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SYMPOSIUM: FRACTURES OF THE ACETABULUM

Treatment of Acetabulum Fractures Through the Modified Stoppa Approach: Strategies and Outcomes

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Abstract

Background Since the original description by Letournel in 1961, the ilioinguinal approach has remained the predominant approach for anterior acetabular fixation. However, modifications of the original abdominal approach described by Stoppa have made another option available for reduction and fixation of pelvic and acetabular fractures.

Questions/purposes We evaluated our results in patients with acetabulum fractures with the modified Stoppa approach in terms of (1) hip function as measured by the Merle d'Aubigne hip score; (2) complications; and (3) quality of fracture reduction and percentage of fractures that united.

Methods Between September 2008 and August 2012, 289 patients with acetabular fractures were treated at our Level I trauma center. Twelve percent (36 of 289) of patients were treated operatively using the modified Stoppa approach. Ninety-seven percent (35 of 36) of our patients had fracture patterns involving displacement of the posterior column. Six (17%) were converted early to a total hip arthroplasty, and 14 (39%) were lost to final followup, leaving 22 of 36 for subjective clinical outcome analysis at a mean of 32 months (range, 9–59 months). Our general indications for this approach during the period in question were fractures of the anterior column and anterior wall, anterior column with posterior hemitransverse fractures, both column fractures, transverse fractures, and T-type fractures. Followup included regularly scheduled office visits with radiographs (AP pelvis, Judet views) that were graded by the treating surgeon and by the authors of this study (MJI, BCT) and patient outcome surveys.

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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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Results Merle d'Aubigne hip scores were very good in 55% (12 of 22), good in 9% (two of 22), medium in 18% (four of 22), fair in 5% (one of 22), and poor in 14% (three of 22), and 70% (23 of 33) of patients were able to ambulate without any assistive devices. Complications included one superficial infection and three deep infections, two patients with temporary lateral thigh numbness, no obturator nerve palsies, and one inguinal hernia. Three deaths in the cohort were seen in followup as a result of unrelated causes. Radiographic grading of fracture reductions after surgery revealed that 27 (75%) were anatomic, six (17%) were satisfactory, and three (8%) were unsatisfactory. A total of 94% of the fractures united.

Conclusions In agreement with prior published data, our results show good functional outcomes with minimal complications using the modified Stoppa approach for a variety of acetabular fractures. Our results highlight the difficulty but feasibility in treating posterior column displacement through an anterior approach. Consideration for dual approaches with posterior column involvement may be warranted to optimize fracture reduction and functional outcomes.

Level of Evidence Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Operative approaches to the acetabulum generally can be classified as anterior, posterior, extensile, or combined and largely include the Kocher-Langenbeck, iliofemoral, ilioinguinal, extended iliofemoral, triradiate, and combined anterior and posterior approaches [1, 2]. Since the original description by Letournel in 1961 [9], the ilioinguinal approach has remained the workhorse approach for anterior acetabular fixation. However, the type and nature of each acetabular fracture substantially influence which approach is used. If wide displacement is present in both the anterior and posterior columns of the acetabulum, an extended or combined approach can be used. An extensile approach may offer increased visualization with easier reduction and application of instrumentation but may subject patients to increased morbidity compared with more limited approaches [3, 4, 13].

In 1989, Stoppa [15] described a midline approach to repair inguinal hernias using Dacron mesh. Through that approach, Stoppa showed excellent exposure of the true pelvis, which spurred further interest in using the approach for acetabular fixation. Ultimately, Cole and Bolhofner [1] and later Hirvensalo et al. [3] were able to independently describe this approach to the anterior acetabulum and pelvis through an intrapelvic dissection from midline. The principal difference between the ilioinguinal approach and the modified Stoppa approach was the avoidance of the "middle window," thus sparing dissection of the inguinal canal, femoral nerve, and external iliac vessels. This modified approach, when executed correctly, provides clear acetabular access including access to the pubic body, superior ramus, pubic root, the ilium above and below the pectineal line, the quadrilateral plate, the medial aspect of the posterior column, the sciatic buttress, and the anterior sacroiliac joint [15]. General agreement exists for the use of the modified Stoppa approach for the vast majority of fractures that can be managed with an ilioinguinal approach [1, 4, 5, 13], but controversy remains regarding this utility's approach in more difficult fracture patterns such as posterior column fractures.

The purpose of this study is to report on the perioperative safety and functional outcomes of patients with acetabulum fractures treated using the modified Stoppa approach as an alternative to the traditional ilioinguinal approach. We therefore sought to evaluate our results in patients with acetabulum fractures using the modified Stoppa approach in terms of (1) hip function as measured by the Merle d'Aubigne hip score; (2) complications; and (3) quality of fracture reduction and percentage of fractures that united.

Patients and Methods

After obtaining formal institutional review board approval, a prospectively collected database at an urban Level I trauma center was electronically searched, and all operatively treated acute acetabular fractures (n = 289) treated between September 2008 and August 2012 were reviewed. Exclusion criteria included: patients treated nonoperatively, patients who were younger than 18 years of age at the time of their injury, and patients who were treated without use of this approach. Use of a different surgical approach for operative fixation was another primary reason for patient exclusion. Thirty-six patients with acute acetabular fractures treated by the modified Stoppa approach were ultimately reviewed for this study. Sixty-four percent (23 of 36) required exposure of the lateral window for fracture reduction and/or fixation placement. Six patients underwent THA as a result of posttraumatic arthritis. Two of the six patients undergoing THA were lost to followup and not included in final subjective outcome scoring. Three patients died from causes unrelated to their pelvic injury before 1-year followup and are included in the perioperative analysis but excluded from final subjective outcome scoring. The decision for use of the modified Stoppa approach was based on fracture pattern and surgeon preference. Relative indications for use of the Stoppa approach

in this study included: fractures of the anterior column and anterior wall, anterior column with posterior hemitransverse fractures, both column fractures, transverse fractures, and T-type fractures. Ninety-seven percent (35 of 36) of patients treated with the modified Stoppa had a fracture pattern with displacement involving the posterior column, whereas only one patient had an isolated anterior column fracture. The patients included here represented 12% of the surgically treated acetabular fractures (36 of 289) during our study period from 2008 to 2012. Undoubtedly, a subset of patients with similar fracture patterns was treated without use of the modified Stoppa approach. Surgeon preference was the primary driving force behind the approach used and many of the patients initially screened in this study were treated by surgeons who do not use the modified Stoppa approach. The mean patient age in this series was 47 years (SD, 16 years), and the large majority of patients was male (Table 1).

Preoperative evaluations, including analysis of plain radiographs and CT scans, were essential for determining operative plan. All patients in this study had an AP pelvis radiograph, Judet pelvis radiographs, and a CT scan of the pelvis as part of the standard protocol for these injuries. Classification of all fractures was done preoperatively with a combination of the radiographic views by the treating surgeon and was later confirmed by independent review by two of the authors (MJI, BCT) [7].

Of note, 19 of the 36 patients in this study had associated pelvic ring injuries; if operative stabilization of the pelvic ring was performed, it was completed through the same approach or through a percutaneous approach for posterior iliosacral screw placement at the time of acetabular fixation. All patients included in this study were treated by one of four fellowship-trained orthopaedic trauma surgeons (BCT, JC, BGF, KP).

The modified Stoppa approach has been well described previously by several authors, and the surgical approach and techniques used by the operating surgeons in this study were identical to these previous reports [1, 15]. In brief, operative treatment includes supine positioning on a flat radiolucent table with the ipsilateral hip and knee flexed to relax the iliopsoas and external iliac/femoral neurovascular bundle. Foley catheter drainage of the bladder is used for all patients to improve visualization, provide bladder protection, and monitor fluid balance. The operating surgeon is positioned on the contralateral side to the injured acetabulum. A transverse Pfannestiel-type incision is made two fingerbreadths above the pubic symphysis, and dissection is made through skin and subcutaneous tissue down to the rectus fascia, exposing the linea alba clearly. A vertical longitudinal split is then made in the rectus abdominus along the linea alba; the length of this cephalad-caudad split is the limiting factor in extent of exposure. The transversalis fascia is opened just superior to the symphysis, allowing access to the potential retropubic space of Retzius. This space is further developed with blunt finger dissection and placement of a malleable retractor used to mobilize and hold the bladder out of the surgical field. Subperiosteal dissection is performed from the pubic symphysis in a lateral direction, extending to the pelvic brim and internal iliac fossa. All vascular anastomoses, including the corona mortis, are attended to using ligation or vascular clips, and the iliopsoas is elevated off the internal iliac fossa. Access to the quadrilateral surface is then obtained with mobilization and protection of the obturator neurovascular bundle through careful placement of a retractor in the sciatic notch. Access to the iliac wing for fractures that involve the anterior column is available through the lateral window of the ilioinguinal approach. This window involves an incision along the superior border of the iliac wing with release and reflection of the abdominal muscles proximally; submuscular dissection along the internal iliac wing allows access to most anterior column fractures and provides additional access for hardware and/or screw placement.

Postoperatively, drains placed in the space of Retzius (and lateral window, if used) were removed when less than 30 mL of drainage over a 24-hour period was seen. Because postoperative ileus is common, careful postoperative monitoring of the patient and slow advancement of the diet were undertaken. Bowel sounds and presence of flatus guided the advancement of the diet. All patients used sequential compression stockings and pharmacologic deep vein thrombosis prophylaxis for at least 21 days postoperatively. Depending on associated injuries and patient stability, mobilization with physical therapy was begun as soon as possible. Patients remained touch-down weightbearing to the operative side for a minimum of 8 weeks and advanced according to their overall injury pattern(s). Heterotopic ossification prophylaxis was not routinely

Table 1. Patient demographics

Variable	Results
Age (years)	46.5 ± 16.1 (18–87)
Sex (male)	31 (86.1%)
Body mass index (kg/m^2)	29.8 ± 9.5 (21.1–45.0)
Employment	12 (33.3%)
Tobacco use	15 (41.7%)
Other injuries	31 (86.1%)
Acetabular fracture	36 (100%)
Pelvic ring injury	19 (52.8%)

Categorical variables are given as absolute numbers with percentages in parentheses. Noncategorical variables are given as means ± SDs with ranges in parentheses.

administered after these approaches. Followup evaluation included postoperative visits and radiographs at 3 weeks, 8 weeks, 4 months, 6 months, 1 year, and yearly thereafter if indicated. Pain, function, and mobility were evaluated at each sequential followup visit.

Clinical results were evaluated at a mean of 32 months based on a 7-point scale for pain, hip mobility, and ambulation described by Merle d'Aubigne and Postel [11]. Summation of individual scores for pain and hip mobility generates an absolute hip function score. Patients can then be placed into one of five functional classes: very good (11–12 points), good (10 points), medium (9 points), fair (8 points), or poor (< 8 points) Radiographic results, including injury pattern, quality of reduction, and long-term outcomes (Kellgren and Lawrence radiographic hip arthritis classification), were independently reviewed by two of the authors (MJI, BCT) and also recorded. Quality of reduction was graded on AP pelvis and two Judet pelvis views, and the radiographic views with the worst of the three Matta grading scores were kept as the grade for the reduction. The Matta grading scores were classified as anatomic (0–1 mm), satisfactory (2–3 mm), or unsatisfactory (> 3 mm) based on millimeters of displacement [10]. No postoperative CT scans were obtained to assess reduction or fracture union.

Table 2. Patient outcomes

Variable	Results
Followup length (months)	32.1 ± 16.6 (8.6–59.2)
Workers' Compensation involvement	1 (2.7%)
Deep venous thrombosis	3 (8.3%)
Pulmonary embolism	1 (2.7%)
Infection	
Superficial	1 (2.7%)
Deep	3 (8.3%)
Union	34 (94.1%)
Time to union (months)	3.5 ± 0.9 (2–6)
Thigh numbness	
Medial	None
Lateral	2 (5.6%)
Unassisted ambulation	23 (69.7%)
Hip arthritis	
Kellgren-Lawrence classification	1.8 ± 1.4 (0–4)
Merle d'Aubigne hip score	
Pain	4.4 ± 1.6 (1–6)
Mobility	5.4 ± 1.2 (2–6)
Walking	4.7 ± 1.6 (0–6)
Absolute function	9.9 ± 2.1 (5–12)

Categorical variables are given as absolute numbers with percentages in parentheses. Noncategorical variables are given as means ± SDs with ranges in parentheses.

Results

Merle d'Aubigne and Postel scores demonstrated 54% (12 of 22) of patients scored very good, 9% (two of 22) good, 18% (four of 22) medium, 5% (one of 22) fair, and 14% (three of 22) poor in terms of absolute hip function. Absolute hip function was determined by summation of each patient's pain and hip mobility scores (Table 2). Seventy percent (23 of 33) of our patients demonstrated unassisted ambulation at final followup. Interestingly, all patients reporting poor results (n = 3) uniformly had fracture patterns involving displacement in the posterior column with one of these patients necessitating a dual approach after a hip fracture/dislocation injury. A dual approach was used in only 8% (three of 36).

No intraoperative complications were seen in this cohort, and incidence of postoperative complications was relatively low (Table 2). Three patients experienced deep postoperative infections, all of whom returned to the operating room for formal irrigation and débridement and maintenance of implants; these patients all subsequently went on to uneventful union. Three patients experienced a postoperative deep vein thrombosis and one patient was diagnosed with a nonfatal pulmonary embolus. One patient developed a postoperative rectus hernia at 4 months postoperatively, eventually requiring surgical repair. Two patients, both of whom required use of the lateral window, developed a lateral femoral cutaneous nerve palsy, one of which subsequently resolved without sequelae. Obturator nerve palsy, as diagnosed through loss of medial thigh sensation or weakness of hip adductors, was not seen in this patient cohort.

Use of the modified Stoppa approach for operative treatment of acute complex acetabular fractures appears to allow successful fracture reduction (Table 3). Radiographic grading of the fractures immediately postoperatively revealed that 27 (75%) of the reductions were graded as excellent, six (17%) as good, and three (8%) as poor (Fig. 1). Radiographic analysis demonstrated that 94% of patients achieved osseous union by 3.5 ± 0.9 months (range, 2–6 months). Radiographic results were rated using the Kellgren-Lawrence osteoarthritis classification system, and final evaluation indicated 48% of patients with no arthritic changes, 21% with mild arthritis, 14% with moderate arthritis, and 17% with severe arthritis. The average radiographic grade was 2 ± 1 (range, 0–4). Six patients underwent THA (17%) for posttraumatic arthritic changes at a mean of 11 months (range, 4–16 months). Clinical outcomes were included in our analysis on four of the six of patients who had undergone THA. The remaining two were lost to final followup.

Table 3. Operative variables

Variable	Result
Time from injury to operating room (days)	4.5 ± 5.3 (0–30)
Fracture pattern	
Transverse	5 (13.9%)
T-type	6 (16.7%)
Both column	15 (41.7%)
Anterior column	1 (2.8%)
Anterior column–posterior hemitransverse	7 (19.4%)
Transverse–posterior wall	2 (5.6%)
Estimated blood loss (mL)	1041.4 ± 946.7 (100–5000)
Change in hemoglobin (g/dL)	1.8 ± 1.3 (0.2–4.6)
Patients transfused	26 (72.2%)
Units transfused	1.9 ±1.8 (0–6)
Use of lateral window	23 (63.9%)
Use of supplemental posterior approach	3 (8.3%)
Operating room time (minutes)	320.2 ± 81.8 (199–568)

Categorical variables are given as absolute numbers with percentages in parentheses. Noncategorical variables are given as means ± SDs with ranges in parentheses.

Discussion

Surgical treatment of acetabular fractures has historically been done through anterior, posterior, extensile, or combined approaches with emphasis on improved fracture visualization and anatomic reduction. This strategy of fracture fixation is effective [6, 11] but is associated with risk of injury to anatomic structures around the pelvis and acetabulum. The introduction of the modified Stoppa approach for anterior intrapelvic acetabular treatment allowed avoidance of the middle window of the ilioinguinal approach, thus potentially minimizing risks of iatrogenic injury to the inguinal canal, femoral nerve, and external iliac vessels. The rationale of this study, along with previous series by Cole and Bolhofner [1], Hirvensalo et al. [3], and Sagi et al. [14], is to provide clinical evidence that this potentially less invasive technique can be efficacious while minimizing patient morbidity.

Like with all retrospective analyses, this study is limited by selection bias, which generally tends to inflate the apparent benefits of the treatment in question. In this report, 36 of the possible 289 acetabular fractures were treated using the modified Stoppa approach although there undoubtedly was a greater number of the original 289 fractures in patients who could have received this approach using the general indications we used in this report. This could be perceived as a direct selection bias in that we preferentially chose to treat certain fractures through the modified Stoppa approach. However, of the total eligible patients, many had a fracture pattern deemed inappropriate for the modified Stoppa approach and several of the treating surgeons preferred a different approach. The relatively limited number of patients with this procedure further limits this study's generalizability, although our findings were generally supported by similar studies of others [1, 3, 4, 14]. The limited sample size may not fully capture the data variability or secular trends seen with this patient population and therefore errant conclusions could be made. The sample size was further narrowed by obtaining complete subjective scores on only 61% (22 of 36) of our patients. A total of 17% of our patients (six of 36) ended up receiving a THA as a result of posttraumatic arthritis and four of six of these patients were included in our final analysis (Fig. 2). Their subjective outcome scores potentially could inflate our results; however, it is important to note that half of the patients undergoing THA who completed subjective outcome scores had medium or fair results. In addition, the results from our practice site may not apply to all sites; patients in this study were treated from injuries caused by high-energy trauma at a busy Level I trauma center, where experienced acetabular surgeons and thorough multidisciplinary patient care are available. Similar high-level patient care settings are not always accessible, and the results of these techniques may be different according to treatment teams and available resources.

Our primary aim was to determine whether good functional outcomes of displaced acetabular fractures, as measured by the Merle d'Aubigne hip score, can be obtained with use of this approach. Our results showed 64% good or very good absolute hip function scores at nearly 3 years postoperatively, which is somewhat less than previously reported by Sagi et al. [14], who reported 88% good or very good results at 1 year postoperatively However, Sagi et al. reported 24% (12 of 50) of their patients with isolated anterior column involvement, which is significantly higher than our 3% (one of 36). Anterior column fractures are intuitively easier to reduce and fix through an anterior approach and this may be one potential source of our outcome differences. The vast majority of our patients had fractures with posterior column involvement (35 of 36), which can increase the difficulty in obtaining an anatomic reduction through an anterior approach and subsequently affect functional outcomes. The same can be said for Cole and Bolhofner [1] who showed 89% excellent/good clinical outcomes but had 16% (nine of 55) of patients with isolated anterior column/wall involvement. Hirvensalo et al. [3] reported an 80% rate of Harris hip scores > 75, indicating fair or greater outcome, which better correlates with our 86% (19 of 22) rate of fair or better outcomes with the Merle d'Aubigne scoring system.

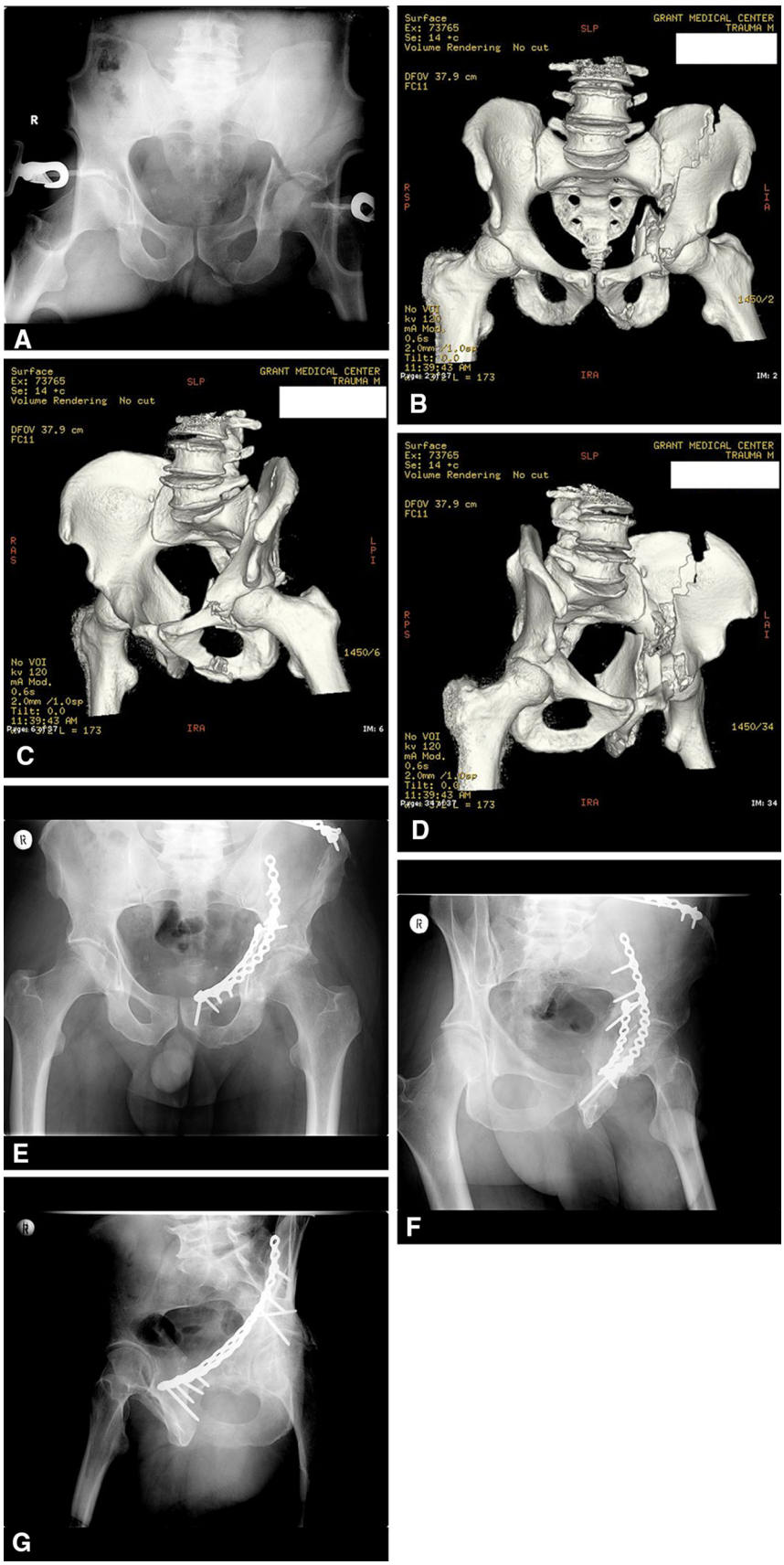

Fig. 1A–G (**A**) A left-sided both column acetabular fracture is shown with an initial AP radiograph. (**B**) Three-dimensional (3-D) AP projection and (**C–D**) 3-D reconstructed Judet views. Two-year followup after fixation through the Stoppa approach and lateral window is shown in **E**, **F**, and **G**.

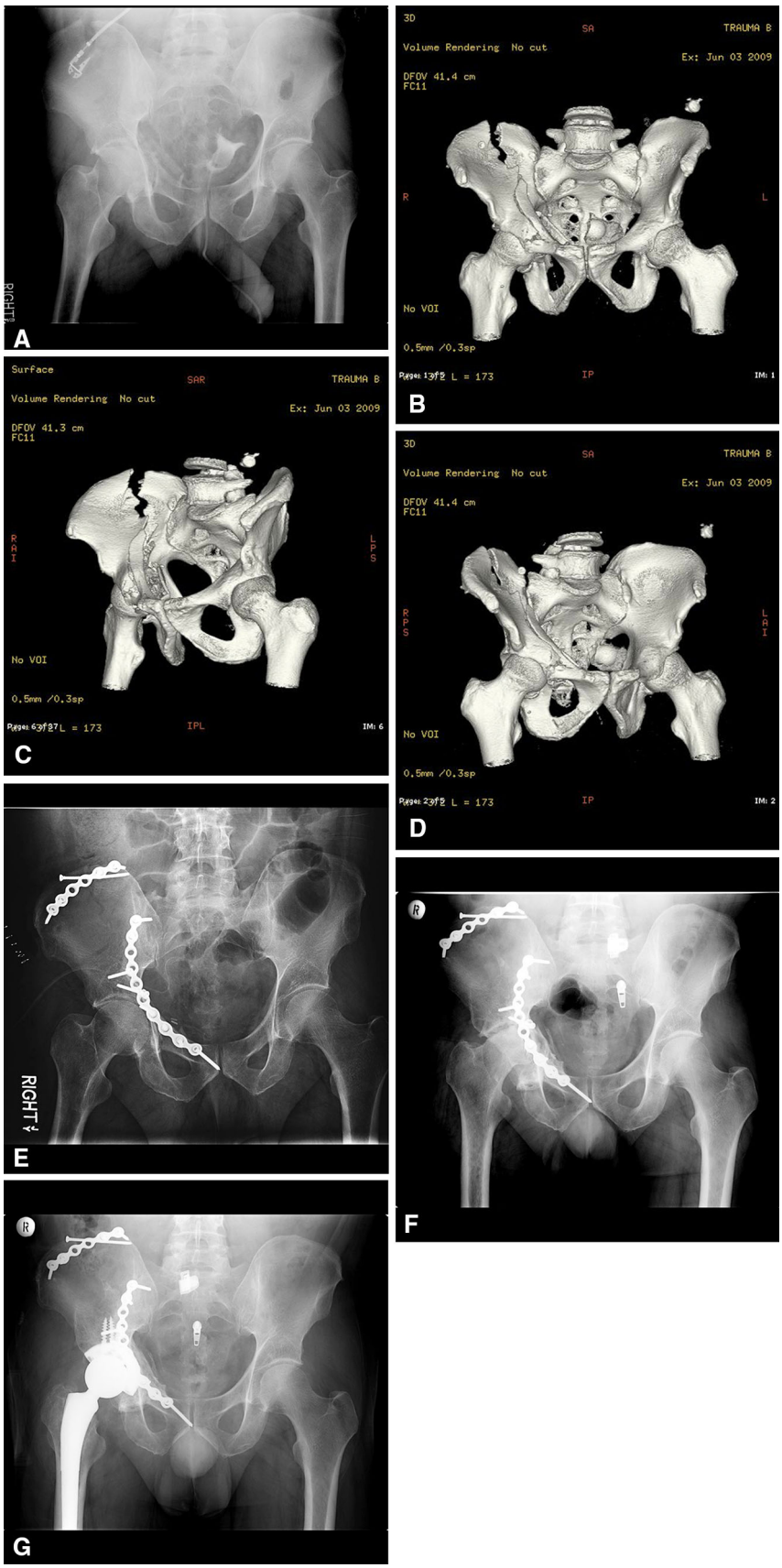

Fig. 2A–G A right-sided comminuted anterior column acetabular fracture is shown in **A** through **D**, whereas the immediate postoperative AP radiograph is shown in **E**. Significant posttraumatic degenerative changes are seen by 9 months postoperatively (**F**), and this patient ultimately underwent THA with successful improvement of pain and outcome (**G**).

In addition, our perioperative complication rate, including infection, hernia, and neurovascular injury, was less than 10%, which is lower than Letournel's and Matta's studies using the ilioinguinal approach showing complication rates of 20% and 13%, respectively [7, 11]. Our complication rate is also in line with previously published studies using the modified Stoppa approach [4, 14]. One unexpected finding was the presence of proximal lateral thigh numbness postoperatively in two patients who underwent fixation of their acetabular fractures with the modified Stoppa approach and use of the lateral window. Conversely, we did not discover any transient obturator nerve palsies, which has a reported incidence of up to 26% [1, 15]. Other extensile approaches such as the ilioinguinal are thought to be associated with higher rates of wound complications and morbidity [3, 4, 13]. The middle window of the ilioinguinal approach skeletonizes the external iliac vessels and lymphatic channels of the inguinal canal and is associated with thrombosis and lymphedema [14, 15]. The more limited modified Stoppa approach used in this study has several advantages: (1) less invasive dissection without exposure of the inguinal canal; (2) direct visualization of the entire pelvic brim from the pubic body to the anterior aspect of the sacroiliac joint; (3) direct visualization and access to the external iliac to obturator anastomosis; (4) direct visualization and access to the quadrilateral plate allowing for reduction and plating; and (5) direct visualization and access to the posterior column from the greater sciatic notch to the ischial spine allowing reduction and plating [15].

The ability to achieve good radiographic reductions using the ilioinguinal and other more extensile approaches is well established [8]. Letournel described his results using the ilioinguinal approach and noted excellent reductions in 61% of associated both column fractures, 86% of anterior column fractures, and in 68% of anterior column-posterior hemitransverse fractures. With the modified Stoppa approach, we had similarly good results. We achieved 27 anatomic (75%), six satisfactory (16.7%), and three unsatisfactory (8.3%) reductions. These percentages correlate well with previously published studies using the modified Stoppa approach by Sagi et al. [14] (70% excellent), Hirvensalo et al. [3] (84% good), and Cole and Bolhofner [1] (64% excellent).

Minimization of perioperative complications while allowing access for anatomical reduction and fixation is a perceived benefit of the modified Stoppa approach for acetabular fractures, and our findings are largely consistent with that of previous studies [1, 3, 4, 12, 14]. This study shows good outcomes are obtainable in what we perceive to be very difficult fractures extending into and displacing the posterior column. Our slightly lower functional results likely indicates that posterior column displacement is a characteristic that portends more difficult reduction and possibly lower functional outcomes if treated with the modified Stoppa approach only. This study also had greater length of followup than most of the previously referenced studies, which may allow us to highlight progression toward posttraumatic conditions such as osteoarthritis better than shorter followup could provide. We reaffirm that this appears to be a safe exposure that appears to be equivalent to the more extensive ilioinguinal approach in terms of functional outcomes, although further evidence comparing the two approaches is needed along with evidence discussing which fractures or fracture characteristics are best treated with either approach.

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