A cetabular fractures occur in approximately 3 per 100,000 individuals annually,1 making their management and rehabilitation a concern for orthopedic surgeons. Approximately 30% of all acetabular fractures are posterior wall fractures.2 These injuries are many times thought to be simple in nature because of their single fracture plane and surgeon familiarity with the posterior approach to the hip, but this is often not the case.3 Although overall outcomes of surgically managed acetabular fractures tend to be positive at long-term follow-up (excellent results in 75% to 81% of cases),1,4,5 posterior wall fractures have a disproportionately large number of poor results4,6 (unsatisfactory results in 18% to 32% of cases).3 Complications include sciatic nerve injury (3% to 18%), heterotopic ossification (7% to 20%), and osteonecrosis of the femoral head (5% to 8%).6 Fixation is far superior to conservative management in terms of long-term func-

abstract

Despite overall improved outcomes with open reduction and internal fixation of acetabular fractures, posterior wall fractures show disproportionately poor results. The effect of weight bearing on outcomes of fracture management has been investigated in many lower extremity fractures, but evidence-based recommendations in posterior wall acetabular fractures are lacking. The authors systematically reviewed the current literature to determine if a difference in outcome exists between early and late postoperative weight-bearing protocols for surgically managed posterior wall acetabular fractures. PubMed and MEDLINE were searched for posterior wall acetabular fracture studies that included weight-bearing protocols and Merle d’Aubigné functional scores. Twelve studies were identified. Each study was classified as either early or late weight bearing. Early weight bearing was defined as full, unrestricted weight bearing at or before 12 weeks postoperatively. Late weight bearing was defined as restricted weight bearing for greater than 12 weeks postoperatively. The 2 categories were then compared by functional score using a 2-tailed t test and by complication rate using chi-square analysis. Six studies (152 fractures) were placed in the early weight-bearing category. Six studies (302 fractures) were placed in the late weight-bearing category. No significant difference in Merle d’Aubigné functional scores was found between the 2 groups. No difference was found regarding heterotopic ossification, avascular necrosis, superficial infections, total infections, or osteoarthritis. This systematic review found no difference in functional outcome scores or complication rates between early and late weight-bearing protocols for surgically treated posterior wall fractures. [Orthopedics. 2017: 40(4):e652-e657.]
tional outcome; however, the effects of the rehabilitation protocol are unclear.

The relationship between mechanical loading forces and the healing of fractures is garnering increasing interest. Bone healing after a fracture progresses through 3 subsequent, yet overlapping, phases: inflammation, bone production, and bone remodeling. Central to this process is the intricate communication and function of osteocytes, osteoblasts, and osteoclasts by the receptor activator of nuclear factor kappa B ligand and osteoprotegerin. Mechanical loading can also induce bone production and bone remodeling through a similar mechanism. Loading forces increase hydrostatic pressure gradients within the lacunae, stimulating osteocyte production of osteoprotegerin.

Although early loading has the potential to aid in bone formation and fracture healing, the relationship appears to be beneficial only at intermediate levels of strain. High levels of strain have been shown to increase the likelihood of weaker, fibrous union. This theory is further supported by animal models showing that moderate axial loading leads to greater bone formation and faster time to union compared with no loading or excessive early loading.

Varying postoperative rehabilitation protocols for posterior wall fractures, ranging from immediate partial weight bearing with progression to full weight bearing after 6 weeks as tolerated to limited weight bearing after 12 weeks with full weight bearing only after clinical and radiographic union, are reported in the literature. The most common protocol recommends touchdown weight bearing for 6 to 12 weeks postoperatively with gradual progression to full weight bearing.

Early weight bearing has been studied extensively in many lower extremity fractures and has shown varying degrees of postoperative benefit; however, explicit studies on weight bearing in acetabular fractures are lacking. The purpose of this study was to review the current literature on weight bearing for surgically managed posterior wall acetabular fractures to determine if a statistically significant difference in outcome exists between early and late weight-bearing protocols.

**MATERIALS AND METHODS**

The authors’ methods followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist and flow diagram (Figure). PubMed and MEDLINE were searched up to May 31, 2015. Key words used were posterior wall acetabular fracture, acetabular, fracture, weight bearing, weight-bearing, Merle, and d’Aubigné. A total of 207 articles were identified.

Only studies exclusively about posterior wall acetabular fractures or separating this type from other acetabular fractures, stating postoperative weight-bearing protocol, and including Merle d’Aubigné score distribution and/or average score were included. Studies not in English, case reports, letters, editorials, and abstracts without corresponding fully referenced articles were excluded.

The reference list of each included article was analyzed for additional relevant publications.

Risk of bias for individual studies was assessed prior to data extraction and contributed to the overall strength of the body of evidence. Potential bias across studies was found not to impact the cumulative evidence presented in this study.

A total of 12 studies/articles were ultimately selected for inclusion. Information extracted from each article included

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**Figure**: Process of article selection.

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Citation acquired from search: PUBMED: 145 MEDLINE: 62

181 excluded for not meeting eligibility criteria

26 potentially relevant studies retrieved in full text for more detailed analysis

14 studies excluded for not meeting eligibility criteria

12 studies included in systematic review
<table>
<thead>
<tr>
<th>Article (Year)</th>
<th>Study Type</th>
<th>Mean (Range) Age, y</th>
<th>No. of Fractures</th>
<th>Weight-Bearing Schedule</th>
<th>Fracture Type(s)</th>
<th>Repair Type(s)</th>
<th>Average Merle d'Aubigné Score or Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magu et al¹¹ (2014)</td>
<td>Retrospective case series</td>
<td>41 (25-60)</td>
<td>25</td>
<td>Partial weight bearing for 6 weeks, gradual progression to full from 6 to 12 weeks</td>
<td>Posterior wall acetabular fracture</td>
<td>ORIF</td>
<td>14.92-16.92</td>
</tr>
<tr>
<td>Matta et al⁴ (1996)</td>
<td>Prospective case series</td>
<td>Not clear</td>
<td>22</td>
<td>30-lb weight bearing beginning in the 1st week, full weight bearing allowed after 8 weeks</td>
<td>Posterior wall acetabular fracture</td>
<td>ORIF</td>
<td>12.72-15.81</td>
</tr>
<tr>
<td>Saterbak et al¹² (2000)</td>
<td>Retrospective case series</td>
<td>35 (20-78)</td>
<td>42</td>
<td>Non-weight bearing for 6 weeks, progressive weight bearing for the next 6 weeks</td>
<td>Posterior wall acetabular fracture</td>
<td>ORIF</td>
<td>15.2</td>
</tr>
<tr>
<td>Mitsionis et al¹³ (2012)</td>
<td>Retrospective case series</td>
<td>36 (16-54)</td>
<td>19</td>
<td>Full weight bearing by 8 to 28 weeks (mean, 21 weeks)</td>
<td>Posterior wall acetabular fracture with dislocation</td>
<td>ORIF in all but 1 case</td>
<td>15</td>
</tr>
<tr>
<td>Moed et al¹⁴ (2002)</td>
<td>Prospective case series</td>
<td>38 (16-74)</td>
<td>100</td>
<td>Toe-touch weight bearing (20-30 lb) for 10 to 12 weeks</td>
<td>Posterior wall acetabular fracture</td>
<td>ORIF</td>
<td>15.93-16.93</td>
</tr>
<tr>
<td>Giannoudis et al¹⁵ (2007)</td>
<td>Prospective case series</td>
<td>42 (19-79)</td>
<td>29</td>
<td>Toe touch (crutches/walker) began at 6 to 12 weeks, full weight bearing by 3 months</td>
<td>Comminuted and displaced posterior acetabular fractures</td>
<td>ORIF using 2-level reconstruction technique</td>
<td>15.79-16.62</td>
</tr>
<tr>
<td>Zhang et al¹⁶ (2014)</td>
<td>Retrospective cohort study</td>
<td>35.7 (18-61)</td>
<td>53</td>
<td>Toe touch (crutches/walker) for 3 months, then weight bearing unaided</td>
<td>Posterior wall acetabular fracture</td>
<td>ORIF with either WAAP or pelvic reconstruction plate</td>
<td>15.17</td>
</tr>
<tr>
<td>Ebraheim et al¹⁷ (2007)</td>
<td>Retrospective case series</td>
<td>41 (14-80)</td>
<td>32</td>
<td>Toe touch (10 kg) with walkers from day 2 to 3 months, full weight bearing after 3 months</td>
<td>Posterior wall acetabular fracture</td>
<td>ORIF with buttress technique</td>
<td>14.53-16.00</td>
</tr>
<tr>
<td>Zhang et al¹⁸ (2014)</td>
<td>Prospective cohort study</td>
<td>47 (30-77)</td>
<td>50</td>
<td>Walker from 2 to 6 weeks, toe-touch crutches at 6 to 12 weeks, weight bearing as tolerated after 12 weeks</td>
<td>Comminuted posterior wall acetabular fracture</td>
<td>ORIF ATMFS or conventional plates</td>
<td>14.59</td>
</tr>
<tr>
<td>Pascaletta et al¹⁹ (2014)</td>
<td>Prospective case series</td>
<td>57.6 (26-89)</td>
<td>10</td>
<td>No weight bearing for 12 weeks</td>
<td>Comminuted posterior acetabular fractures</td>
<td>ORIF with autogenous bone graft</td>
<td>14.90-16.20</td>
</tr>
<tr>
<td>Im et al²⁰ (2005)</td>
<td>Retrospective case series</td>
<td>41 (21-61)</td>
<td>15</td>
<td>Partial weight bearing with one-tenth of body weight and crutches starting at week 2 to 10, full weight bearing only after radiographic union (8 to 24 weeks)</td>
<td>Posterior wall acetabular fracture</td>
<td>ORIF screws only</td>
<td>16.7</td>
</tr>
<tr>
<td>Li et al²¹ (2014)</td>
<td>Randomized, prospective study</td>
<td>41.5 (21-65)</td>
<td>57</td>
<td>Limited weight bearing after 12 weeks, full weight bearing after radiographic and clinical union</td>
<td>Posterior wall acetabular fracture</td>
<td>ORIF with 2 parallel plates</td>
<td>16.05-17.33</td>
</tr>
</tbody>
</table>

Abbreviations: ATMFS, acetabular tridimensional memory fixation system; ORIF, open reduction and internal fixation; WAAP, W-shaped acetabular angular plate.

¹ Studies reported early weight bearing.
² Studies reported late weight bearing.
mean age, age range, weight-bearing schedule, fracture classifications, surgical technique, number of fractures, Merle d’Aubigné score distribution, Merle d’Aubigné average score, average hospital length of stay, and complications. If any of these data were missing, an attempt was made to reach the primary author of the article.

The 12 studies were divided into 2 groups: early weight bearing and late weight bearing. Early weight bearing was defined as full, unrestricted weight bearing at or before 12 weeks postoperatively. Late weight bearing was defined as restricted weight bearing for greater than 12 weeks postoperatively. All fractures from the early group were combined and then compared against all fractures from the late group. Functional scores were compared using a 2-tailed $t$ test. Complication rates were compared using chi-square analysis.

**RESULTS**

The authors’ search yielded no studies that explicitly examined the effects of postoperative weight bearing on outcomes for surgically treated posterior wall fractures. The authors identified a total of 12 articles (Figure) on posterior wall acetabular fracture that stated the weight-bearing protocol and the Merle d’Aubigné functional scores (Table 1).^5,11-21^ A review of the included articles revealed that the typical postoperative weight-bearing protocol for posterior wall acetabular fractures involves a progressive but limited weight-bearing schedule for the first 12 weeks, followed by full weight bearing thereafter. Table 1 is organized from most liberal weight-bearing schedule to most conservative. Although the authors found that these articles did not necessarily examine the same posterior wall fracture subtypes or repair techniques, all were included to increase power.

The Merle d’Aubigné functional score comparison for early vs late group is summarized in Table 2. The authors were able to analyze the 2 groups using a 2-tailed $t$ test, which yielded a nonsignificant $P$ value of .76.

The authors also examined complication rates using chi-square analysis. The $P$ values for heterotopic ossification, femoral head avascular necrosis, superficial infections, total infections, and osteoarthritis are summarized in Table 3. No significant difference in any specific complication was noted between the 2 groups. There was no reported bias within any of the 12 studies included in the authors’ analysis. However, the potential exists for selection bias overall (studies with more difficult cases or certain repair types may have received prolonged immobilization).

**DISCUSSION**

Fractures of the posterior wall are the most common acetabular fractures.^^^^ Absolutesurgical indications for these injuries include inability to achieve or maintain a closed reduction, deteriorating sciatic nerve function after attempted closed reduction, and the presence of an incarcerated fragment that prevents congruent reduction of the femoral head into the intact portion of the acetabulum. Although these fractures can have a relatively simple appearance on plain radiographs and the surgical approach is familiar to most surgeons, studies have shown that the complexity of these injuries can vary widely.^^^^ These fractures can be comminuted and prove difficult to anatomically reduce and can be associated with depression of the articular surface, or marginal impaction, predisposing to poor results.^^^^ Poor results have been reported in 10% to 32% of posterior fractures, even with anatomic reduction.^^^^ Surgical indications and techniques for treating these injuries have been well described; however, postoperative weight-bearing protocols have not been explicitly investigated.^^^^ Even small posterior wall fractures can significantly alter joint mechanics. Notwithstanding an anatomical reduction with lag screws and a reconstruction plate, fixation does not restore the load-to-failure to preinjury measurements, and there is a relatively small difference between construct strength and strength required for physiologic loads. This knowledge prompts the postoperative weight-bearing restrictions placed on these patients.

Early postoperative weight bearing is of increasing interest in orthopedic trauma. Early loading has the potential to aid in bone formation and fracture healing, provided that only moderate strain at the fracture site can be maintained. Additionally, Westerman et al showed that weight-bearing restriction significantly increases energy expenditure. Multiple

### Table 2

<table>
<thead>
<tr>
<th>Weight-Bearing Group</th>
<th>Average Functional Score</th>
<th>Total No. of Fractures</th>
<th>Variance</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>15.50</td>
<td>152</td>
<td>9.82</td>
<td>3.13</td>
</tr>
<tr>
<td>Late</td>
<td>15.80</td>
<td>302</td>
<td>10.32</td>
<td>3.21</td>
</tr>
</tbody>
</table>

### Table 3

<table>
<thead>
<tr>
<th>Complication</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heterotopic ossification</td>
<td>.993</td>
</tr>
<tr>
<td>Avascular necrosis</td>
<td>.306</td>
</tr>
<tr>
<td>Superficial infection</td>
<td>.481</td>
</tr>
<tr>
<td>Total infection</td>
<td>.579</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>.343</td>
</tr>
</tbody>
</table>

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Note: The table entries are placeholders and do not represent actual data from the referenced text.
studies have supported a benefit of early weight bearing, including faster return to work and improved patient quality of life and functional scores. However, due to the lack of literature regarding postoperative weight-bearing protocols in the management of posterior wall fractures, it remains unclear whether early weight bearing provides significant benefit and affects complication rates.

This systematic review yielded a wide range of postoperative weight-bearing protocols, although none of the studies was explicitly designed to test the relationship between weight bearing and outcomes. By dividing the included studies into those with unrestricted weight bearing before or after the 12-week point, the authors attempted to stratify outcomes based on early and late postoperative weight bearing. They found no significant difference between the 2 groups regarding Merle d’Aubigné functional scores or complication rates.

The current study’s design had several limitations. To increase the number of included studies, fracture subtype and fixation constructs remained heterogeneous. The experience level of surgeons performing the procedures was not stated in most of the studies. As with most retrospective studies evaluating weight-bearing protocols, it is impossible to accurately identify patient compliance with recommendations or those patients who “autoprotect” their weight bearing. Additionally, not all studies included average Merle d’Aubigné functional score and standard deviation. Average Merle d’Aubigné scores were estimated by converting the categorical description into maximal and minimal possible numerical equivalents and taking the median of that range. Likewise, only 3 of the 12 studies provided a standard deviation for Merle d’Aubigné score (Im et al., 2014; Zhang et al., 2014; Zhang et al., 2014). To compensate for this, the authors combined the 3 studies to determine a “typical” standard deviation (3.11) for the Merle d’Aubigné functional score. This number was then assigned to each of the studies that lacked a standard deviation.

These data indicate that there may be no difference in functional outcomes or complication rates with early vs late weight bearing for surgically managed posterior wall acetabular fractures. Therefore, should all of these patients be allowed to bear weight earlier rather than later?

**CONCLUSION**

Although the authors’ analysis indicated that there may be no difference in functional outcome scores or complication rates between early and late weight-bearing protocols, they believe that high-quality, prospective, randomized controlled trials on this topic are needed.

**REFERENCES**

24. Moed BR, Carr SE, Gruson KI, Watson JT, Craig JG. Computed tomographic assess-


