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CLINICAL RESEARCH

Weber Osteotomy for Large Hill-Sachs Defects: Clinical and CT Assessments

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Abstract

Background The Weber derotation osteotomy is an uncommon procedure that typically is reserved for patients with engaging Hill-Sachs defects who have had other surgical treatments for shoulder instability fail. It is unknown whether the desired humeral derotation actually is achieved with the Weber osteotomy.

Questions/purposes The purposes of this study were to answer the following questions: (1) What are the complication (including redislocation) and reoperation rates of the Weber osteotomy? (2) What are the American Shoulder and Elbow Surgeons (ASES) and functional (ROM in internal rotation, self care) results? (3) What fraction of the patients had humeral derotation within 10° of the desired rotation?

Methods A chart review of 19 Weber osteotomies and clinical assessment of 10 Weber osteotomies were performed by independent clinicians. The chart review, at a mean followup of 51 months (range, 13–148 months), focused on the complication rate and the frequency of redislocation. The clinical and CT assessments, at a mean followup of 54 months (range, 26–151 months), focused on ASES scores, ability of patients to perform self care with the affected arm, and CT scans to measure change in humeral retroversion.

Results There were 25 complications and nine reoperations in 17 patients (19 shoulders), including pain (six patients, of whom one had complex regional pain syndrome), hematoma, infection, nonunion, delayed union, reoperations related to hardware and other noninstability-related causes (five patients), and internal rotation deficit. Redislocation occurred in one patient, who underwent repeat surgery, and subjective instability developed in two others. The mean ASES score was 78 points (of 100 points); six of the 10 patients (11 procedures) evaluated in person found it difficult or were unable to wash their backs with the affected arm. Humeral derotation varied from 7° to 77°; only three of the nine patients for whom CT scans were available had derotation within 10° of the desired rotation.

Conclusions Complication rates with the Weber osteotomy were much higher than previously reported. Because

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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seven of 17 patients were lost to followup, the redislocation rate may be higher than we observed here. Given the unpredictable variability in humeral derotation achieved with a Weber osteotomy, an improved surgical technique is critical to avoid osteoarthritis and loss of internal rotation associated with overrotation.

Level of Evidence Level IV, case series. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Large and engaging Hill-Sachs defects present a difficult management problem because they cause frequent recurrent shoulder dislocations [1, 4, 5, 16, 19] secondary to bone loss that interferes with an individual's ability to work or perform activities of daily living [5]. Shoulders with engaging Hill-Sachs defects dislocate more easily and often are locked dislocations and more difficult to reduce than shoulders with nonengaging Hill-Sachs defects. Engaging Hill-Sachs defects often require a maneuver (in addition to traction) to disengage the defect to reduce the shoulder [3]. Surgical stabilization of patients presenting with large Hill-Sachs defects is an ongoing orthopaedic challenge. Although there are multiple techniques for treating large Hill-Sachs defects, they are either newly developed [6, 9, 12, 16, 17, 22, 27, 28, 34] or have major drawbacks such as high failure rates [3], early osteoarthritis [32], stiffness [30], limited postoperative weightbearing, limited lifespan, osteolysis, or chondrolysis [24].

The Weber derotational osteotomy, first described in 1984 [33], is an option to stabilize shoulders with large Hill-Sachs defects in patients who have bone loss in the posterolateral aspect of the humeral head and are not candidates for segmental allograft or limited arthroplasty. The Weber osteotomy involves transecting the proximal humerus transversely at the surgical neck and retroverting the humeral head with respect to the humeral shaft. This procedure rotates the Hill-Sachs defect posterolaterally and theoretically, this derotation will prevent the defect from engaging with the glenoid and dislocating the humeral head during normal coupled shoulder motion of abduction and external rotation. The Weber humeral derotational osteotomy [7, 18, 33] is commonly used in Europe to surgically treat large Hill-Sachs defects. Most of the reports are in German [10, 11, 23, 25]. In North America it is an uncommon procedure that typically is reserved for patients with engaging Hill-Sachs defects and for whom conservative and other surgical approaches have failed. There is some disagreement regarding the frequency of complications after this operation [18, 21, 29, 31, 33], and about outcomes pertaining to pain and function [18, 21, 29, 33]; we also do not know whether the desired humeral derotation actually is achieved with the Weber osteotomy. We know, for example, that glenoid osteotomies do not actually achieve the desired glenoid retroversion [14].

The goals of this study were to determine: (1) the complication (including redislocation) and reoperation rates for this operation, (2) the American Shoulder and Elbow Surgeons (ASES) and functional (ROM in internal rotation, self-care) results, and (3) the fraction of patients who had humeral derotation within 10° of the desired rotation?

Patients and Methods

This study was approved by the University of British Columbia clinical research ethics board. All of the research subjects provided informed consent for study participation.

A retrospective chart review of a selective case series of all patients who underwent Weber derotational osteotomies performed by two senior surgeons (RH, WDR), whose shoulder subspecialty practices incorporated multiple surgical options for management of engaging Hill-Sachs defects, from 1993 to 2004 was done. Patients were identified from a database. The inclusion criteria for patients to be selected for a Weber osteotomy included recurrent instability, a prior examination under anesthesia that revealed an engaging Hill-Sachs lesion (humeral head locked out of position), and a glenoid within normal limits (ie, < 10% bone loss). The chart review was performed by an independent surgeon (ALB-H). The chart review focused on abstracting the complication rate and the frequency of redislocation. Seventeen patients who underwent 19 operations were reviewed (Table 1). Ten of the 17 patients were reviewed clinically and radiographically using CT assessment (Table 2). The clinical and CT assessments focused on postoperative ASES scores, internal rotation, ability of patients to perform self-care with the affected arm, and CT scans to measure change in humeral retroversion. It was not possible to contact four patients and three were unable or refused to participate. The seven patients lost to followup were included in the chart review. The mean followup was 54 months (range, 26–151 months) for the 10 patients reviewed clinically and radiographically, and 51 months (range, 13–148 months) for the entire group of 17 patients.

The surgical technique for all 19 Weber osteotomies involved plate and screw fixation with the intended surgical retroversion varying from 20° to 35°. A 20°-guide was used to intraoperatively measure the angle of correction and parallel pin configuration was used to confirm the amount of derotation before plating the osteotomy. Seventeen were fixed with a 90°-blade plate, one of which was

Table 1. Chart review demographics

Demographic characteristics	Data
Number of shoulders	19
Number of patients	17
Sex	15 males*, 2 females
Age (mean)	33
Side	10 right, 9 left
Dominant shoulder	10
Initial injury mechanism	
Sports-related	12
Fall	3
Trauma	3
Rolling over in bed	1
Prior surgeries (mean [range])	2 [0–4]**
Physically demanding occupations	9
Comorbidities	9
Seizure disorder	3
Depression	2
Insulin-dependent diabetes mellitus	2
Bipolar affective disorder	1
Substance abuse	1
Workers compensation claim	1

* Two male patients underwent bilateral procedures; ** only one shoulder did not have prior shoulder stabilization surgery because there was a large engaging Hill-Sachs lesion and the patient had undergone a successful Weber osteotomy of the contralateral shoulder.

Table 2. Clinical assessment demographics

Demographic characteristics	Data
Number of shoulders	11
Number of patients	10
Sex	10 males
Age (mean)	34
Side	7 right, 4 left
Dominant shoulder	7
Initial injury mechanism	
Sports-related	6
Fall	2
Trauma	3
Prior surgeries (mean [range])	1 [0–3]*
Physically demanding occupations	4
Comorbidities	5
Seizure disorder	2
Depression	1
Insulin-dependent diabetes mellitus	1
Bipolar affective disorder	1
Workers compensation claim	0

* One shoulder did not have previous stabilization surgery because there was a large engaging Hill-Sachs lesion and the patient had a successful Weber osteotomy of the contralateral shoulder.

supplemented with a six-hole dynamic compression plate. One was fixed with a manually contoured six-hole semi-tubular plate and supplemental two-hole plate fixation anteriorly. One also was fixed with a cloverleaf plate that was manually contoured and the central portion was cut out. This was supplemented with a lag screw across the osteotomy and local bone graft in the anteromedial gap. Supplemental fixation was added intraoperatively when the surgeon deemed it was required to achieve stable fixation of the osteotomy. Concomitant soft tissue procedures were performed to address the soft tissue disorder (labral surgery for labral tears, capsular surgery for capsular laxity, and one subscapularis shortening for tissue redundancy [predating knowledge that subscapularis shortening is associated with osteoarthritis]). Fifteen of the Weber osteotomies were combined with labral and/or capsular surgery (six Bankart repairs, eight revision Bankart repairs, and/or three capsular shifts). Four osteotomies did not have associated labral or capsular surgery. In this group, one osteotomy was combined with subscapularis shortening, one was combined with subscapularis repair, and two osteotomies were isolated bony osteotomy procedures. Patients were seen for followup within 2 weeks and then at 6 weeks, 3 months, 6 months, and 1 year after surgery. Radiographs were taken immediately after surgery, 6 weeks after surgery, and subsequently as required. The postoperative protocol for all patients was to wear a sling for 6 weeks with daily removal of the sling for pendulum exercises and passive shoulder forward elevation to 90°. ROM and strengthening were progressed with clinical and radiographic evidence of union.

The primary outcome measure for the chart review and clinical assessment was redislocation rate. The secondary outcome measures for both were complications and reoperation rate. Additional secondary outcome measures for only the clinical assessment were ASES scores and ability of patients to perform self-care with the affected arm. The clinical assessment practitioners (ALB-H, CD) were independent observers who were blinded to each patient's clinical history.

Radiologic measurements were assessed using a 64-slice CT unit (Toshiba, Torrance, CA, USA) using a volume acquisition and reconstructed scans at 2 mm thickness. Images were acquired through the proximal 6 cm and distal 5 cm of the humerus. Sagittal and coronal reconstructions were routinely performed. No intravenous or intraarticular contrast was used. Two observers (one radiologist [CvW] and one orthopaedic surgeon [ALB-H]) familiar with shoulder cross-sectional anatomy evaluated the images, with differences resolved by consensus. These observers were blinded to these patients' clinical histories.

Humeral retroversion on CT was quantified by two observers (CvW, ALB-H) measuring orientation of the surgically repositioned proximal humeral head articular surface with respect to the distal transepicondylar axis as per Hernigou et al. [15]. The control contralateral shoulder retroversion was assumed to be within 2.1° of the preoperative retroversion of the operative shoulder [15]. Intended surgical humeral head retroversion (20°–35°) was correlated with surgically achieved humeral head retroversion through the CT scan. Nine of the 10 patients who underwent CT scans were included in the humeral retroversion calculation. One was excluded because that patient's contralateral shoulder had undergone surgery and could not serve as a normal reference.

Results

The complication rate after Weber osteotomy was high. The chart review revealed 25 complications in 19 shoulders, including nine reoperations on seven shoulders. One patient's shoulder redislocated and the patient underwent repeat surgery for this. Two patients had subjective instability (one was secondary to a motor vehicle accident and was treated with arthroscopic labral repairs, the second was managed nonsurgically), two patients had superficial infections that were managed successfully without surgery, and five patients had persistent pain develop. One of these five patients had complex regional pain syndrome develop (Table 3).

The mean ASES score was 78 with half scoring greater than 90; three scoring 60, 76, and 88; and two scoring 44 (as a result of pain, > six of 10). For the 10 patients (11 shoulders) who returned for clinical assessment, three reported pain greater than 3 of 10 on the VAS and two of these three patients could not sleep on the affected side. The average loss of internal rotation was 29°. Two of 10 patients were unable to reach their ipsilateral pocket and one was unable to reach the opposite axilla (for self-hygiene). Furthermore, two patients found it difficult to wash their backs and four were unable to do so at all. One was unable to toilet. One patient found it difficult to throw a ball and two were unable to throw a ball.

Of the nine patients who had CT scans that could be compared with a normal contralateral shoulder, only three had retroversion angles within 10° of the desired rotation. The change in humeral retroversion after a Weber osteotomy ranged from 7° to 77° (Table 4).

Discussion

A Weber osteotomy is an uncommonly performed approach for a complicated problem. Case series on the subject provide somewhat disparate results in terms of complications and recurrence [7, 18, 21, 29, 31, 33], and, to our knowledge, the ability of this approach to retrovert the humerus the desired amount has not been validated using CT scans. The goals of our study were to determine: (1) the complication (including redislocation) and reoperation rates of this operation, (2) the ASES and functional (ROM in internal rotation, self-care) results, and (3) the fraction of the patients who had humeral derotation within 10° of the desired rotation.

This study has numerous limitations. First, we used two observers who evaluated the images and resolved differences by consensus. This did not allow us to determine reliability of the technique. However both observers were experienced and blinded so it is unlikely that they overestimated the benefit of the approach. Second, this series was relatively small, and a large number of patients were lost to followup for clinical assessment after the chart review. These limitations, in particular, cause us to believe that ours may be best-case results with this approach, as some of the patients lost to followup may have had a redislocation or had reoperation elsewhere. Third, the concomitant soft tissue procedures and fixation methods varied between surgical procedures. Fixation methods changed as technology progressed. Given the varying soft tissue disorders and small number of procedures over a long period, it was not possible to keep techniques uniform. Subscapularis shortening was performed on only one of 19 shoulders. A fourth limitation of this study is that the clinical followup for patients who underwent the Weber osteotomy was only performed at 54 months, not earlier. This does not allow direct comparison with remplissage series that report followup only to a maximum of 30 months [2, 13, 26, 27, 35]. Remplissage involves arthroscopic capsulotenodesis of the posterior capsule and infraspinatus tendon into the Hill-Sachs defect.

In general, our series had a similar redislocation rate and higher complication rate than English European series of the Weber osteotomy [7, 18, 21, 29, 31, 33]. Our patients had higher dislocation and complication rates than those in remplissage series for large engaging Hill-Sachs defects, although all the remplissage series had shorter followups than our series of patients who underwent Weber osteotomies [2, 13, 27, 35]. Our patients also had a higher dislocation rate than those in the largest reported osteochondral allograft series [24]. In addition, we report a reoperation rate that is not discussed in the English literature regarding Weber osteotomies [7, 18, 20, 29, 31, 33], is only partly reported in the osteochondral allograft literature [24], and is higher than those reported in the remplissage literature [2]. Our series had a 5% to 10% redislocation rate that was similar to the 5.4% to 10.5% rate reported in the English literature for Weber osteotomies [7, 18, 21, 29, 33]. In patients who did not undergo capsular or subscapularis

Table 3. Chart review for complications after Weber osteotomy

Patient	Complication	Management	Risk factors*	Additional surgery and fixation†	ASES scores	Surgical humeral derotation (achieved) (degrees)
5	Dislocation	Glenoid bone grafting; subsequent hardware removal and pectoralis major transfer	Seizure disorder	Bankart	60	33
16	Instability (subjective)	Arthroscopic anterior and posterior labral repairs	Motor vehicle accident postoperative; smoker; seizure disorder; substance abuse	Bankart	NA	NA
7	Instability (subjective)	NA	Head injury; seizure disorder	Subscapularis shortening; 2-hole plate	92.3	12
12	Infection (superficial)	NA	Seizure disorder; insulin-dependent diabetes mellitus	Bankart	NA	NA
14	Infection (superficial)	Antibiotics	NA	Revision Bankart and capsular shift	NA	NA
7	Pain	Hardware removal	Smoker	Revision Bankart	75.5	22
10	Pain	Hardware removal	Hypothyroidism; migraines; depression	Inferior capsular shift	NA	NA
9	Pain	NA	Smoker; motor vehicle accident postoperative	Revision Bankart and capsular shift	95.3	39
3	Pain	NA	NA	Revision Bankart	44.3	7
7	Pain	Hardware removal	Head injury; seizure disorder	Subscapularis shortening; 2-hole plate	92.3	12
15	Pain	Stellate ganglion blocks	Smoker; seizure disorder; substance abuse	Bankart	NA	NA
18	Hematoma	Drained in office	Smoker	Revision Bankart	NA	NA
19	Hematoma	Surgical evacuation	NA	Oblique lag screw	NA	NA
7	Hematoma	NA	Head injury; seizure disorder	Subscapularis shortening; 2-hole plate	92.3	12
16	Internal rotation loss	NA	Smoker; seizure disorder; substance abuse	Bankart	NA	NA
4	Internal rotation loss	NA	Smoker	Revision Bankart	75.5	22
6	Internal rotation loss	NA	Bipolar affective disorder	Bankart	91.2	63
8	Internal rotation loss	NA	NA	Revision Bankart	44	77
15	Internal rotation loss	NA	Smoker; seizure disorder; substance abuse	Bankart	NA	NA
18	Internal rotation loss	NA	Smoker	Revision Bankart	NA	NA
10	Stiffness	Hardware removal	Hypothyroidism; migraines; depression	Inferior capsular shift	NA	NA
5	Delayed union	NA	Seizure disorder	Bankart	60	33

Table 3. continued

Patient	Complication	Management	Risk factors*	Additional surgery and fixation†	ASES scores	Surgical humeral derotation (achieved) (degrees)
15	Nonunion	Bone grafting	Smoker; seizure disorder; substance abuse	Bankart	NA	NA
11	Osteoarthritis	NA	Seizure disorder; insulin-dependent diabetes mellitus	Revision Bankart; 6- hole DCP	87.8	NA
7	Osteoarthritis	Arthroscopic debridement	Head injury; seizure disorder	Subscapularis shortening; 2-hole plate	92.3	12

* No patients with complications had workers compensation claim; †additional surgical procedures concomitant with the Weber osteotomy and supplemental fixation to a blade plate. Patients did not undergo subscapularis shortening unless it is specifically listed under Additional surgery; DCP = dynamic compression plate; NA = not applicable or not available (ASES scores and humeral derotation available only for patients assessed clinically).

Table 4. Change in humeral retroversion after Weber osteotomy

Patient	Measured surgical change in retroversion (°)*	Intended change in retroversion (°)
1	41	20
2	22	25
3	7	20
4	22	20
5	33	25
6	63	20
7	12	35
8	77	20
9	39	20
Mean	35	
Range	7–77	

* Only data for nine patients shown because one underwent bilateral surgeries.

shortening, our redislocation rate was 7% (one of 15). This was better than in another series that had a 20% dislocation rate in shoulders that did not have capsular or subscapularis shortening [31]. Our series had a higher dislocation rate at longer followup with a 5% to 10% redislocation rate at 54 months compared with a 0% to 8% rate at or less than 30 months [2, 13, 27, 35] reported in the remplissage series. Our series also had a higher dislocation rate (5% to 10% redislocation rate at 54 months) than the largest reported osteochondral allograft series (0% redislocation rate at 50 months) at similar followups [24]. We report complications including subjective instability, pain, hematoma, and infection that were not highlighted in the English literature regarding Weber osteotomy. Pain was highlighted in one remplissage series [26]. Similar to the largest reported series of Weber osteotomies, we report delayed union, nonunion, and posttraumatic arthritis [33]. Similar to two series of Weber osteotomies [7, 33] and one remplissage series [2], we report stiffness. In comparison to the largest published osteochondral allograft series, there is no report of overall allograft series reoperation rate; however, there is a similar postoperative hardware removal rate for our Weber series (three of 19) and the allografts (two of 18) [24]. One remplissage series had a dramatically lower reoperation rate (one of 47) [2] than our Weber series (nine of 19).

In our series, there was a loss of internal rotation that averaged 29° at clinical followup. Neither the English literature for Weber osteotomy or osteochondral allografts reports measurements of internal rotation, difficulty with self-care, or ASES scores [7, 18, 21, 24, 29, 31, 33]. Weber and remplissage studies show some lesser loss of external rotation compared with our loss of internal rotation. In the largest Weber series of 180 patients, the average loss of external rotation was 5° [33] compared with 29° loss of internal rotation in our series. One remplissage series of 47 patients had an approximate loss of 10° external rotation at 24 months followup [2] compared with 29° loss of internal rotation in our series Our series had lower ASES (78 versus 96) scores at 54 months compared with three remplissage series at 24 to 30 months [2, 13, 35].

To our knowledge, our study is the first comparing intended and surgically achieved humeral retroversion after a Weber osteotomy. We questioned the predictability of humeral rotational osteotomies because glenoid osteotomies have been proven unpredictable for glenoid articular realignment [14]. Change in retroversion could be measured for only nine of 11 shoulders because one patient had bilateral procedures, so that patient's contralateral shoulder could not serve as a normal reference. This small sample size did not allow for any statistical analysis. Nonetheless, the wide variation of 7° to 77° derotation (only three had retroversion angles within 10° of the desired rotation) showed that derotation of the proximal humerus is not predictable with a Weber osteotomy despite the use of a 20°-guide and parallel pin technique to facilitate osteotomy retroversion. Flury et al. reported a comparison of surgical osteotomy rotation results focusing on joint degeneration but not the intended retroversion [8]. Our series had two cases of gross overrotation, which also was reported as a complication in the largest Weber series in the literature [33]. The concern with overrotation is that it has been associated with increased degenerative changes [8]. Our series had only one recurrent dislocation after Weber osteotomy confirming that in the majority of cases, Hill-Sachs defects have been rotated enough to prevent them from contributing biomechanically to instability. Perhaps the extensive postsurgical scarring also restricts glenohumeral dislocations. If derotation is the primary factor that stabilizes the shoulder, it would be reasonable to aim for retroversion less than 20° to reduce the development of osteoarthritis, as suggested by Flury et al. [8].

Our series had a high complication rate (more than one complication per patient), and CT findings suggested that the Weber osteotomy is difficult to perform accurately. Although our redislocation rate was low, the loss to followup was high, limiting our ability to draw firm conclusions on that point. The Weber osteotomy should be reserved as a salvage option for stabilizing shoulders with large Hill-Sachs defects in patients who are not candidates for segmental allograft or limited arthroplasty. Given the unpredictable variability in humeral derotation achieved with a Weber osteotomy, an improved surgical technique is critical to avoid unnecessary complications of diminished internal rotation and osteoarthritis associated with overrotation.

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