluate functional outcomes more than 5 years after acetabulum fracture and to determine factors related to function.

Methods: This retrospective study consisted of 205 adult patients treated for acetabulum fracture who completed the Musculoskeletal Function Assessment (MFA) a minimum of 5 years following injury. The MFA includes survey of daily activities, gross and fine mobility, social and work function, sleeping, and mood. Higher scores indicate worse function.

Results: Two hundred five patients with 210 fractures, 69.3% of whom were male, with mean age of 45.7 and mean body mass index 30.1 were included after mean 128 months follow-up. Fracture patterns included OTA/AO 62A (37.1%), 62B (40.5%), or 62C (22.4%), and 80.0% were treated surgically. Late complications were noted in 35.2%, including posttraumatic arthrosis (PTA; 19.5%), osteonecrosis and/or heterotopic ossification. Mean MFA of all patients was 31.4, indicating substantial residual dysfunction. Worse MFA scores were associated with morbid obesity (body mass index >40; 42.3, P <.09), and current tobacco smoking history vs former smoker vs nonsmoker (45.2 vs 36.1 vs 23.0, P <.002). Patients with late complications had worse mean MFA scores (38.7 vs 27.7, P =.001); PTA was the most common late complication, occurring in 19.5%.

Conclusions: More than 5 years following acetabulum fracture, substantial residual dysfunction was noted, as demonstrated by mean MFA. Worse outcomes were associated with late complications and tobacco smoking. While fracture pattern was not associated with outcome, those patients who had late complications, mostly PTA, had worse outcomes.

1. Introduction

Acetabulum fractures are often high-energy injuries in younger patients, and as such, they usually occur with other injuries. Regarding elder patients, a growing number are also sustaining high-energy trauma, as life expectancy has increased, and effectiveness of trauma systems has also improved. However, most acetabulum fractures in elder patients still occur secondary to low-energy falls. In developed countries, the incidence of high-energy fractures, often treated surgically, has been decreasing, while the incidence of low-energy fractures is increasing.[1–3]

While there are multiple variables that may affect recovery such as type of injury and treatment, baseline medical and psychosocial status likely have an important impact on recovery and long-term function.[4–6] A paucity of data have been published regarding patient-reported functional outcomes. Much of the existing literature is limited by poor scientific rigor of previously utilized outcomes instruments.[7] However, some of the modern generalized musculoskeletal instruments have demonstrated validity based on physical components of scores.[7,8] The purpose of this project was to evaluate functional outcomes more than 5 years after acetabulum fracture in a large sample of patients treated at a single institution, and to determine factors related to function. We hypothesized that the severity of injury, late complications, and underlying social factors would impact scores on self-reported functional assessment questionnaires.

2. Patients and methods

Adult patients treated for acetabulum fracture between 2000 and 2013 at a single level 1 trauma center were identified from a fracture registry. Institutional Review Board approval was obtained. All 765 patients with 779 fractures that were treated either nonoperatively or operatively with open reduction and internal fixation (ORIF) and had survived their initial hospital stay with a minimum of 5 years since date of injury were included. Demographic data, social history, injury features, and treatment details were abstracted from the medical record. Plain radiographic images and CT scans of the pelvis were reviewed to
provide OTA/AO and Letournel classifications of fractures.\(^9\text{-}^{11}\) Clinical and radiographic records were reviewed to detect complications related to injury and treatment, including early complications: surgical site infection, thrombotic complications; and late complications: posttraumatic arthritis (PTA), osteonecrosis, and heterotopic bone formation. Surgical site infection was defined as erythema and/or purulent drainage at the surgical site. Thrombotic complications included deep venous thrombosis noted at or proximal to the knee and pulmonary embolism. Arthritis was defined as any joint space narrowing, subchondral sclerosis, subchondral cysts, and/or osteophyte formation. Osteonecrosis was defined as subchondral sclerosis and collapse of the femoral head. Heterotopic bone was defined by any new ossification around the hip joint. Secondary procedures were documented. A minimum of 12 months of follow-up was required to assess patients clinically and radiographically for these complications.

Patients were contacted by a trained researcher not involved in their care to obtain functional outcomes surveys after minimum 5 years following injury. Contact was attempted via telephone or mail, or during a scheduled clinic visit. Functional outcomes were evaluated with the Musculoskeletal Function Assessment (MFA), a general health status measure.\(^12\) The MFA has 10 categories: mobility, hand and fine motor function, housework, self-care, sleep and rest, leisure and recreation, family relationships, cognition and thinking, emotional adjustment and adaptation, and employment. The reliability, validity, consistency, and responsiveness of the MFA has been described.\(^12\text{-}^{14}\) Overall MFA scores range from 0 to 100, with low scores indicating better function.

Clinical outcome variables included complications and secondary procedures. Functional outcomes included MFA scores. Possible predictive variables included fracture features (fracture pattern, marginal impaction, femoral head injury, history of dislocation), treatment, age, sex, BMI, Injury Severity Score (ISS), associated injuries (head, chest, abdomen, spine, extremity), and complications. A \(t\) test was used to identify associations between MFA scores and possible predictive variables. The \(t\) test or analysis of variance was used to identify associations between the functional outcomes and the clinical outcomes. In all cases, \(P < .05\) was considered significant.

### 3. Results

After a minimum of 5 years follow-up from acetabulum fracture 205 patients sustaining 210 fractures (5 patients sustained bilateral acetabular fractures) completed the MFA after mean 128 months follow-up (range: 60–219 months). The remaining 560 patients did not complete a survey: 88 patients were deceased, 6 declined, and 371 could not be reached, while 95 patients had isolated acetabular fractures. Fracture patterns and features of the acetabulum fractures are shown in Table 1.

Mean MFA for the entire group of 205 patients was 31.4, substantially worse than an uninjured reference sample population (9.3, \(P < .0001\)).\(^{14}\) Men had a trend toward lower MFA scores suggesting better outcomes than females (29.7 vs 35.2, \(P = .13\)) (see Table 2). Age when injured was not associated with MFA score. However, morbid obesity was associated with a trend toward worse outcome scores, as those with BMI >40 had mean MFA of 42.3 vs 35.7 (30–40) vs 31.5 (<30), \(P = .09\). The minority of patients were tobacco smokers (15%). 27.8% of patients were current smokers, 16.6% former smokers, and 33.2% nonsmokers. Patients who were never tobacco smokers had better functional outcomes with lower mean MFA than their counterparts (23.0, \(P < .002\)).

One hundred sixty-eight (80%) were treated with ORIF, while the others were managed nonoperatively. No difference was seen in outcomes when patients treated operatively were compared with those having nonoperative management. Neither ISS nor history of multiple (versus isolated) injuries was associated with outcome scores. Furthermore, fracture pattern, presence of associated dislocation, marginal impaction, or femoral head injury were not associated with MFA scores (Table 2).

Surgical complications were identified in 82 patients (40%). Twenty-five (12.2%) experienced early complications with 1 patient experiencing 2 early complications, and 74 patients (35.2%) had late complications. Of note, 14 patients (6.8%) had both early and late complications. Early complications included superficial infection (0.5%), deep infection (1.5%), DVT (9.3%), and pulmonary embolism (2.0%). None of these had an impact on functional outcome (Table 3), possibly due to small sample size. Overall, patients with early complications had mean MFA of 37.8 (vs 30.5, \(P = .24\)).

However, those with late complications had worse mean MFA scores (38.7 vs 27.7, \(P = .001\)). Among these, 19.5% developed PTA, 18.6% had heterotopic ossification (HO), and 4.8% had osteonecrosis. Patients with fractures which developed PTA had worse outcomes (38.0 vs 30.0, \(P = .06\)), as did those who developed HO (41.7 vs 29.2, \(P = .004\)). Twenty-two patients underwent THA for pain relief, but their MFA scores did not show improvement. Sixteen had repeat MFA after THA (mean 34.6 versus 43.3 (n = 61)).

### 4. Discussion

The purposes of this project were to evaluate functional outcomes more than 5 years after acetabulum fracture and to determine factors related to function, as reported by patients who completed the MFA. Overall the mean MFA score of 31.4 indicated substantial residual dysfunction compared with an uninjured reference value of 9.3 (\(P < .0001\)).\(^{14}\) Furthermore, the published mean MFA reference value 1 year after hip injury is 25.5, again significantly better than the mean of our group (\(P < .0001\)).\(^{14}\) Other authors have noted poor mean scores on the MFA (ranging from 25 to 36)\(^5\text{-}^{15}\) or SF-36,\(^16\text{-}^{18}\) although few have reported outcome more than 5 years after injury.\(^{16}\)

This study objectively evaluated multiple patient characteristics and injury features to assess for associations with outcome. Fracture pattern, specific features of the acetabulum fracture, and...
ISS were not related to mean MFA scores, in contrast to other authors.\textsuperscript{[5,6,19]} Kreder et al reported MFA and SF-36 scores after minimum 1 year follow-up for surgically treated posterior wall fractures. Patients with marginal impaction or associated (versus simple) patterns had worse scores.\textsuperscript{[5]} It may be that after a longer period of follow-up patients have adapted to their functional situation, and that the initial injury details seemingly have less impact over time.\textsuperscript{[20,21]}

We observed a trend for women to report worse outcomes than men. Other authors have described worse self-reported outcomes in women when compared with men, irrespective of type and severity of injury.\textsuperscript{[22–27]} Variations in culture and socialization may account for differences in reporting based on sex. Contrary to some other reports, we did not observe an effect of age on outcome scores. Prior authors have speculated that in older patients, adaptation of expectations occurs along with less strenuous physical needs, resulting in less likelihood to report dysfunction.\textsuperscript{[24,28–30]}

Recently, attention has been given to the unique challenges of managing obese patients with acetabulum fractures. Longer surgical times and poor access and visualization may result in fewer anatomic reductions.\textsuperscript{[31,32]} Early and late complications appear more likely in the obese population.\textsuperscript{[33–35]} Additionally, morbidly obese patients may have worse functional status at baseline, which would predispose to worse survey scores years later.\textsuperscript{[36,37]} Our finding of a trend toward higher mean MFA scores in morbidly obese patients is consistent with these possibilities. Our group of patients with BMI >40 was small, limiting our power to analyze them effectively. Patient education about the impact of high BMI on functional outcome scores may encourage patients to pursue weight loss.

Tobacco smoking was associated with worse outcomes with higher MFA scores than their counterparts. Regarding the deleterious biological and social consequences of tobacco smoking on healing and recovery after major fractures, much has been written.\textsuperscript{[36–42]} Tobacco smokers may have less functional capabilities at baseline, along with reduced capacity for healing and recovery of ambulatory and other functions.\textsuperscript{[43]} Recent reports further suggest that tobacco smoking has effects on intensity of pain and on the incidence of various other mental symptomatology, including depression and anxiety, all of which are likely to impact functional outcome scores.\textsuperscript{[28,29,36,44,45]} Cessation of tobacco smoking should be encouraged; although we are not able to report on potential improvement in functional outcomes following tobacco cessation.

After a minimum of 5 years follow-up complications from the early postinjury period did not have a significant impact on mean MFA scores. This is not surprising, as these issues are likely to affect functional outcomes in the longer term.\textsuperscript{[46]}

### Table 1

| Demographic and injury features are listed, including mean values as indicated or the total number of persons or fractures and percent of total |
|---------------------------------|---------------------------------|-----------------|
| **Study population (n = 205 patients with 210 fractures)** | **Excluded patients (n = 560 with 569 fractures)** | **P value** |
| Mean age (years) | 45.7 | 43.4 | .15 |
| <40 years | 75 (36.6%) | 269 (48.0%) | .009 |
| 40–60 years | 90 (43.9%) | 187 (33.4%) | |
| >60 years | 40 (19.5%) | 104 (18.6%) | |
| Male | 142 (69.3%) | 415 (74.1%) | .23 |
| Mean BMI | 30.1 | 30.2 | .91 |
| Mean ISS | 23.1 | 20.4 | .004 |
| Mechanism of injury | | | |
| Motor vehicle collision | 127 (62.0%) | 354 (63.2%) | .51 |
| Motorcycle crash | 13 (6.3%) | 47 (8.4%) | |
| Fall from height | 29 (14.2%) | 56 (10.4%) | |
| Fall from stand | 14 (6.8%) | 61 (10.9%) | |
| Other | 22 (10.7%) | 40 (7.1%) | |
| Fracture pattern: AO/OTA | | | |
| 62A | 78 (37.1%) | 267 (46.9%) | <.001* |
| 62B | 85 (40.5%) | 204 (36.4%) | |
| 62C | 47 (22.4%) | 95 (16.7%) | |
| Fracture pattern: Letournel | | | |
| Posterior wall | 46 (21.9%) | 166 (29.3%) | |
| Posterior column | 3 (1.4%) | 13 (2.3%) | |
| Posterior column and wall | 19 (9.1%) | 51 (9.0%) | |
| Transverse | 15 (7.1%) | 46 (8.1%) | |
| Transverse and post wall | 39 (18.6%) | 96 (17.1%) | |
| T | 20 (9.5%) | 43 (7.6%) | |
| Anterior wall | 0 | 6 (1.1%) | |
| Anterior column | 11 (5.2%) | 29 (5.1%) | |
| Anterior column posterior hemitransverse | 23 (11.0%) | 43 (7.6%) | |
| Associated both column | 34 (16.3%) | 75 (13.3%) | |
| Injury features: | | | |
| Posterior dislocation | 90 (42.9%) | 247 (43.4%) | .87 |
| Femoral head injury | 17 (8.1%) | 49 (8.6%) | .72 |
| Marginal impaction | 34 (16.2%) | 99 (17.4%) | .92 |
| Isolated acetabulum fracture | 49 (23.9%) | 143 (25.5%) | .54 |

Column 1 represents the study population with functional outcomes data more than 5 years after injury. Column 2 shows the excluded patients for comparison. BMI = body mass index; ISS = Injury Severity Score; OTA/AO = fracture classification as described by the OTA/AO.
* Comparison vs both other groups.
resolved within the several months following injury and are unlikely to generate later medical or functional consequences. Another instrument specific to hip function may have been more able to detect differences among patients. In contrast, late complications, especially PTA and HO, were associated with very poor mean MFA scores, which is consistent with other studies with shorter follow-up. \cite{5, 6, 46, 47} Our study is limited in that we did not attempt to determine impact of secondary procedures for pain relief, specifically THA, on functional outcome scores. We did not assess potential influence of fracture pattern or of reduction quality on development of PTA; however, it is well established that fracture patterns, involving posterior wall or dome impaction or comminution, are more likely to result in PTA. \cite{5, 6, 18, 48, 49} Reduction quality also plays a key role in mitigating PTA. \cite{5, 6, 15, 16, 18} Our data also showed no differences in MFA scores when operative and nonoperative patients were compared; however, this probably reflects that nonoperative patients had less displaced fractures, which portend a better long-term prognosis. Displaced fractures when treated surgically overall appear to have similar mean functional outcomes, indicating the value of reduction and fixation in improving function.

Other limitations to this study include a large percentage of patients who were lost to follow-up, possibly following up at other institutions whose records would not be seen within our electronic medical record. Furthermore, patients experiencing difficulties, whether from their acetabulum or from other injuries, could be more likely to follow up and report dysfunction. We noted the initial group had lower ISS and a trend toward more isolated injuries. However, this paper does have a large sample, with moderate mean follow-up, and it adds to the small body of existing literature on this topic, in a time where increasing emphasis is being placed on patient-reported outcomes.

After minimum 5-year follow-up from acetabulum fracture, functional limitation was observed frequently according to self-reported MFAs. Worse functional outcomes were associated with late complications, morbid obesity, and tobacco smoking. While fracture pattern was not associated with outcome, those patients who had late complications, mostly PTA and HO, had worse outcomes. This information will aid in counseling patients with underlying risk factors, such as obesity and tobacco smoking about effects on function more than 5 years following injury.

### Table 2

|                | n   | Mean MFA score | P value |
|----------------|-----|----------------|---------|
| Male           | 142 | 29.7           | .13     |
| Female         | 63  | 30.7           |         |
| Age <40 years  | 75  | 36.6           |         |
| Age 40–60 years| 90  | 43.9           |         |
| Age >60 years  | 40  | 19.5           | .48†    |
| BMI<30         | 77  | 53.8           |         |
| BMI 30–40      | 46  | 33.6           |         |
| BMI >40        | 18  | 12.6           | .09†    |
| Current smoker | 57  | 35.8           |         |
| Former smoker  | 34  | 21.4           |         |
| Nonsmoker      | 68  | 42.8           | <.002†  |

Fracture pattern:

|                | n   | Mean MFA score | P value |
|----------------|-----|----------------|---------|
| 62A            | 78  | 37.1           |         |
| 62B            | 85  | 40.5           | .07*    |
| 62C            | 47  | 22.4           | .39*    |
| Low-energy injury| 36 | 17.6           | .29     |
| High-energy injury| 169| 82.4           | .45     |
| Operative      | 168 | 80.0           |         |
| Nonoperative   | 42  | 20.0           |         |
| Isolated injury| 49  | 23.9           | .22     |
| Multiple injuries| 156| 76.1           | .29     |
| ISS<24         | 71  | 56.8           | .97     |
| ISS≥24         | 54  | 43.2           | .38     |

Injury features:

|                | n   | Mean MFA score | P value |
|----------------|-----|----------------|---------|
| Posterior dislocation | 90 | 42.9% | .62 |
| Femoral head injury | 17 | 8.1% | .84 |
| Marginal impaction | 34 | 16.2% | .60 |

### Table 3

| Complications and secondary operations | n       | Mean MFA score | P value |
|----------------------------------------|---------|----------------|---------|
| Early complications                     | 25      | 12.2%          | .24     |
| None                                   | 180     | 30.5           |         |
| Superficial infection                   | 1       | 0.5%           | 47.0    |
| Deep infection                          | 3       | 1.5%           | 37.7    |
| None                                   | 203     | 98.0%          | 31.2    |
| DVT                                     | 19      | 93.3%          | 34.3    |
| No DVT                                  | 188     | 90.7%          | 31.0    |
| PE                                      | 4       | 2.0%           | 38.0    |
| No PE                                   | 201     | 98.1%          | 31.3    |
| Late complications                      | 74      | 35.2%          | .001    |
| None                                   | 136     | 64.8%          | 27.7    |
| PTA                                     | 41      | 19.5%          | .06     |
| No PTA                                  | 169     | 80.5%          | 30.0    |
| Osteonecrosis                           | 10      | 4.8%           | 45.8    |
| No osteonecrosis                        | 200     | 95.2%          | 30.8    |
| Ho                                      | 39      | 18.6%          | 41.7    |
| Secondary operation                     | 171     | 81.4%          | 29.2    |
| No secondary operation                  | 173     | 81.4%          | 30.4    |

DVT = deep vein thrombosis; HO = heterotopic ossification; PE = pulmonary embolism; PTA = posttraumatic arthritis.

### References

1. Boudissa M, Francomy F, Kerschbaumer G, et al. Epidemiology and treatment of acetabular fractures in a level-1 trauma centre: retrospective study of 414 patients over 10 years. Orthop Traumatol Surg Res. 2017;103:333–339.
2. Mauler C, Hao J, Cuellar DO, et al. The epidemiology and injury patterns of acetabular fractures: are the USA and China comparable? Clin Orthop Relat Res. 2014;472:3332–3337.
3. Rinner PP, Latein MK, Huttunen T, Kannus P, Mattila VM. The incidence and trauma mechanism of acetabular fractures: a nationwide study in Finland between 1997-2014. Injury. 2017;48:2157–2161.
4. Kandasamy MS, Duraisamy M, Ganeshanker K, Kurup VG, Radhakrishnan S. Acetabular fractures: an analysis on clinical outcomes of surgical treatment. Int J Res Orthop. 2017;3:122–126.
5. Kredel HJ, Zozen N, Birkofer CM, et al. Determinants of functional outcome after simple and complex acetabular fractures involving the posterior wall. J Bone Joint Surg Br. 2006;88-B:776–782.
6. Moed BR, Yu PH, Gruson KI. Functional outcomes of acetabular fractures. J Bone Joint Surg Am. 2003;85:1879–1883.
7. Dodi A, Osterhoff G, Guy P, Lefaivre KA. Assessment of functional outcomes of surgically managed acetabular fractures. A systematic review. Bone Joint J. 2016;98-B:690–695.
8. Lefaivre KA, Slobogean GP, Ngai JT, Broekhuysen HM, O’Brien PJ. What outcomes are important for patients after pelvic trauma? Subjective responses and psychometric analysis of three published pelvic-specific instruments. J Orthop Trauma. 2014;28:3–27.
9. Judet R, Judet J, Letournel E. Fractures of the acetabulum: classification and surgical approaches for open reduction. J Bone Joint Surg Am. 1964;46-A:1615–1646.
10. Letournel E. Acetabulum fractures: classification and management. Clin Orthop Relat Res. 1980;151:81–106.

11. Marsh JL, Slono TF, Age J, et al. Fracture and dislocation classification compendium–2007: Orthopaedic Trauma Association classification database and outcomes committee. J Orthop Trauma. 2007;21(suppl 10): S1–S3.

12. Martin DP, Engelberg R, Age J, Snapp D, Swiontkowski MF. Development of a musculoskeletal extremity health status instrument: The Musculoskeletal Function Assessment instrument. J Orthop Res. 1996;14:173–181.

13. Engelberg R, Martin DP, Age J, Obremsky W, Coronado G, Swiontkowski MF. Musculoskeletal Function Assessment instrument: criterion and construct validity. J Orthop Res. 1996;14:182–192.

14. Engelberg R, Martin DP, Age J, Swiontkowski MF. Musculoskeletal Function Assessment: reference values for patient and non-patient samples. J Orthop Res. 1999;17:101–109.

15. Moed BR, McMichael JC. Outcomes of posterior wall fractures of the acetabulum. J Bone Joint Surg Am. 2007;89:1170–1176.

16. Borg T, Hailer NP. Outcome 5 years after surgical treatment of acetabular fractures: a prospective clinical and radiographic follow-up of 101 patients. Arch Orthop Trauma Surg. 2015;135:227–233.

17. Frietman B, Bier J, Edwards MJR. Patient-reported outcome measures after surgery for an acetabular fracture. Bone Joint J. 2018;100-B:640–645.

18. Pascarella R, Cerbasi S, Politano R, et al. Surgical results and factors influencing outcome in patients with posterior wall acetabular fracture. Injury. 2017;48:1819–1824.

19. MacKenzie EJ, Burgess AR, McAndrew MP, et al. Patient-oriented functional outcome after unilateral extremism fracture. J Orthop Trauma. 1993;7:393–401.

20. Ringburg AK, Polnder S, van Ierland MC, et al. Prevalence and prognostic factors of disability after major trauma. J Trauma. 2001; 70:916–922.

21. Sober HL, Koese O, Bautz-Holter E, Finset A. Returning to work after severe multiple injuries: multidimensional functioning and the trajectory from injury to work at 5 years. J Trauma. 2011;71:425–434.

22. Heilbrook TL, Hoyt DB. The impact of major trauma: quality-of-life outcomes are worse in women than in men, independent of mechanism and injury severity. J Trauma. 2004;56:284–290.

23. Holtslag HR, van Beeck EF, Lindeman E, Leenen LP. Determinants of long-term functional consequences after major trauma. J Trauma. 2007; 62:919–927.

24. McCarthy ML, MacKenzie EJ, Bossie MJ, Copeland CE, Hash CS, Burgess AR. Functional status following orthopedic trauma in young women. J Trauma. 1995;39:828–836.

25. Probst C, Zelle B, Panzica M, et al. Clinical re-examination 10 or more years after polytrauma: Is there a gender related difference? J Trauma. 2010;68:706–711.

26. O’Toole RV, Castillo RC, Pollak AN, MacKenzie EJ, Bossie MJ, LEAP Study Group. Determinants of patient satisfaction after severe lower-extremity injuries. J Bone Joint Surg Am. 2008;90-A: 1206–1211.

27. Vallier HA, Cureton BA, Schubeck D, Wang XF. Functional outcomes in women after high energy pelvic fracture. J Orthop Trauma. 2012; 26:286–301.

28. MacKenzie EJ, Bossie MJ, Kellam JF, et al. Early predictors of long-term work disability after major limb trauma. J Trauma. 2006;61:688–694.

29. MacKenzie EJ, Bossie MJ, Pollak AN, et al. Long-term persistence of disability following severe lower-limb trauma. Results of a seven-year follow-up. J Bone Joint Surg Am. 2005;87:1801–1809.

30. Ryan SP, Mansson TT, Scadini MF, et al. Functional outcomes of elderly patients with nonoperatively treated acetabular fractures that meet operative criteria. J Orthop Trauma. 2017;31:644–649.

31. Porter SE, Russell GV, Dews RC, Qin Z, Woodall JR, Graves ML. Complications of acetabular fracture surgery in morbidly obese patients. J Orthop Trauma. 2008;22:589–594.

32. Karunakar MA, Shah SN, Jerabek S. Body mass index as a predictor of complications after operative treatment of acetabular fractures. J Bone Joint Surg Am. 2005;87:1498–1502.

33. Childs BR, Nahm NJ, Dolen AJ, Vallier HA. Obesity is associated with more complications and longer hospital stays after orthopaedic trauma. J Orthop Trauma. 2015;29:504–509.

34. Morris BJ, Richards JE, Guillamondegu E, et al. Obesity increases early complications after high-energy pelvic and acetabular fractures. Orthopedics. 2015;38:e881–e887.

35. Verbeck DO, van de List JP, Tissue CM, Helfet DL. Predictors for long-term hip survivorship following acetabular fracture surgery: importance of gap compared with step displacement. J Bone Joint Surg Am. 2018;100:922–929.

36. Sprague S, Bhandari M, Heevelt MJ, et al. Factors associated with health-related quality of life, hip function, and health utility after operative management of femoral neck fractures. Bone Joint J. 2018;100-B:361–369.

37. Zielinski SM, Keijsers NL, Praet SF, et al. Functional outcome after successful internal fixation versus salvage arthroplasty of patients with a femoral neck fracture. J Orthop Trauma. 2014;28:e273–e280.

38. Castillo RC, Bossie MJ, MacKenzie EJ, Patterson BM. LEAP Study Group. Impact of smoking on fracture healing and risk of complications in limb-threatening open tibia fractures. J Orthop Trauma. 2005;19:151–167.

39. Harvey EJ, Age J, Selznick HS, Chapman JR, Henley MB. Deleterious effect of smoking on healing of open tibia-shaft fractures. Am J Orthop. 2002;31:518–521.

40. Herrugou J, Schind F. Smoking as a predictor of negative outcome in diaphyseal fracture healing. Int Orthop. 2013;37:883–887.

41. Napora JK, Grimberg D, Childs BR, Vallier HA. Factors affecting functional outcomes after clavicle fracture. J Am Acad Orthop Surg. 2016;24:721–727.

42. Vallier HA, Cureton BA, Patterson BM. Factors affecting functional outcomes after distal tibia fractures. J Orthop Trauma. 2012;26: 178–183.

43. Borrelli Jr Jr, Goldfarb C, Rucci W, Wagner JM, Engberg JR. Functional outcome after isolated acetabular fractures. J Orthop Trauma. 2002;16:73–81.

44. Busto UE, Redden L, Mayberg H, Kapys S, Houle S, Zawertailo LA. Dopaminergic activity in depressed smokers: a positron emission tomography study. Synapse. 2009;63:681–689.

45. Ditre JW, Zale EI, LaRowe LR, Kosiba JD, De Vita MJ. Nicotine deprivation increases pain intensity, neurogenic inflammation, and mechanical hyperalgesia among daily tobacco smokers. J Abnorm Psychol. 2018;127:578–589.

46. Braun EJ, Wrona J, Veith NT, et al. Predictive value of clinical scoring and simplified gait analysis for acetabulum fractures. J Surg Res. 2016;206:405–410.

47. Engberg JR, Steger-May K, Anglen JO, Borrelli Jr Jr. An analysis of gait changes and functional outcomes in patients surgically treated for displaced acetabular fractures. J Orthop Trauma. 2009;23:346–353.

48. Anglen JO, Burd TA, Hendricks KJ, Harrison P. “The Gull sign” a harbinger of failure for internal fixation of geriatric acetabular fractures. J Orthop Trauma. 2003;17:625–634.

49. Saterbak AM, Marsh JL, Nepola JV, Brandser EA, Turbett T. Clinical complications of acetabular fracture surgery in morbidly obese patients. J Orthop Trauma. 2009;157:1648–1657.

50. Leard Jr, Sturdevant KL, Idell TA, et al. Prediction of postoperative complications after pelvic and acetabular trauma. J Trauma. 2000;49:380–385.

51. Schwab AE, Fehring TK, Fehring TE, et al. Pelvic and acetabular trauma: a comprehensive review. J Orthop Trauma. 2005;19:157–162.

52. Ditre JW, Zale EI, LaRowe LR, Kosiba JD, De Vita MJ. Nicotine deprivation increases pain intensity, neurogenic inflammation, and mechanical hyperalgesia among daily tobacco smokers. J Abnorm Psychol. 2018;127:578–589.