

Outcomes of Posterior Wall Fractures of the Acetabulum

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Background: The Musculoskeletal Function Assessment (MFA) is a validated, reliable, self-administered questionnaire that is useful for determining functional status. The Merle d'Aubigné score is a clinical measure of hip function. The purpose of the present study was to evaluate the outcome information provided by these two instruments after operative treatment of elementary posterior wall fractures of the acetabulum.

Methods: Forty-six patients who had been followed for a minimum of two years after operative treatment of an elementary posterior wall fracture of the acetabulum were included in the study. Functional outcomes were assessed with use of the ten individual indices and total score of the MFA, and clinical outcomes were evaluated with use of the Merle d'Aubigné score. The MFA scores were compared with previously reported normative values and with previously reported values for similar patients with hip injuries. The duration of follow-up ranged from two to fourteen years (mean, five years).

Results: The mean Merle d'Aubigné score was 17 (standard deviation, 1; range, 14 to 18), indicating overall good-to-excellent clinical results. However, the mean total MFA score was 23.17, which was significantly worse than the normative mean of 9.26 ($p < 0.001$). All MFA indices except hand/fine motor were similarly significantly worse than expected norms. The mean MFA total score was statistically similar to that reported by others for patients with hip injuries. The emotional category of the MFA score was found to be an important determinant of the total score. The Spearman rho correlation coefficient between the Merle d'Aubigné score and the MFA score was -0.62 ($p < 0.001$). However, the Merle d'Aubigné score data were asymmetric, demonstrating a ceiling effect (crowding of the scores at the upper end of the scale, limiting the ability of the score to demonstrate differences between patients with supposedly better clinical outcomes).

Conclusions: The total MFA scores for patients with a posterior wall fracture of the acetabulum were significantly worse than normative reference values. Thus, complete recovery after a posterior wall fracture of the acetabulum is uncommon, with residual functional deficits involving wide-ranging aspects of everyday living that do not necessarily have an obvious direct connection to hip function. Although the modified Merle d'Aubigné score may be useful for evaluating isolated hip function in patients who have been treated for an acetabular fracture, its shortcomings limit its usefulness as a method for evaluating functional outcome in these patients. Research efforts should be directed toward the identification of the psychosocial and other underlying determinants of functional outcome and potential related treatment interventions.

A modified version of the Merle d'Aubigné clinical hip score is currently the most generally accepted clinical grading system for evaluating outcomes after acetabular fractures¹⁻³. Widespread use of this clinical measure of hip function (or one of its derivatives) originates from the classic publications of Letournel and Judet^{4,5} describing the grading

of outcomes following acetabular fractures. However, a previous study showed the limited usefulness of the Merle d'Aubigné score as a method to evaluate the functional outcome following treatment of an acetabular fracture⁶. The Musculoskeletal Function Assessment (MFA) is a 101-item self-reported health-status instrument designed for patients

Disclosure: The authors did not receive any outside funding or grants in support of their research for or preparation of this work. Neither they nor a member of their immediate families received payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund, foundation, division, center, clinical practice, or other charitable or nonprofit organization with which the authors, or a member of their immediate families, are affiliated or associated.

with disorders of the musculoskeletal system, including fractures⁷. It has been shown to be stable and to have internal consistency, content validity, and criterion validity⁷⁻¹⁰. The purpose of the present study was to evaluate the outcome information provided by these two instruments after operative treatment of elementary posterior wall fractures of the acetabulum.

Materials and Methods

Beginning in 1996, all patients returning for outpatient follow-up at one year or more after surgical treatment of an acetabular fracture were asked to complete the MFA health status questionnaire. The patients' outcome was further evaluated with use of a modified Merle d'Aubigné clinical score^{2,11}. To be included in the study group, the patient had to have had a unilateral elementary type posterior wall fracture of the acetabulum as defined by Letournel and Judet¹ (OTA type 62-A1¹²) and a minimum of two years of postoperative follow-up, including a complete physical examination with a modified Merle d'Aubigné score and successful completion of the MFA questionnaire. The patients were enrolled from a cohort of 703 patients in whom an acetabular fracture had been treated operatively by one surgeon (B.R.M.) between 1984 and 1999 according to a standardized protocol^{2,11,13}. Of the 221 patients who initially enrolled in the study, seventy-one did not provide all of the required data and 104 had fracture types other than a unilateral elementary posterior wall fracture of the acetabulum, leaving forty-six patients for study. These forty-six patients are a subset of a previously reported larger series of 150 patients with acetabular fractures of all types⁵. The authors of the previous study analyzed the outcomes of treatment of all ten acetabular fracture types. However, they did not individually address the outcome of the posterior wall fracture, which is the most common type of acetabular fracture and also considered the simplest type. Furthermore, the impact of this common injury on specific aspects of daily living (as represented by the subscores of the MFA) was not addressed in the previous study. The duration of follow-up of the present study, which was approved by our institutional review board, ranged from two to fourteen years (mean, five years).

There were thirty-seven male and nine female patients, ranging in age from seventeen to sixty-five years (mean, thirty-six years) at the time of injury. The acetabular fracture was on the left side in twenty patients and on the right in twenty-six. Twenty-eight of the forty-six patients had an associated musculoskeletal or other system injury. The cause of injury was a motor-vehicle accident in forty-one patients, a fall in three, and another type of trauma in two (see Appendix).

A trained orthopaedic technician performed the clinical grading with use of the modified Merle d'Aubigné score (which grades hip pain, hip range of motion, and gait, each on a 6-point scale) according to a set protocol^{11,13}. The modified Merle d'Aubigné raw score can range from 3 to 18, with 18 categorized as an excellent final clinical grade; 17, as a very good grade; 16 or 15, as a good grade; 14 or 13, as a fair grade;

and <13, as a poor grade^{1,2,6,11}. Often, these grades are combined (e.g., excellent-to-good compared with fair-to-poor) in the presentation of clinical results^{1-3,6,11,13}.

The MFA questionnaires were completed by the patients themselves after they had received the recommended standard instructions, and scoring was performed with use of the recommended algorithm^{10,14}. The MFA score can range from 0 to 100, and the lower the score, the better the outcome^{10,14}. It consists of ten individual indices: self-care, sleep/rest, hand/fine motor, mobility, housework, employment/work, leisure/recreation, family relationships, cognition/thinking, and emotional adjustment coping and adaptation. The ten individual indices of the MFA and the total scores were calculated. The mean MFA scores were then compared with previously reported normative values¹⁴ and with previously reported patient data^{14,15} with use of the independent-samples t test. Significant associations and differences were defined as an alpha level of <0.05 (two-tailed).

The magnitude of the association between the MFA and the Merle d'Aubigné scores was assessed with use of the Spearman rho correlation coefficient. Patient factors, including age, gender, and whether the patient had sustained an isolated acetabular fracture or associated injuries, were stratified to evaluate their possible influence on outcome. For the purpose of this analysis, patient age was divided into two groups: younger than fifty-five years of age, and fifty-five years of age or older². Fracture-related factors, including the time to reduction of dislocation (categorized as less than twelve hours, or as twelve hours or more^{2,11}), impaction injury to the femoral head, intra-articular fracture comminution (defined as three or more fragments^{2,16}), the presence of intra-articular free fragments, or the presence of marginal impaction, were analyzed as well. The independent-samples t test was utilized to determine if there were significant differences in the MFA and Merle d'Aubigné scores between patients who had the factors defined above and those who did not. Nonparametric alternative methods were used when assumptions for parametric methods were not met.

Furthermore, a Pearson chi-square analysis was utilized to determine if elevated MFA and lower Merle d'Aubigné scores were significantly associated with the presence or absence of the patient and fracture-related factors. The Mantel-Haenszel odds ratio was used to estimate the risk of an abnormal MFA or Merle d'Aubigné score. Forward, stepwise logistic regression was used to demonstrate which of the determinants (or combination of determinants) could be predictive of these two assessment scores. In order to accomplish this analysis, a cut-point separating a satisfactory from an unsatisfactory outcome was needed for the Merle d'Aubigné and MFA scores. As noted above, on the basis of data available from previous reports^{1-3,6,11}, a Merle d'Aubigné score of ≥ 15 can be categorized as satisfactory and a score of ≤ 14 , as unsatisfactory. As no specific data regarding categorization of MFA scores of injured patients were available, the cut-point was determined to be two standard deviations from the mean normal score¹⁴; an MFA score of ≥ 28 was categorized as unsat-

TABLE I Receiver Operating Characteristic Data

MFA Category	Area Under the Curve
Self-care	0.820
Sleep/rest	0.773
Hand/fine motor	0.628
Mobility*	0.965
Housework	0.888
Employment/work	0.880
Leisure/recreation	0.864
Family relationships	0.828
Cognition/thinking	0.780
Emotional adjustment coping and adaptation*	0.948

*The most important determinants of an unsatisfactory total MFA score.

isfactory and one of ≤ 27 , as satisfactory. Additional statistical analysis was performed by comparing the receiver operating characteristic-area under the curve for each of the ten indices of the MFA score to determine whether some of the domains had more influence than others for discerning whether a patient would have an unsatisfactory total score.

All statistical analyses of the data were performed with version-13.0 SPSS software (Chicago, Illinois) by an independent biostatistician who was not directly involved with the study.

Results

The Spearman rho correlation coefficient between the modified Merle d'Aubigné score and the MFA score was -0.62 ($p < 0.001$), which may be regarded as indicating a marked degree of correlation¹⁷. Despite this significant corre-

lation, the modified Merle d'Aubigné score data were asymmetric (non-normal in their distribution), demonstrating a ceiling effect (crowding of the scores at the upper end of the scale, limiting the ability of the score to demonstrate differences between patients with supposedly better clinical outcomes)^{7,18}. The MFA scores, however, were nearly normal in distribution, without floor or ceiling effects. Similarly, the Spearman rho correlation coefficients between the modified Merle d'Aubigné score and the MFA score for the group with an isolated injury and the group with associated injuries were -0.56 ($p < 0.001$) and -0.63 ($p < 0.001$), respectively (Fig. 1). These results may be regarded as indicating moderate and marked degrees of correlation, respectively¹⁷. The values for the receiver operating characteristic-area under the curve for each of the ten domains defining the MFA score are shown in Table I. These results indicate that the mobility and emotional categories are, overall, the most important determinants of an unsatisfactory total MFA score.

The overall mean Merle d'Aubigné score (and standard deviation) was 17 (standard deviation, 1; range, 14 to 18), indicating generally good-to-excellent clinical results. There were twenty-three excellent results, thirteen very good results, nine good results, and one fair result. However, the mean MFA total score was 23.17 (standard deviation, 19.17; range, 0 to 78), as compared with the normative mean of 9.26 (standard deviation, 8.89; range, 0 to 59)¹⁴ ($p < 0.001$). Similarly, all of the MFA indices except hand/fine motor were significantly different from expected norms (Table II). In addition, the MFA scores in our patients with an elementary posterior wall fracture of the acetabulum were similar ($p = 0.81$) to those reported for fourteen patients (mean age, forty-eight years) followed for nine to twelve months after treatment of a hip or femoral fracture, for whom the MFA scores ranged from 7 to 50 (mean, 24.75; standard deviation, 15.5)¹⁴. Furthermore, the MFA scores in our patients were

TABLE II Comparison of MFA Scores with Available Normative Data

MFA Category	Mean Score (Standard Deviation)		P Value
	Present Study	Normative Mean ¹⁴	
Total score	23.17 (19.17)	9.26 (8.89)	<0.001*
Self-care	8.82 (13.64)	1.72 (4.39)	<0.003*
Sleep/rest	29.35 (35.52)	15.45 (21.88)	<0.01*
Hand/fine motor	5.30 (15.46)	3.66 (12.90)	0.10†
Mobility	30.22 (25.21)	11.94 (12.73)	<0.001*
Housework	26.81 (26.35)	7.77 (15.38)	<0.001*
Employment/work	35.87 (43.03)	5.29 (16.71)	<0.001*
Leisure/recreation	43.49 (35.53)	9.96 (21.88)	<0.001*
Family relationships	19.78 (23.04)	7.89 (16.61)	<0.003*
Cognition/thinking	23.37 (34.32)	6.10 (17.34)	<0.003*
Emotional adjustment coping and adaptation	27.29 (22.19)	15.64 (12.75)	<0.003*

*The value was significant with alpha tested at the 0.05 level. †The value did not reach significance with alpha tested at the 0.05 level.

similar ($p = 0.27$) to those for twenty-three patients with an elementary posterior wall fracture of the acetabulum followed for at least one year by Kreder et al.¹⁵, who found MFA scores ranging from 5 to 61 (mean, 28.04; standard deviation, 16.03). Further comparison with unpublished raw data provided by Kreder et al. (personal communication, 2006) showed similar findings with regard to all of the individual indices of the MFA questionnaire, with the exception of the emotional score, which was significantly worse in the study by Kreder et al. ($p = 0.003$) (Table III).

The Merle d'Aubigné score was not found to be significantly associated with any of the tested patient factors (gender [$p = 0.34$], age [$p = 0.15$], or isolated compared with associated injury [$p = 0.16$]) when those factors were analyzed individually. The MFA score was also not found to be significantly associated with any of the tested patient factors (gender [$p = 0.27$], age [$p = 0.71$], or isolated compared with associated injury [$p = 0.16$]). In addition, the Merle d'Aubigné score was not found to be significantly associated with any of the tested fracture factors (time to reduction of dislocation [$p = 0.92$], im-

paction injury to the femoral head [$p = 0.50$], intra-articular fracture comminution [$p = 0.37$], presence of intra-articular free fragments [$p = 0.13$], or presence of marginal impaction [$p = 0.51$]) when those factors were analyzed individually. However, the presence of marginal impaction was associated with a significantly higher mean MFA score ($p = 0.04$). The MFA scores were not significantly associated with the time to reduction of dislocation ($p = 0.67$), impaction injury to the femoral head ($p = 0.32$), intra-articular fracture comminution ($p = 0.13$), or presence of intra-articular free fragments ($p = 0.15$).

Subsequent multivariate statistical analysis to determine which factor(s) could be predictive of an unsatisfactory MFA or Merle d'Aubigné score revealed only the presence of marginal impaction ($p = 0.04$) to be predictive of an unsatisfactory MFA score. Analysis of the Merle d'Aubigné scores was hampered by the fact that there was only one unsatisfactory result (≤ 14) in this series. Moving the cut-point upward did not produce a predictive factor even when an unsatisfactory result was redefined as a Merle d'Aubigné score of ≤ 17 . Over-

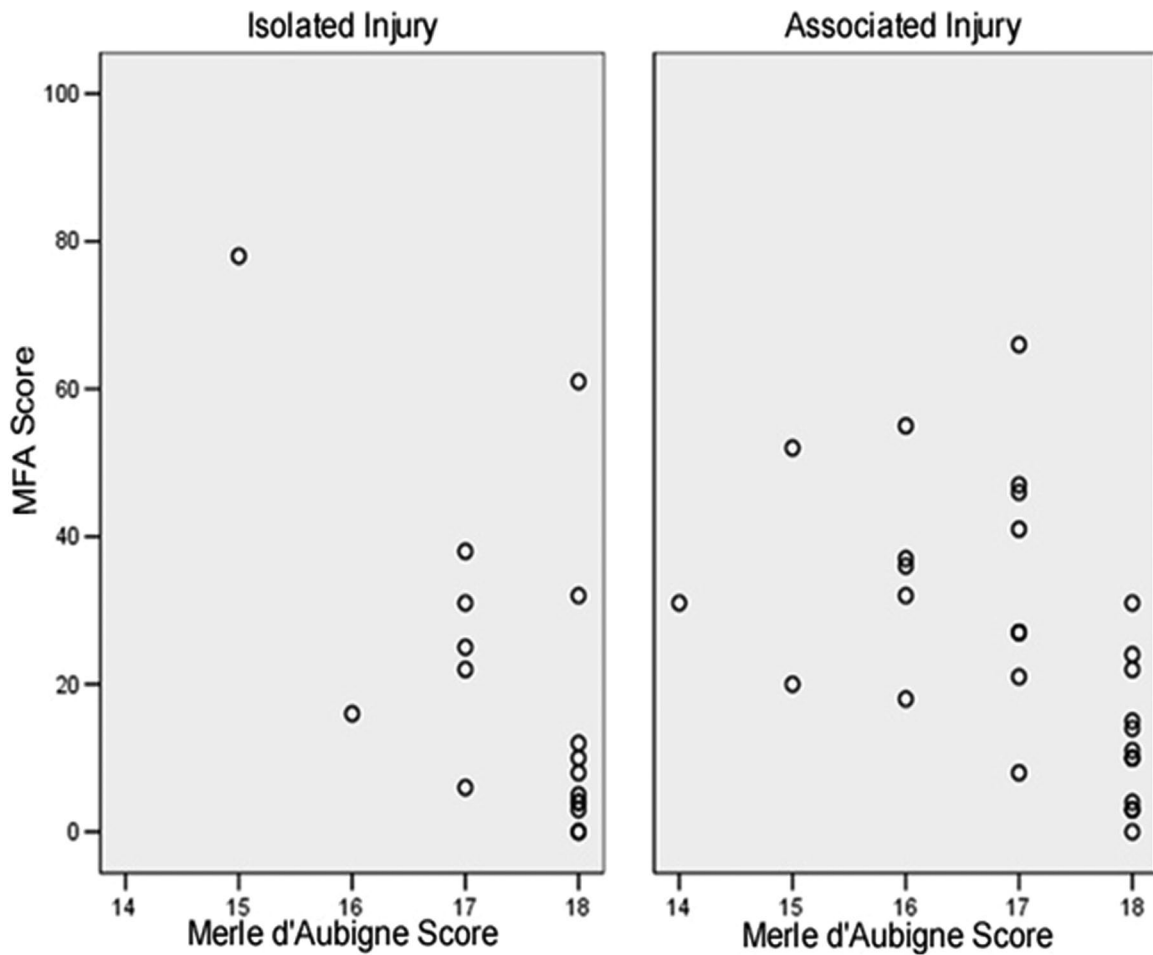


Fig. 1

Data plots for the Musculoskeletal Function Assessment (MFA) and Merle d'Aubigné scores for the group with an isolated injury and the group with associated injuries. The Spearman rho correlation coefficient is -0.56 for the group with an isolated injury and -0.63 for the other group.

TABLE III Comparison of MFA Scores with Those in Patients with a Posterior Wall Fracture in a Previous Study

MFA Category	Mean Score (Standard Deviation)		P Value
	Present Study	Study by Kreder et al. ¹⁵	
Total score	23.17 (19.17)	28.04 (16.03)	0.27
Self-care	8.82 (13.64)	6.28 (9.67)	0.43
Sleep/rest	29.35 (35.52)	41.30 (27.92)	0.13
Hand/fine motor	5.30 (15.46)	5.59 (17.09)	0.94
Mobility	30.22 (25.21)	32.61 (22.56)	0.69
Housework	26.81 (26.35)	30.92 (25.50)	0.53
Employment/work	35.87 (43.03)	50.00 (42.64)	0.20
Leisure/recreation	43.49 (35.53)	52.17 (31.00)	0.30
Family relationships	19.78 (23.04)	20.43 (30.07)	0.92
Cognition/thinking	23.37 (34.32)	18.48 (32.17)	0.57
Emotional adjustment coping and adaptation	27.29 (22.19)	43.72 (20.33)	0.003*

*The value was significant with alpha tested at the 0.05 level.

all, the results of this statistical analysis to determine the predictive value of the fracture factors were considered to be unstable as a result of the small sample size and relatively large variability of the data set.

Discussion

Despite the common practice of using clinical measures, such as the Merle d'Aubigné score, to evaluate the outcomes in patients with orthopaedic conditions, a validated, self-reported patient questionnaire is most useful for determining health status^{8,19}. The MFA, a validated well-designed self-reported patient questionnaire, is a useful outcome instrument for patients with musculoskeletal disorders^{7,9}. We are not aware of any published clinical studies in which both the MFA and the Merle d'Aubigné scores were used as measures to specifically evaluate the outcomes of treatment of elementary posterior wall fractures of the acetabulum. Considering that the posterior wall fracture is the simplest and most common type of acetabular fracture¹, it was thought that a detailed study of this patient subgroup was warranted.

The potential confounding factor in this study was whether the acetabular fracture was isolated or associated with another injury. Therefore, the data were analyzed to account for this variable. We believe that including only patients with an isolated fracture in this study would have limited the number of patients and restricted the clinical applicability of the findings, since the majority of acetabular fractures are associated with additional fractures or other system injuries.

We are aware of only one report of MFA reference values for individuals who were not patients¹⁴. These non-patient scores range from 0 to 59, with a mean of 9.26 (standard deviation, 8.89). This report also included scores for a sample of fourteen patients with a hip or femoral fracture and compared baseline scores from three to six months after injury with those obtained, respectively, after nine to twelve months of

follow-up. The follow-up scores ranged from 7 to 50, with a mean of 24.75, which was significantly worse than the score for the individuals who were not patients, indicating a poorer level of health status for the patient population and a failure of the patients to return to a preinjury functional level. This conclusion requires an assumption that the non-patient sample in the study represented a normative population, providing a baseline with which to compare the health status of injured patients. Our study showed similar findings in a larger group of patients with a fracture (of the posterior wall of the acetabulum), who had values that differed significantly from those in the non-patient sample ($p < 0.001$) and were statistically similar to those in the patients with the hip or femoral fracture ($p = 0.81$).

Saterbak et al. reported a mean MFA score of 47.3 for patients who had a clinical failure after treatment of a fracture involving the posterior wall of the acetabulum compared with 26.1 for those who did not have a failure after treatment of such a fracture¹⁶. They found a significant difference ($p < 0.05$) in seven of the ten indices of the MFA between the failure and non-failure groups. As in the present study, they also found a negative correlation between the Merle d'Aubigné score and the MFA score. However, only twenty of their forty-two patients had sustained an acetabular fracture involving only the posterior wall. Twenty-two had sustained a more complex injury, which involved, in addition to the posterior wall fracture, a transverse fracture in eighteen patients, a T-type fracture in two, and a posterior column fracture in two.

In a study of a diverse group of injuries consisting of elementary and associated acetabular fractures involving the posterior wall, Kreder et al. reported on a subset of forty-four elementary posterior wall fractures¹⁵ followed for a minimum of one year. Of the patients with these fractures, twenty-three completed an MFA questionnaire and the thirty-six-item Short-Form Health Survey to evaluate functional outcome.

However, Kreder et al. did not describe clinical outcome scoring of hip function, other than listing postoperative complications and grading follow-up radiographs for residual fracture displacement, arthritis, and heterotopic bone formation. As described in the Results section of the present study, these investigators reported findings similar to ours for the total score and all individual indices of the MFA questionnaire with the exception of the emotional score, which was significantly worse in the study by Kreder et al. ($p = 0.003$; Table III). The reason(s) for this difference between the two studies cannot be determined from the available data. However, patient follow-up was shorter in the study by Kreder et al. Furthermore, they did not differentiate between isolated fractures and those associated with other injuries, and their patients may have sustained more severe associated injuries. Despite these differences, the consistency of the overall data and the importance of the emotional category of the MFA score as a negative determinant of functional outcome are confirmed.


The importance of the emotional category of the MFA is underscored by the receiver operating characteristic data. While it appears to be intuitive that the mobility category would be the most important determinant of functional outcome after any musculoskeletal injury, it is surprising that the emotional category would be the next most important. Although the numbers of patients were small, the findings of the present study, in conjunction with those of others^{6,14-16}, send a consistent message: there are important factors determining our patients' functional outcome other than how well we repair the fracture. Other researchers have noted that psychological distress is strongly associated with patient self-assessed outcome²⁰⁻²². It may be that patients' preinjury psychological make-up is a critical determinant of their emotional response to injury and ultimate functional outcome. Including some measure of psychological health during the acute management phase of patients who have sustained a musculoskeletal injury—and providing treatments geared toward improving any observed deficits—may be just as important as obtaining an anatomic fracture reduction.

Statistical analysis to determine which factor(s) could be predictive of an unsatisfactory MFA or Merle d'Aubigné score revealed only the presence of marginal impaction ($p = 0.04$) to be predictive of an unsatisfactory MFA score. Factors such as patient age, marginal impaction, intra-articular fragments, posterior wall comminution, femoral head lesions, residual

displacement, time to reduction of hip dislocation, and radiographic grade have been variously shown to have or not have value for predicting clinical outcome by authors of studies with more patients than were included in ours^{2,3,11,15}. This analysis was not the point of our study, and our results must be considered to be unstable because of the small sample size and relatively large standard deviations from the mean.

In the present study, a high negative correlation ($r = -0.62$; $p < 0.001$) was found between the modified Merle d'Aubigné and MFA scores. However, the relatively high (worse) MFA scores for these patients with an acetabular fracture, as compared with those in a non-patient, normal population, indicate that a complete return to a preinjury functional level is uncommon for these patients despite a good-to-excellent Merle d'Aubigné clinical score. This finding was evident in nine of the ten MFA indices. Although the hand/fine motor subscore in our group with a posterior wall fracture was not significantly different from the non-patient reference value, it appears that the residual functional deficits following a posterior wall fracture are wide-ranging, affecting many aspects of everyday life not necessarily having an obvious direct connection to hip function. Although the modified Merle d'Aubigné score may be useful for evaluating isolated hip function in patients with a posterior wall fracture of the acetabulum, without consideration of other factors its shortcomings (such as the ceiling effect) limit its usefulness as a method for evaluating the functional outcome in these patients. Research efforts should be directed toward the identification of the underlying determinants of these other factors of functional outcome and related potential treatment interventions.

Appendix

 Tables showing detailed clinical data on all study patients are available with the electronic versions of this article, on our web site at jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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