Extensile Triradiate Approach for Complex Acetabular Reconstruction in Total Hip Arthroplasty

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The triradiate approach as described by Mears has been used for open reduction of complex dual-column acetabular fractures. Mears extended the anterior limb of this incision to the symphysis pubis by the ilioinguinal approach. From a consecutive series of 43 total hip revisions, this approach was used successfully in seven cases in which extensile exposure was necessary to revise complicated acetabular reconstructions for arthroplasty. The approach was also used to perform complex acetabular reconstruction after en bloc tumor resection. Three patients had severe intrapelvic component protrusio and anterior column deficiency where close proximity of the prosthesis and femoral neurovascular bundle were detected before surgery. Massive allograft and pelvic reconstructions were used to span large anterior column defects and to stabilize pelvic dehiscence. Complications included one hip dislocation and one posterior flap tip necrosis. Follow-up ranged from six to 34 months. No graft failure has been noted.

The use of anterior and posterior column-plating for stabilization of pelvic dehiscence and for major column defects have been advocated in revision total hip arthroplasty (THA). The described surgical exposures used in these reports were either the direct lateral or posterior with trochanteric osteotomy or "slide".

The rationale for stability is to obtain healing of pelvic discontinuity, which behaves much as a transverse acetabular fracture delayed union. Furthermore, pressfit acetabular component insertion requires structural continuity of the acetabulum.

With the goals of improving plating techniques and optimizing allograft reconstruction, the triradiate extensile approach with an ilioinguinal extension described by Mears was selected. Dissection of two anatomic specimens demonstrated that the entire external and internal surfaces of the acetabulum could be reached in the approach. The ilioinguinal extension allowed access from the pubic symphysis to the sacral alar wing. All important neurovascular structures were easily identified. This report describes the surgical technique in detail and reviews representative cases in which it was used.

MATERIALS AND METHODS

From a consecutive series of 43 THA revisions, five patients required this extensile approach. Two additional tumor cases were treated with en bloc resection and subsequent reconstruction using matching pelvic allografts. The follow-up period ranged from six to 34 months (Table 1).

Careful preoperative workup to rule out infection included sedimentation rate, complete blood count, hip aspiration, and Indium white blood cell scan. Judet and inlet/outlet views of each pelvis were obtained. Additional studies including femoral arteriogram and intravenous pyelogram were obtained if component protrusion or prolapse was
TABLE 1. Case Review of Acetabular Allograft Reconstructions

<table>
<thead>
<tr>
<th>Follow-up Time (months)</th>
<th>Diagnosis</th>
<th>Operative Fixation</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 34</td>
<td>Failed THA Pelvic dehiscence</td>
<td>Allograft; double column plate</td>
<td>Early dislocation resolved</td>
</tr>
<tr>
<td>2 30</td>
<td>Failed THA Acetabular component prolapse</td>
<td>Allograft</td>
<td>None</td>
</tr>
<tr>
<td>3 28</td>
<td>Recurrent pigmented villonodular synovitis</td>
<td>Total acetabular allograft; double column plate</td>
<td>Mild lateral femoral cutaneous neuropraxia</td>
</tr>
<tr>
<td>4 12</td>
<td>Anterior column defect</td>
<td>Allograft; anterior column plate</td>
<td>None</td>
</tr>
<tr>
<td>5 11</td>
<td>Acetabular component prolapse</td>
<td>None</td>
<td>Posterior flap tip necrosis</td>
</tr>
<tr>
<td>6 11</td>
<td>Malignant fibrous histiocytoma</td>
<td>Total acetabular allograft; double column plate</td>
<td>Iliac vein thrombosis</td>
</tr>
<tr>
<td>7 6</td>
<td>Anterior column defect</td>
<td>Allograft; anterior column plate</td>
<td>None</td>
</tr>
</tbody>
</table>

THA, total hip arthroplasty.

Present. Tumor cases underwent three dimensional computed tomography (CT) and magnetic resonance imaging (MRI).

**Operative Technique**

The patient must be placed in the lateral decubitus position and stabilized with either a “bean” bag or patient positioner that allows access posteriorly to the gluteal cleft and anteriorly to the symphysis pubis. It is important to stabilize the chest anteriorly, as the patient naturally tends to roll forward or prone. Perineal adhesive drapes are applied. The triradiate approach uses the standard posterolateral incision that begins 12 cm distal to the tip of the trochanter and parallel to the lateral femoral shaft (Fig. 1A). The incision extends proximal to the tip of the greater trochanter and then posterior toward the posterior superior iliac spine for 8–10 cm. No undermining of subcutaneous tissue is done because this approach relies on fascial blood supply to all flaps. The fascia lata is incised in line with the incision, which avoids the distal insertion of the tensor fascia lata. At the tip of the greater trochanter, the gluteus maximus is split posteriorly toward the posterior superior iliac spine. This split must stop at least 4 cm from the posterior superior iliac spine to avoid injury to the superior gluteal vessels and nerve. A finger is inserted under the insertion of the gluteus maximus tendon into the linea aspera and this tendon is incised for 3 cm. Bleeders are always encountered and are cauterized. The sciatic nerve then is identified and traced from the sciatic notch distally. If scar tissue is present, the nerve is best found distally below the linea aspera in virgin tissue. The nerve is encircled with Penrose drain and should be made patulous by flexing the knee. The posterior hip capsule is exposed by incising the posterior external rotators from the posterior greater trochanter.

The anterior limb of the triradiate incision is made by incising from the tip of the greater trochanter anteriorly to the anterior superior iliac spine. This limb approximates an angle of 120° with the posterior limb incision. The tensor fascia lata muscle is carefully identified and must be incised on the most anterior aspect (Fig. 1B). A common error is to miss this interval and incise posterior to the tensor muscle; this devascularizes the muscle by cutting the vessel arising from the superior gluteal artery. This triangular fascial flap can be reflected dorsally to expose the external hip joint. Trochanteric osteotomy then can be done at the vastus lateralis tubercle and extending medially to a point of junction between the superior hip capsule and the gluteus minimus tendon. The entire lateral wall of the ilium and the hip capsule are exposed.

The anterior iliinguinal extension is made by extending the incision from the anterior superior iliac spine to a point 3 cm above the symphysis pubis. The lateral femoral cutaneous nerve is identified 1–2 cm medial to the anterior superior iliac spine, and is protected. The external oblique fascia is exposed and the round ligament in females or
FIGS. 1A–1G. (A) Incision of extensile triradiate approach (A–D) with ilioinguinal extension. (B) Incision of gluteus maximus muscle and tensor fascia lata. (C) Incision of sartorius, deep and reflected head of rectus femoris. (D) Incision of inguinal ligament. (E) Cross section of inguinal canal. (F) Incision of iliopsoas fascia. (G) Mobilized bundles: (1) psoas muscle femoral nerve; (2) femoral artery and vein; (3) round ligament.

the spermatic cord in males is identified medially and encircled with a Penrose drain. At this point, the anterior hip flexors (i.e., sartorius, direct, and reflected of rectus femoris) are incised and mobilized to expose the anterior wall of the acetabulum (Fig. 1C). The external oblique fascia is incised in line with the skin incision at least 1 cm above the external inguinal ring. The ilioinguinal ligament is identified at the distal insertion of the external oblique fascia. This ligament is incised 1–2 mm proximal in the thickened fascia and the common origin of the internal oblique and transversalis muscles is retracted superiorly, exposing the underlying psoas sheath (Fig. 1D). The iliopsoas muscle with the femoral nerve lying on the anteromedial muscle belly can be identified and encir-
cled with a Penrose drain. By palpating medially under the psoas muscle, the finger stops at the iliopectineal fascia and the femoral artery can be palpated on the other side of this fascial barrier (Fig. 1E). The incision of ilioinguinal ligament extends medially over the femoral artery and vein. Before their complete identification, it is helpful to delineate the iliopectineal fascia and incise it with scissors down to the pubic tubercle on the superior pubic ramus (Fig. 1F). Access to the artery and vein is facilitated and the remainder of the ilioinguinal ligament can be incised. A right-angle clamp can be passed under the femoral artery and vein, and these structures encircled with a Penrose drain. An important step at this point is to look for the “corona mortis,” which is a communicating vessel between the inferior epigastric branch of the femoral artery and the obturator artery before it exits below the lateral superior pubic ramus. This vessel is present about 20% of the time and can cause some constricting bleeding if avulsed. The remaining medial pectineus muscle is easily reflected to expose the medial pubis.

Several “windows” are created, which gives complete access to the superior pubic ramus, the anterior acetabular wall, and the entire anterior column of the pelvis (Fig. 1G). Exposure of the inner table of the ilium all the way to the sacroiliac joint and of the medial quadrilateral plate can be made by reflecting the fascial insertion of the anterior iliac wing from the anterior superior iliac spine posteriorly off the crest for about 5 cm. The dorsal flap can be retracted superiorly to improve exposure.

At the completion of the procedure, closure of the medial approach is done by carefully reapproximating the inguinal ligament using nonabsorbable suture to avoid hernia formation. The sartorius and rectus femoris muscles are reattached to their anatomic origins using drill holes. Drains are placed medially under the ilioinguinal ligament and along the medial iliac wing. The anterior superior fascial incision on the iliac wing is closed. The greater trochanter is replaced to the proximal femur. A posterior drain is placed behind the hip joint. External rotators are reapproximated through drill holes on the greater trochanter, and the gluteus maximus tendon insertion is repaired. The tensor fascia lata is reattached to its insertion in the fascia lata and the fascia lata and gluteus maximus split are reapproximated. Skin and subcutaneous tissues are closed in usual fashion.

**Postoperative Management**

The patient is placed in an abduction splint on the operating table to prevent dislocation. The patient may be up in a chair on Day 1. After drains are removed at 48 hours, physical therapy may start, which includes transfer techniques and gait training to the normal leg. The patient remains completely nonweight-bearing on the operated side. No hip exercises are initiated until six weeks have passed to allow for healing of detached muscles and trochanter. If hip stability is a problem, the patient may need to be kept at bed rest in abduction splints for four to six weeks, followed by three months of an abduction orthosis.

**RESULTS**

Skin incisions healed in all cases except Case 3, in whom there was a small tip necrosis of the posterolateral flap. This patient had at least three prior incisions that had been made in separate planes. Also, an improper stitch may have been used at the apex of the flap. Slight serous drainage was noted in several patients, but this usually resolved by two weeks after surgery.

No significant intraoperative neurovascular complications occurred in any patient. The lateral femoral cutaneous nerve and obturator nerve were sacrificed in one tumor resection, but these structures were preserved in all other cases. One patient had a transient neuropraxia of the lateral femoral cutaneous nerve that later resolved. One tumor-resection patient developed iliac vein thrombosis within the first week and required anticoagulation, which continued until follow-up examination.

Allograft reconstructions remain functional in all cases. In three cases with follow-up periods longer than 12 months, it is likely that the allografts have incorporated, based on radiographic review, which demonstrates obliteration of host-graft union sites. There has been no component migration or loss of plate fixation in any patient.

One patient dislocated the femoral prosthesis in the early postoperative course, and had required a trochanteric osteotomy for exposure. This was managed with six weeks of bed rest with abduction plasters, followed by an abduction orthosis for an additional four months. The two patients in whom **en bloc**
tumor resection was required were treated with trochanteric osteotomy and abductor incision, respectively, and did not dislocate after surgery. Trochanteric osteotomy is avoided at this time, particularly if pressfit femoral component insertion is desirable.

CASE REPORTS

Case 1

In 1984, three years after a successful THA, a 64-year-old woman sustained a fall. The injury caused gross acetabular loosening, as well as a pelvic dehiscence and a significant anterior column defect. Initial revision was done with a cemented oversized protrusio ring. A couple of lag screws placed posteriorly attempted to secure the acetabular disruption. At the time of reevaluation, gross migration had occurred and the patient was virtually wheelchair bound from pain. An arteriogram identified the external iliac artery lying on the anterior rim of the prosthesis and displaced from its usual course. Judet views were helpful in this case, clearly demonstrating the disruption of the ilioinguinal line with medial displacement of the superior pubic ramus, as well as showing virtually no bone remaining of the anterior column of the acetabulum.

The reconstruction used the extensive approach, requiring careful dissection of the femoral vessels from the adherent capsule anterior to the implant. Trochanteric osteotomy was done and the cemented femoral stem was left unrevised. The anterior column defect was reconstructed, using an internal plate spanning the defect from the pubic symphysis to the iliac wing. The posterior column was plated as well to restore structural integrity to allow for acetabular component pressfit. A femoral-head allograft was placed against the anterior column plate and secured with screws through the plate and additional screws from the superior lateral iliac wing. After surgery, the wound healed primarily, but the hip dislocated on Day 6. Closed reduction was done and a plaster abduction was applied for six weeks, followed by an abduction splint for four months. No further dislocation occurred, and the patient remained pain free through the 28-month follow-up interval, with no evidence of component migration (Fig. 2).

Case 2

A 38-year-old man was diagnosed as having recurrent pigmented villonodular synovitis of the hip joint. Three previous operative procedures were unsuccessful in obtaining local control of disease. The patient had developed severe pain and was ambulatory only with crutches. Computed tomography clearly demonstrated extensive involvement of the acetabulum and femoral head. En bloc tumor resection was planned, and a matching pelvic bulk allograft was procured for subsequent use. The operative procedure consisted of the extensive approach, exposing all surfaces of the acetabulum. The joint was not entered and the acetabulum was resected en bloc with osteotomies at the ischium, superior iliac wing, and anterior column joint lateral to the obturator foramen. Trochanteric osteotomy was not done, but the gluteus medius tendon insertion was incised to enable removal of the spec-

Figs. 2A–2D. (A) Oblique radiograph demonstrates large protrusio cup and cement mass with break of ilioinguinal line. (B) Diagram of anterior column bone loss and pelvic dehiscence. (C) Diagram of anterior column plate with allograft. (D) Diagram of double-column plating.
imen. Low extracapsular femoral neck osteotomy was done to remove the diseased proximal femur. The pelvic allograft was cut to match the resected acetabular specimen and inserted into the defect. After the graft–host surfaces were perfectly matched, temporary stabilization was done with Kirschner wires. Final fixation was achieved with a 4.5-mm AO pelvic plate on the posterior column and a 3.5-mm AO pelvic plate on the anterior column spanning the allograft from the pubic symphysis to the medial iliac wing. The acetabular component was cemented into the bulk allograft, and a pressfit femoral stem with a calcare buildup was used. The gluteus medius was reattached with nonabsorbable sutures and stable hip reduction was achieved. Afer surgery, the wound healed primarily and the patient was kept nonweight-bearing for four months. Partial weight-bearing was maintained for two additional months. At the 18-month follow-up examination, the patient walked without pain or limp.

CASE 3

A 62-year-old woman with severe rheumatoid arthritis was treated with a revision THA in 1983 using a 75-mm protrusio ring prosthesis. Before rerevision, this patient developed severe pain, was wheelchair bound, and a large palpable mass in the left lower quadrant was detected. Radiograms demonstrated the component and entire cement mantle prolapsed into the pelvis. Preoperative studies included pelvic CT, arteriogram, barium enema, intravenous pyelogram, and routine Judet views. The prosthesis was identified adjacent to the ureter, possibly causing mild ureteral outlet obstruction. The extensile approach was used to allow intrapelvic exposure of neurovascular structures and the external hip joint for component removal. The acetabular component was freely movable and surrounded by a dense capsular membrane. Anterior column defect and pelvic dehiscence were present. The femoral component was extracted from the pelvis and removed. This allowed removal of the acetabular component through the large acetabular defect. At this point, the ureter as well as other neurovascular structures were identified inside the pelvis, undamaged. With extensive pelvic bone loss, staged reconstruction was planned for a later time. After surgery, the wound healed except for tip necrosis of the posterior flap, which healed by secondary intention. The intravenous pyelogram reverted to normal.

DISCUSSION

A growing body of literature documents the risks of significant anterior neurovascular injury in revision THA and it is likely that operative mortalities may occur with this problem. This report describes a new surgical approach that was developed initially to deal with the problem of anterior column deficiency and the need to explore neurovascular structures to prevent iatrogenic injury in complex acetabular reconstructions. By using this approach, the vascular bundle in the inguinal canal is easily identified and can be safely dissected away from the underlying prosthesis or cement mass. If this precaution is not taken, it is likely that the scar tissue adherent to the prosthesis will involve the perivascularg tissues and cause avulsion of the vessels if the prosthesis is removed by force.

Several reports have demonstrated both the eventual incorporation of allografts used about the acetabulum and the potential structural integrity that is offered by this technique. Biomechanical parameters defining allograft function are poorly understood. Makley has shown that rigid allograft fixation must be present for predictable graft–host bone union and eventual incorporation of the allograft. Acetabular allograft reconstructions have been accomplished through more simple lateral hip approaches in which trochanteric osteotomy has been done to maximize exposure. The exposure of the posterior column for plating reconstruction can be done optimally through this approach, but anterior column plating is extremely difficult. For this reason, anterior pelvic plate-fixation is best accomplished through the ilioinguinal approach, which allows application of this plate from the pubic symphysis, across the anterior column to a point high on the iliac wing.

The ilioinguinal approach has become the standard incision for trauma surgeons dealing with anterior column/wall fractures, and the complications of this technique are few. By mobilizing the psoas and femoral nerve bundle and the neurovascular bundle, “windows” are created, exposing the areas where screw placement is made. Using an AO 3.5-
mm pelvic reconstruction plate, contouring is simple and at least three or four bicortical screws can be placed on either side of the anterior column defect for rigid fixation. In addition, screws at the defect site can be used to stabilize bulk femoral head allografts.

Anterior column deficiency creates a loss of the structural integrity of the acetabulum such that a pressfit acetabular component cannot be stabilized because of the break in the acetabular ring. In these cases, typically, only the posterior column remains intact and the hoop strain for successful pressfit insertion far exceeds the anatomic possibility. The three cases of this study in which anterior column-plating was used have all functioned well after this reconstruction. Similarly, pelvic dehiscence or gross separation of the acetabulum in the horizontal plane functions much as nonunion of a transverse acetabular fracture. The treatment of this entity requires plating of both the anterior and posterior column.4,14

From review of the literature, only a few reports of en bloc or “total” allograft acetabular replacement have been attempted.6,22,25,29 The two en bloc resections with allograft reconstruction in this study were made possible by the extensile approach described. Success likely depended on the rigid fixation achieved using AO pelvic reconstruction plates and the close apposition of large cancellous surfaces. Both grafts have incorporated at this point, but the long-term outcome of this graft technique remains unknown. The presence of the anterior and posterior column plates diminish fatigue loading on the allograft and, it is hoped, will improve longevity.

The cases of acetabular protrusio demonstrate the clearest indication for the extensile approach. In this situation, virtually all intrapelvic neurovascular structures were identified adjacent to the encapsulated prosthesis as well as the ureter and bladder. With adequate exposure, the prosthesis was easily “shelled out” from underlying structures. Also in these cases, extensile exposure of the proximal femur was needed for prosthesis and cement removal. Eftekhar and Nercessian5 have described a combined two-approach method for this problem, but the current authors’ experience suggests that removal of the acetabulum component through the “original” hole requires less dissection than attempting removal through an abdominal incision.

Trochanteric osteotomy was needed in two cases and was mandatory in the case of en bloc tumor resection. Without this added exposure, removing the tumorous acetabulum with wide margins would have been impossible. Osteotomy was not required in the other cases, and this possibility enhances the potential for using a pressfit femoral component in the revision setting.

The lateral femoral cutaneous nerve was resected in one tumor case but remained intact in the other cases. After identification, the nerve superficially follows the course of the psoas muscle and femoral nerve and can be protected along with these structures. Given the magnitude of the exposure, damage of the nerve would be considered only a minor drawback of this approach.

REFERENCES