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Research article

Clinical outcomes of patients with symptomatic acetabular rim fractures after arthroscopic FAI treatment

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ABSTRACT

This study aims to investigate the influence of the acetabular rim fractures on outcomes of hip arthroscopy at minimum 2-year follow-up. Between January 2009 and August 2012, data were prospectively collected on all patients undergoing hip arthroscopy. Anatomic findings, including presence of rim fractures, were recorded intraoperatively. Patients were assessed preoperatively and at 3 months, 1 year and minimum 2 years postoperatively with four patient-reported outcome measures: modified Harris Hip Score, Non-Arthritic Hip Score, Hip Outcome Score-Activities of Daily Living and Hip Outcome Score-Sport Specific Subscales. Pain was estimated using a visual analog scale. Satisfaction was measured on a scale from 0 to 10. Patients with rim fractures were identified and retrospectively matched to a control group based on gender, BMI category, and age at surgery within 3 years and compared in terms of demographic factors, intraoperative findings, procedures and outcomes. Twenty-one patients with rim fractures were matched to a control group of 21 patients with symptomatic femoroacetabular impingement without rim fractures. No significant differences were detected with respect to demographic characteristics, surgical procedures (besides the removal of rim fractures), or in terms of preoperative, postoperative, or improvement in patient-reported outcome scores and satisfaction. The presence or absence of an acetabular rim fracture does not significantly influence clinical outcomes at minimum 2-year follow-up after hip arthroscopy. Case–control study design is used in this study.

INTRODUCTION

Ossicles around the hip were first described in 1737 by Albinus and were termed 'os acetabuli' by Krause in 1876 [1]. Currently, they are referred to as unfused secondary ossification centers or rim fractures in patients with hip dysplasia, previous trauma, osteochondritis dissecans, retroverted acetabuli and femoroacetabular impingement (FAI) [1–4]. It is believed that they are a consequence of the forces transmitted to the acetabular bony edge creating a fracture [1–4]. However, previous *in vitro* studies have demonstrated that compressive forces result in mineralization of the acetabular labrum, resulting in a painful hip mimicking or coexisting with FAI [5, 6].

Rim fractures have been described as vertically oriented gaps between the fragment and stable rim, which magnetic resonance imaging (MRI) has shown to be composed of labrum, articular cartilage and bone [6, 7].

Typically, the treatment of these fragments includes complete excision in cases where the center edge (CE) angles are adequate, with or without the fragment (lateral CE angle $>$ 20–25°, anterior CE angle $>$ 20°). In those cases where the CE angle is $<$20–25° on coronal imaging (anteroposterior pelvis) and $<$20° on a false profile view, partial resection and internal fixation of the remaining portion is considered. Fixation of the entire fragment is considered if the fragment is necessary for normal coverage,

and the hip would be dysplastic without the fragment. Some studies have shown iatrogenic dislocations and subluxations after excessive arthroscopic rim resections [8–11].

This study provides the first case–control study reporting on the effect of acetabular rim fractures on 2-year outcomes following arthroscopic treatment of the hip.

The first question to be answered in this study is what are the outcomes of arthroscopic treatment of FAI accompanied by removal of an acetabular rim fracture? The second purpose of this study was to investigate the influence of the acetabular rim fractures on outcomes of arthroscopic hip preservation surgery for FAI at minimum 2-year follow-up, in comparison with patients with FAI without rim fractures. We hypothesized that, since acetabular rim fractures were a potential underlying cause of the patient's preoperative symptoms, patients treated for acetabular rim fractures would demonstrate a greater improvement in outcomes, compared with patients who did not have rim fractures.

MATERIALS AND METHODS

Patient selection

A matched-pair controlled case study, using retrospectively collected data, was conducted for patients who underwent arthroscopic hip preservation surgery between January 2009 and August 2012. Anatomic findings, including presence of rim fractures, were recorded intraoperatively. Labral tears were described using the Seldes classification system [12]. Acetabular chondral lesions were described using the acetabular labrum articular disruption (ALAD) [13] and Outerbridge classification systems [14]. Femoral head chondral lesions were described using the Outerbridge classification system. Ligamentum teres tears were described using the descriptive [15] and Gray and Villar classification systems [16]. All procedures were performed by the senior surgeon (BGD). Patients were assessed preoperatively and at 3 months, 1 year and minimum 2 years postoperatively with four patient-reported outcome (PRO) measures: modified Harris Hip Score (mHHS), Non-Arthritic Hip Score (NAHS), Hip Outcome Score-Activities of Daily Living (HOS-ADL) and Hip Outcome Score-Sport Specific Subscales (HOS-SSS). Pain was estimated on the visual analog scale (VAS). Satisfaction with surgery was measured with the question 'How satisfied are you with your surgery results? (1 = not at all, 10 = the best it could be)'. We performed preoperative and postoperative X-ray measurement of the Lateral Center Edge Angle (LCEA), Anterior Center Edge Angle (ACEA) and COS (Cross-Over Sign). Investigational review board approval was obtained prior to initiation of this study.

Statistical analyses

Patients with and without rim fractures were retrospectively matched based on gender, BMI category and age at surgery within 3 years and compared in terms of demographic factors, intraoperative findings, procedures and outcomes (Table I). An *a priori* power analysis showed that at least 17 patients per group were needed to rule out type II error when comparing PRO scores between the two groups, assuming a 10-point difference in the means and a 10-point standard deviation in both groups. *P* values <0.05 were considered statistically significant.

RESULTS

The study period and matching criteria yielded 21 patients with rim fractures and 21 patients without rim fractures. No significant differences were detected in terms of demographic characteristics, including age at surgery, BMI, worker's compensation claim, or conversion to total hip arthroplasty (Table II). No other intraoperative findings, other than the acetabular rim fractures themselves, demonstrated significant or nearly significant differences between groups (Table II). Of the 21 patients with rim fractures, 20 underwent fragment or loose body removal and 1 patient underwent to partial resection of the fragment, while none of the patients without rim fractures required this procedure ($P < 0.0001$). The mean *P* values of the PRO scores comparing both groups preoperatively showed no significant differences (Fig. 1), but we were expecting a difference after the surgery. Patients with rim fractures demonstrate higher VAS at 1-year post-surgery ($P = 0.047$) but at 2 years of follow-up, this difference was not statistically significant ($P = 0.1$) (Fig. 2). We took the five most performed procedures on both groups and

Table I. Matching criteria

Matching criterion	*Categories or range*
Gender	Male
	Female
BMI	Normal ($<25\ kg/cm^2$)
	Overweight ($\geq 25\ kg/cm^2$ and $<30\ kg/cm^2$)
	Obese ($\geq 39\ kg/cm^2$)
Age	Within 3 years

Table II. Demographic factors

	Rim fracture	*No rim fracture*	P *value*
Number of patients	21	21	
Gender (male)	15 (71.43%)	15 (71.43%)	1
Laterality (right)	14 (66.67%)	11 (52.38%)	0.3
Age at surgery (years)	33 (15.6–49.1)	33 (15.7–49.2)	1
Height (in.)	68.5 (62–77)	69.4 (63–75)	0.5
Weight (lb)	178.8 (120–277)	172.7 (100–260)	0.7
BMI (kg/cm^2)	26.5 (19.4–36.7)	24.9 (17.7–33)	0.2
Workers' compensation claim	0 (0%)	2 (9.52%)	0.5
Follow-up time (months)	27 (24.2–38.5)	26 (23.5–34.6)	0.4
Conversion to THA/BHR	0 (0%)	0 (0%)	0.9

Percentages and ranges are given in parentheses.

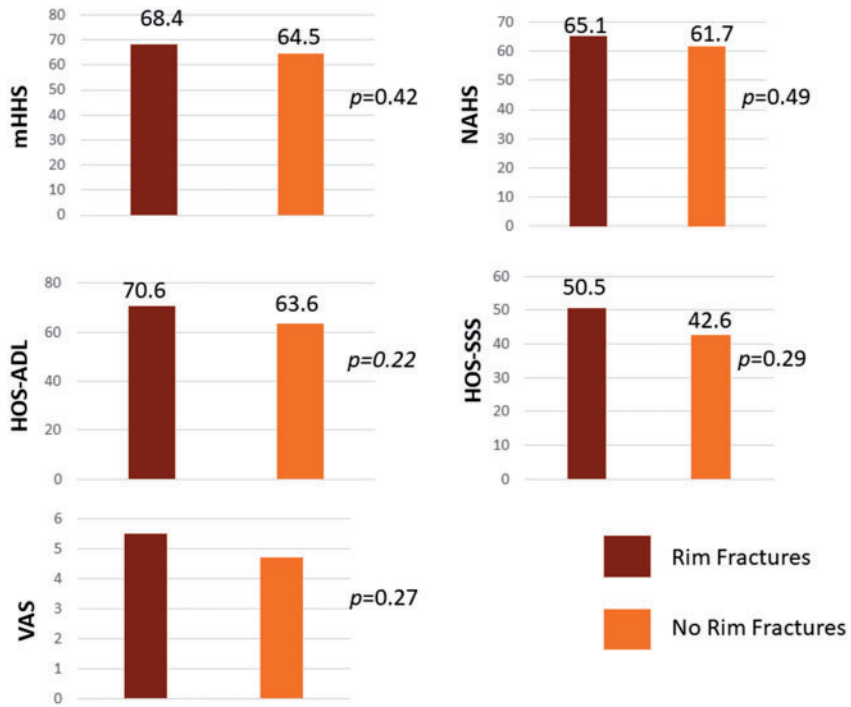


Fig. 1. Preoperative PRO scores and VAS comparing the group with rim fractures versus the group without rim fractures.

measure the *P* values at 2 years of follow-up showing that there was no statistically significant difference between groups in terms of postoperative, or improvement in PRO scores, or in satisfaction. Nevertheless, we found that the patients without rim fractures had better PRO scores compared with the group of patients with rim fractures (Fig. 3A–D). When we compared the *P* values of the preoperative and postoperative X-ray measurements LCEA, ACEA and COS the difference between groups was not statistically significant (Fig. 4).

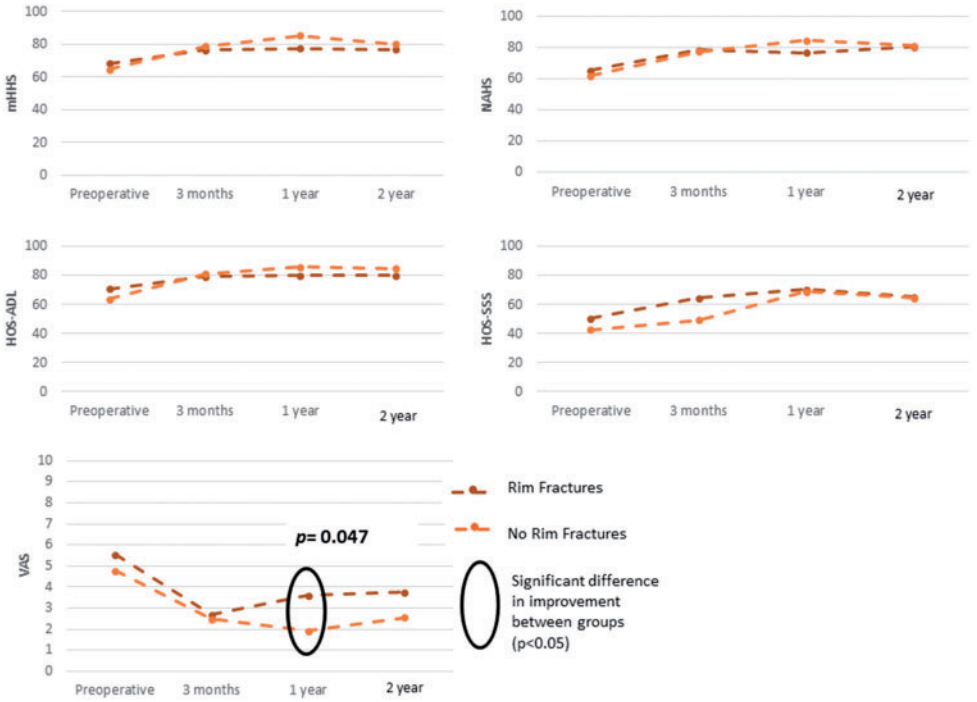


Fig. 2. PRO scores and VAS at preoperative and postoperative (3 months, 1 year and 2 years) time points.

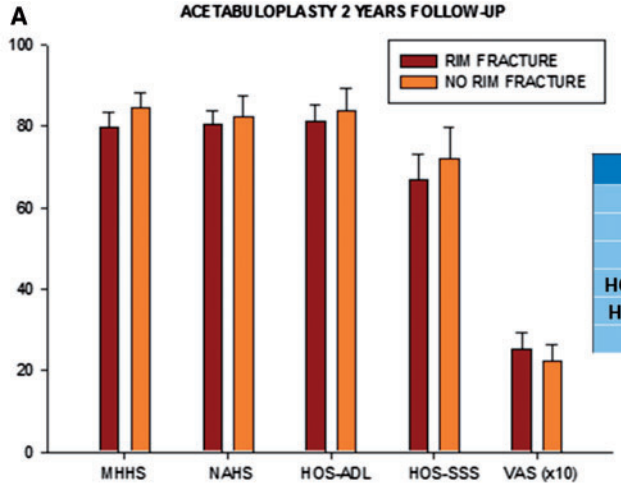
DISCUSSION

The function of the 'os acetabuli', or acetabular rim fracture, in the acetabular anatomy remains unclear [8]. One hypothesis is that 'os acetabuli' and rim fractures are the result of abnormal acetabular development in congenital hip dysplasia or Perthes disease [1–3], or the consequence of stress fractures from repetitive contact of the femoral neck against the acetabular rim in pincer impingment [2, 7, 8]. It has been described by Martínez *et al.* [7] that in the presence of pincer type impingement, 'os acetabuli' and rim fractures may present with a prevalence of 3.6%. Jackson *et al.* [6] identified an amorphous calcification deposited in the anterosuperior labrum in 16 patients at the time of arthroscopy. All patients had labral tears and all patients had at least one component of FAI.

We hypothesized that patients with FAI and acetabular rim fractures may have better outcomes after arthroscopic treatment, considering that the acetabular rim fracture could be an underlying factor that increased the patients' symptoms preoperatively. However, the current study did not demonstrate any statistically significant differences in PRO scores or conversion to total hip replacement at minimum 2-year follow-up between patients treated for rim fractures and patients who did not have rim fractures. Perhaps due to the larger number of structures implicated in FAI and the variable pattern of impingement, a specific and significant effect of acetabular rim fractures on patient outcomes was not observed.

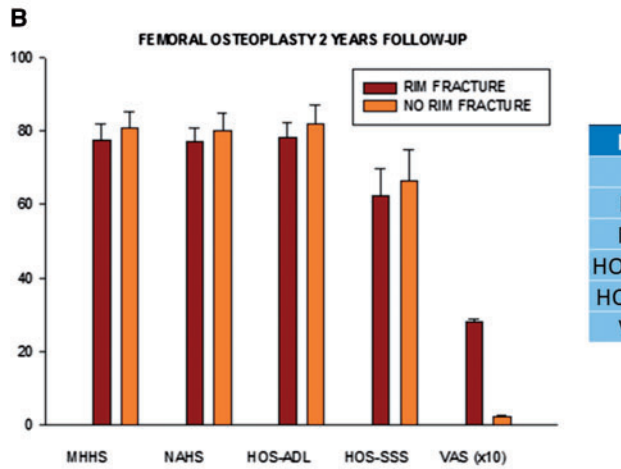
Our study has some important limitations. First, our selection of patients for rim fractures removal is mostly based on the symptoms and maybe the symptoms are from the FAI. Second, we analyzed function with the mHHS, although this PRO has been validated in hip arthroscopy, its reliability needs to be tested [17]. The HOOS, which we could only assess at latest follow-up, is better suited for evaluation of outcomes in the younger, more active population undergoing hip arthroscopy. Finally, we did not have consistent documentation of chondromalacia at arthroscopy in this retrospective study. However, the four subgroups were comparable in terms of presence of preoperative radiographic osteoarthritis, all of our cases had a Tönnis grade $\leq$1.

Arthroscopic techniques may be employed to treat FAI, as well as acetabular bony fragments associated with FAI. Given that optimal surgical treatment has not been specified in the literature, excision, fixation, or a combination thereof are the main types of treatment options. In 2009, Epstein *et al.* [2] reported one case of arthroscopic internal fixation of an unstable fracture of the acetabular rim after removal of the fibrocartilaginous junction. In 2011, Larson *et al.* [4] performed an arthroscopic partial excision and internal fixation, both with excellent results at 2 years of follow-up.



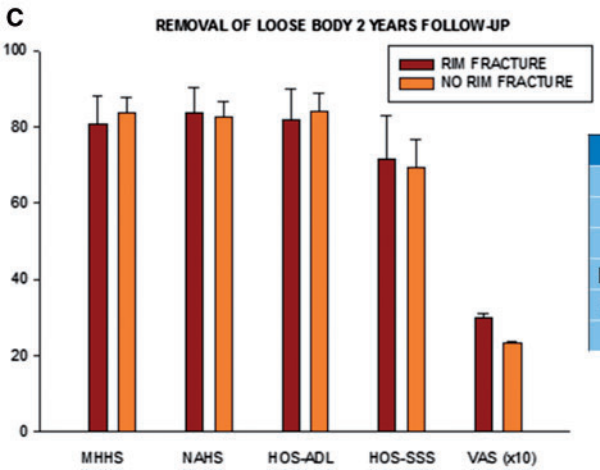
ACETABULOPLASTY 2 YEARS FOLLOW-UP			
	RIM FX	P vs	NO RIM FX
HSS	79.61 ± 16.28	(P = 0.372)	84.38 ± 15.8
NAS	80.59 ± 14.43	(P = 0.417)	82.50 ± 19.90
HOS-ADL	81.18 ± 17.20	(P = 0.370)	83.89 ± 21.80
HOS-SSS	66.77 ± 28.29	(P = 0.532)	71.87 ± 32.93
VAS	2.53 ± 1.84	(P = 0.806)	2.24 ± 1.64

Mann-Whitney U Rank Sum Test



FEMORAL OSTEOPLASTY 2 YEARS FOLLOW-UP			
	RIM FX	P vs	NO RIM FX
HSS	77.64 ± 16.87	(P = 0.512)	80.82 ± 18.61
NAS	77.13 ± 15.23	(P = 0.334)	79.92 ± 20.32
HOS-ADL	78.09 ± 17.46	(P = 0.227)	81.72 ± 21.78
HOS-SSS	62.39 ± 29.51	(P = 0.557)	66.31 ± 34.86
VAS	2.82 ± 2.12	(P = 0.847)	2.47 ± 1.91

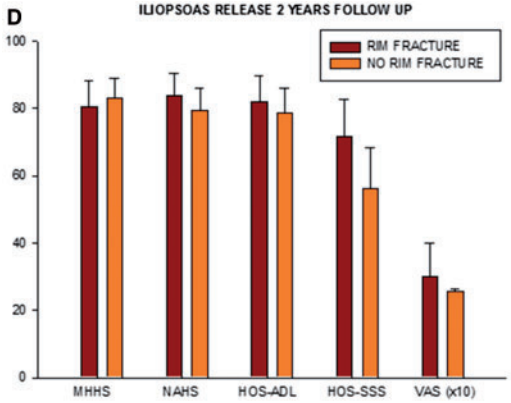
Mann-Whitney U Rank Sum Test



REMOVAL OF LOOSE BODY 2 YEARS FOLLOW-UP			
	RIM FX	P vs	NO RIM FX
HSS	79.77 ± 16.69	(P = 0.230)	83.74 ± 17.87
NAS	79.62 ± 15.22	(P = 0.146)	82.50 ± 19.56
HOS-ADL	81.19 ± 17.48	(P = 0.082)	84.15 ± 20.52
HOS-SSS	66.76 ± 28.83	(P = 0.352)	69.15 ± 34.91
VAS	2.8 ± 1.98	(P = 0.547)	2.38 ±1.88

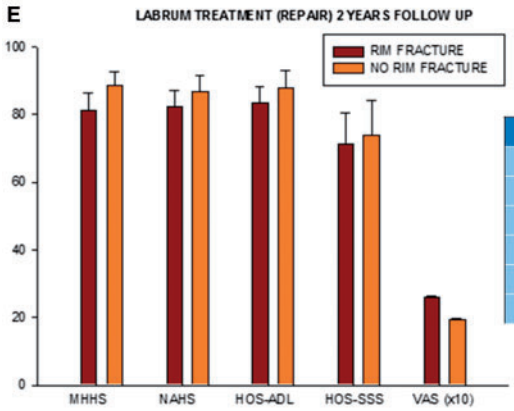
Mann-Whitney U Rank Sum Test

Fig. 3. (**A**) PRO scores and VAS at 2-year follow in Acetabuloplasty patients comparing the group with rim fractures versus the group without rim fractures. (**B**) PRO scores and VAS at 2-year follow in femoral osteoplasty patients comparing the group with rim fractures versus the group without rim fractures. (**C**) PRO scores and VAS at 2-year follow in Removal of Loose Body patients comparing the group with rim fractures versus the group without rim fractures. (**D**) PRO scores and VAS at 2-year follow in Iliopsoas Release patients comparing the group with rim fractures versus the group without rim fractures. (**E**) PRO scores and VAS at 2-year follow in Labral Repair patients comparing the group with rim fractures versus the group without rim fractures.



ILIOPSOAS RELEASE 2 YEARS FOLLOW-UP			
	RIM FX	P vs	NO RIM FX
HSS	80.58 ± 18.23	(P = 0.186)	82.94 ± 17.90
NAS	83.75 ± 15.83	(P = 0.234)	79.44 ± 19.21
HOS-ADL	81.76 ± 19.53	(P = 0.140)	78.59 ± 22.09
HOS-SSS	71.47 ± 27.69	(P = 0.656)	56.01 ± 37.27
VAS	3 ± 2.44	(P = 0.536)	2.55 ± 1.94

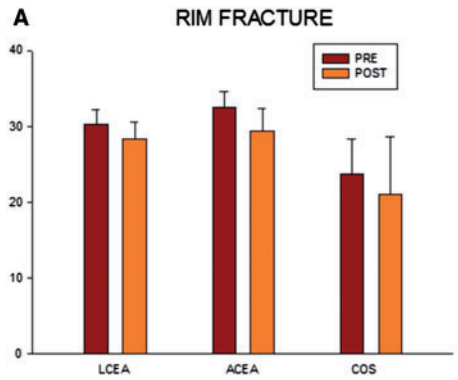
Mann-Whitney U Rank Sum Test



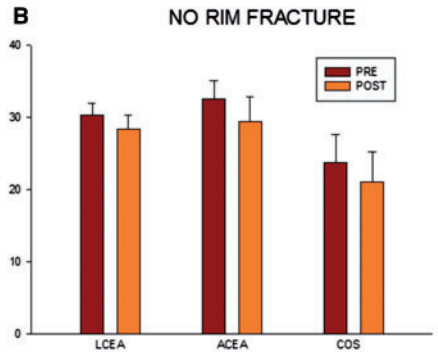
LABRUM TREATMENT (REPAIR) 2 YEARS FOLLOW-UP			
	RIM FX	P vs	NO RIM FX
HSS	81.26 ± 17.16	(P = 0.067)	88.34 ± 14.18
NAS	82.29 ± 16.17	(P = 0.148)	86.56 ± 17.00
HOS-ADL	83.81 ± 17.03	(P = 0.060)	87.71 ± 18.38
HOS-SSS	71.27 ± 31.13	(P = 0.482)	73.61 ± 35.83
VAS	2.58 ± 2.02	(P = 0.420)	1.92 ± 1.31

Mann-Whitney U Rank Sum Test

Fig. 3. Continued



RIM FRACTURE			
	PRE	P vs	POST
LCEA	30.12 ± 8.40	(P = 0.758)	29.77 ± 9.39
ACEA	32.23 ± 7.63	(P = 0.352)	29.81 ± 12.48
COS	28.56 ± 14.03	(P = 0.320)	26.56 ± 18.38



NO RIM FRACTURE			
	PRE	P vs	POST
LCEA	30.28 ± 7.21	(P = 0.351)	28.35 ± 8.37
ACEA	32.5 ± 9.54	(P = 0.866)	29.31 ± 14.07
COS	23.67 ± 15.03	(P = 0.652)	21.07 ± 15.70

Fig. 4. X-ray measurements at preoperative and postoperative time points comparing the group with rim fractures versus the group without rim fractures.

CONCLUSIONS

The presence or absence of an acetabular rim fracture does not appear to significantly impact patient reported clinical outcomes at minimum of 2 years following arthroscopic hip preservation surgery. The outcomes of this investigation may contribute to future efforts to identify optimal treatments for acetabular rim fractures.

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CONFLICT OF INTEREST STATEMENT

Brian D. Giordano is a paid consultant to Arthrex Inc., collects research support, and royalties. Benjamin G. Domb reports personal fees and other from Arthrex, other from Breg, other from ATI, personal fees and other from Pacira, personal fees and other from Stryker, personal fees from Orthomerica, personal fees from DJO Global, personal fees from Amplitude, personal fees from Medacta, outside the submitted work; and Dr. Domb is a board member for the American Hip Institute, which funds research and is the institute where our studies are performed. Dr. Domb is also a board member at the AANA Learning Center Committee and Arthroscopy Journal.

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