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Direct anterior approach for total hip arthroplasty using the fracture table

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Abstract Total hip arthroplasty is a successful procedure for treatment of painful hip arthritides. A large volume of literature is devoted to the patient outcomes and complication profiles of the commonly used surgical approaches to help refine the technique, enhance patient function, and limit cost and patient morbidity. The direct anterior approach has been reported using a fracture table to promote surgical exposure to the proximal femur. This technique is described herein with attention paid to the technical points which facilitate surgical exposure, patient safety, and functional outcome. Following a literature review of recent reports using this procedure are reviewed in context of the reported complications. The results show the direct anterior approach using a fracture table performed by experienced surgeons is an effective technique which provides early postoperative function and reduces the risk of dislocation.

Keywords Total hip arthroplasty · Smith-Petersen · Heuter · Direct anterior approach · Fracture table · Orthopaedic table · Anterior total hip replacement

Introduction

Total hip arthroplasty is a successful surgical treatment for painful hip conditions with high return of function for patients post operatively [1]. Despite the successes that have been reported over multiple decades, there is a constant push to refine the technique to allow improvement in patient outcome, complication rate, and increase efficiency in surgical throughput.

The four main surgical approaches to the hip for total hip arthroplasty utilize different intervals to the hip joint and therefore entail risk and benefit profile based on the anatomic structures involved [2, 3]. For example post-operative dislocation rate, post-operative limp, nerve injury, hip scores and patient satisfaction, infection rates, heterotopic ossification, are factors which have been used to evaluate and compare total hip approaches. While some studies have found statistical association between approach and outcome, most consider the individual surgeon's comfort and proficiency with a single approach the most important [3].

The anterior approach to the hip for total hip arthroplasty has in the past decade has become more popular with surgeons for multiple reasons. It utilizes anterior internervous and intermuscular plane, and is described as a modified Hueter approach, as utilized by Judet and Judet in 1950 [4]. Due to the intermuscular nature, it is regarded as allowing faster patient recovery to ambulation, normal abductor strength, and decreased dislocation rate. This approach provides a direct view of the acetabulum with visualization of the anterior iliac spine landmarks to allow reference for appropriate cup positioning. However, the femur canal preparation and component placement is considered difficult with this approach. Attempts to retract the proximal femur anteriorly has been reported to contribute to proximal femur and femoral shaft fractures [5]. This has also necessitated dissection of muscle from the proximal femur as well, compromising the intermuscular nature of the approach. The use of the orthopaedic traction table allows positioning assistance of the femur to permit

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adequate exposure of the femur, which allows accurate femur component positioning as well.

The results have provided a view of this procedure as an effective approach by experience surgeons with potential benefit in post-operative recovery and dislocation rates. Herein we review the technique as performed at our institution, and outcome data in the context of recent literature using the anterior approach with a fracture table for total hip arthroplasty.

The learning curve for this technique consists primarily of the surgeon gaining experience with the surgical approach. The key aspects are becoming familiar with the proximal femoral anatomy to indentify the location for the femoral neck cut based on anatomic landmarks, learning to adequately mobilize the hip capsule from the proximal femur, and learning to adequately lateralize the proximal femur when preparing the stem to avoid varus and calcar fracture.

Procedure

Patient positioning

The patient is positioned supine on a fracture table that allows for controlled positioning of the each lower extremity independently, including full freedom of rotation and movement into hyperextension. The surgical table requires a perineal post be used to stabilize the patient, and act as a counter point for gentle traction of the operative limb. A well-padded perineal post can avoid concerns for develop of pudenal nerve compression from traction in the supine position. Well padded boots are placed on the patient's feet which are secured to the traction arms of the table. The method of securing the patient feet is important to maintain traction during the surgery. Sequential compression devices are placed on both legs and used throughout the procedure. During the preparation of the femoral canal trendelenberg positioning of the table is required. This can be accomplished at time of initial set-up, or later during the procedure. For patients who are not intubated with regional anesthetic techniques prolonged trendelenberg positioning may increase the risk of GI reflux, therefore intra-operative position may be preferred for such patients. During the femoral preparation a table attachment is used to support the proximal femur. A sterile attachment bracket must be placed onto a nonsterile support device through the drapes. This bracket is placed before the initial incision is made, and the defect in the drapes is sealed with an adhesive barrier.

Surgical approach

The incision is made anteriorly beginning approximately 1 cm lateral and distal to the anterior superior iliac spine and extending distally in line with the femoral neck. Sharp dissection is continued through the subcutaneous tissues. A plastic soft-tissue protector can be used in obese patients to retract the subcutaneous tissue superficial to the tensor fascia facilitating visualization. The fascia over the tensor fascia lata is then incised just lateral to the medial border of the tensor fascia lata muscle belly. The tensor fascia lata muscle is mobilized laterally and the anterior inferior iliac spine is palpated. The Smith-Petersen intermuscular and internervous plane is entered through the tensor fascia lata fascia to gain access to the deeper gluteus medius and rectus femoris interval to access the anterior hip capsule. A retractor is placed along the external surface of the innominate bone at the point of the anterior inferior iliac spine, extending the retractor tip posteriorly for a short distance. The tensor muscle is retracted laterally. This exposes the superior lateral aspect of the hip capsule. A cobb elevator is used to elevate the proximal portion of the rectus femoris from the hip capsule in an oblique direction from superior laterally to distal medially to the recess of the medial femoral neck. A blunt tipped retractor is used to retract the rectus femoris muscle medially. The lateral femoral circumflex vessels are at this point identified and ligated, and divided. This is important as access to the base of the femoral neck facilitates the procedure.

Hip exposure

The hip capsule is opened through a longitudinal capsulotomy beginning at the anterior inferior iliac spine extending to the base of the femoral neck. A slight release of the proximal lateral hip capsule at the acetabular rim allows a retractor to be moved from adjacent to the AIIS to inside the hip capsule allowing visualization of the lateral aspect of the femoral head. Distally the capsulotomy is extended medially toward the medial femoral neck. This creates a medially based flap of capsule that is maintained to provide a soft-tissue layer between the iliopsoas tendon and the acetabular rim. A small lateral extension of the distal capsulotomy is valuable as well as this exposes the junction of the base of the femoral neck as it transitions to the greater trochanter. This land mark is necessary to visualize the line for transection of the femoral neck. A pointed tip curved retractor is used to retract the anterior hip capsule. The point is passed through the medial flap of hip capsule a centimeter or more away from the acetabular rim, and the point is then placed over the acetabular rim and retracted superiomedially. This exposes the anterior rim of acetabulum. Anterior osteophytes are then removed when present. The hip joint is then distracted using gradually applied traction from the table, and a hip skid is used to disrupt the ligamentum teres. The femoral head can be dislocated with external rotation at this point. The proximal

femur head and neck is then resected at the appropriate level according to pre-operative planning protecting the surrounding tissues with retractors about the femoral neck. The resected femoral head is removed and measured.

Acetabulum

The acetabulum can be directly inspected at the base of the exposure. The acetabulum is evaluated, labrum and osteophytes are removed. The acetabulum is reamed under fluoroscopic control to gauge cup abduction angle and version. Care is taken to ensure accurate orientation of the intra-operative fluoroscopy image to base the assessment of cup position. The orientation of the pelvis with fluoroscopy in the AP plane is verified relative to the pre-operative plain radiographs. A Press fit uncemented acetabular component is then placed. Screw stabilization for the cup is used at the discretion of the surgeon. A polyethylene liner is then impacted. Typically when the position of the cup is satisfactory on intra-operative fluoroscopy imaging no trial of the acetabular liner is necessary. A manual assessment is done to ensure the anteromedial edge of the cup is covered by the anterior medial acetabular rim to lessen the likelihood of iliopsoas irritation post-operatively.

Femur

Access to the proximal femur for preparation and component placement is gained with external rotation and extension of the proximal femur. The femur is then maximally externally rotated to extent the soft tissue attachments allow. Axial traction is released. External rotation is often facilitated by slight knee flexion after release of traction. The hip is then extended and adducted to allow access to the resected portion of the femoral neck. The table is placed into slight trendelenberg positioning at this point (if not already so positioned) to allow increase extension. With traction released the operative leg moves into a moderate knee flexion with a figure 4 type positioning with external rotation, extension, and adduction. The remaining lateral capsule is released at this time to allow further access to the superior aspect of the femoral neck and piriformis fossa or medial aspect of the trochanteric fossa. . The soft tissue release of the remaining hip capsule from the base of the femoral neck is key in obtaining access to prepare the proximal femur. External rotation of the femoral shaft should be at least 90°, ie the patella is facing 90° externally rotated, and the proximal femur must be slightly lateral to the acetabular component. Typically three retractors are used following capsular release: A curved retractor on the medial aspect of the calcar, a curved retractor is placed on the lateral aspect of the greater trochanter to provide a path for the femoral broaches, and a sterile proximal femur support hook attached through drapes to the table. The supporting devise is a broad curved surface used to support the proximal femur in the wound during canal preparation while protecting the skin and soft tissues. The actual femoral support is placed around the femur and connected to the sterile bracket. The support staff then are able to gently elevate the support bracket via the table. The purpose of the table support is to stabilize the proximal femur during canal preparation. While the proximal femur is elevated slightly, at no time is the femur elevated out of the surgical field. A box cutting osteotome is used to access the canal with appropriate version and lateralization and followed by reaming and broaching to the appropriate size. Care must be taken to ensure the proximal femur is adequately lateralized to avoid varus positioning of the stem. The cortical margin of the superior neck in line with the femoral canal must be resected to allow for adequate canal preparation. Generally the femur is prepared with a broach only prosthesis. Most systems now make offset or curved broach handles to facilitate placement of the femoral broach and stem. Once an adequate canal fit is obtained with the broach, and the proximal femur prepared, the retractors are removed and the femur is repositioned to full extension.

With traction of the table and gentle internal rotation of the leg the hip is reduced. All traction is then released. Careful fluoroscopy is used to evaluate canal fit of the femoral prosthesis and overall position. The position of instability is extension and external rotation. Typically with 90° of external rotation and neutral rotation the hip is very stable with an appropriately placed prosthesis. A fluoroscopic image of the operative hip to include proximal femur and acetabulum is printed on transparent film. A second image of the contralateral hip is also printed using the same image orientation and magnification. The two images can be superimposed to assess the length and offset of the implanted prosthesis. Generally length and offset should be restored to match the native hip.

After assessing the trial components the hip is dislocated with traction and external rotation. The leg is again returned to a position of maximal external rotation. The hip is repositioned into hyper extension and adduction. The femoral retractors are replaced and the trial components are revised as necessary or removed to place the prosthesis. The canal is irrigated prior to final placement of the implant. The final components are placed and seated. The retractors are removed, the leg is repositioned, and the hip is reduced. Final fluoroscopic imaging is assessed to ensure accurate positioning. . Stability of the hip is confirmed. In the majority of cases in an uncomplicated primary hip, the acetabular cup is even with or just under the native acetabular rim such that impingement between the femoral prosthesis and cup with flexion is not likely.

Closure

The wound is thoroughly irrigated and closed in a layered manner. Residual medial capsule is important to retain as a layer between the iliopsoas tendon and hip joint. The medial capsule can often be attached to a remnant of lateral capsule or tensor fascia. The fascia over the tensor fascia lata is closed over a deep drain. Generally the lateral femoral cutaneous nerve is not formally identified; however care should be taken during closure to look for the nerve in an abnormally lateral position to avoid irritation from the closure. Closure is followed by the subcutaneous fat layer, and the skin. The patient is allowed to weight-bear as tolerated with anterior hip precautions instructed by the physical therapists.

Literature review

In the scope of total hip arthroplasty literature, there are relatively few studies reporting outcomes with the direct anterior approach using a fracture a table. This is a recent technique with data being reported mainly retrospectively over the past decade. Despite these potential limitations, the summation of data does provide a clear sense of the risk-benefit profile of this approach when performed by experienced surgeons. Several outcomes have been reported by the various authors to allow careful consideration of this technique as a valuable approach to total hip arthroplasty with the potential to enhance patient outcome. A list of reviewed studies by first author is shown in Table 1 with the outcome variables described in each report. These outcomes are discussed in review below [6•, 7, 8••, 9•, 10•, 11•].

Component positioning

The direct anterior approach is reported to provide excellent visualization of the acetabulum, but provide difficult exposure to the femur. The fracture table facilitates femur exposure as described. The use of fluoroscopy intraoperatively further allows feedback in real time on component positioning and fit. Matta et al reported accurate component positioning overall with 96% of acetabular prostheses within the target abduction range, and 93% within range of anteversion [8••]. Leg lengths were overall restored with an average leg length discrepancy of 3 mm in this series. Woolson et al reported greater variation in cup abduction angles with average cup abduction angle 44°, ranging from 33–63°, but 21% were reported to be outliers with cup angles greater than 50° despite using fluoroscopy [11•]. They also reported 18 of 247 (8%) of femoral components placed in more than 5° of varus. Thus, the perceived advantages of this technique for component positioning do not guarantee consistent component positioning. Rather, it appears, familiarity with the procedure and anatomic landmarks is necessary to provide optimal results.

Dislocation rate

Dislocation rate following total hip arthroplasty is commonly reported complication due to the morbidity and potential cost associated with its treatment. This has served as an important benchmark outcome in contrasting the surgical approaches for total hip arthroplasty. It is postulated that the lack of tissue release and anterior capsulotomy involved in the direct anterior approach favor a lower postoperative dislocation rate.

Sariali et al. reported 27 dislocations out of 1764 hips (1.5%), all of which were anterior dislocations and occurring within 2 months postoperatively [9•]. Thirteen (0.7%) occurred post operatively in the hospital, and the remaining fourteen (0.8%) occurred after returning home. Two patients required revision for instability. The authors found that dislocations occurred in the patient subset who was significantly younger by 6.95 y on average, had a higher BMI, had reduced hip range of motion post operatively, and had a smaller femoral head. Patients with AVN as etiology of hip disease were also observed to dislocate at three time the rate of patients with primary osteoarthritis.

Both posterior and anterior dislocations occur with this approach, as Jewett et al. reported 7 dislocations in 800 primary THA (0.88%), including 4 posterior direction, one

Table 1 Summary of items reported by clinical series

	Component positioning	Dislocation	Infection	Revision rate	Intraop fracture	Heterotopic ossification	Neuropraxia
Matta	X	X	X	X	X		X
Woolson	X	X	X	X	X		X
Siguier		X	X	X	X	X	X
Jewett		X	X	X	X		X
Sariali	X	X		X	X	X	
Mast		X	X	X	X	X	X

of which was recurrent [6•]. The authors concluded that the dislocation rate is similar to other total hip approaches despite the use of fluoroscopy to guide component position. Siguier et al reported a comparable dislocation rate 10 of 1037 (0.96%), again with the majority occurring early post operatively [10•]. The authors of this study concluded that the 0.96% dislocation rate was suggestive of superior exposure granted from this approach, enabling accurate component positioning.

Sariali et al also reported the cumulative published dislocation rates by surgical approach [9•]. The posterior approach had an average 4% dislocation rate from 6 studies totaling 10,187 procedures. The transtrochanteric had an associated 1.6% dislocation rate average from 6 studies totaling 1052 hips. The anterolateral approach has an average dislocation rate of 2% in 5 studies with 7473 total hips performed. The associated dislocation rate in patients undergoing the direct anterior approach on a fracture table is 1% over 4697 patients, as shown in Table 2.

Fractures

The limited exposure the femur and the application of traction to enhance femoral component placement has been reported to contribute to intraoperative fracture by many authors. Most fractures involve the proximal femur, including greater trochanter avulsion fractures or calcar fractures, and require no osteosynthesis or post-operative precautions [6•, 8••, 9•]. For example, Matta et al. reported seven proximal femur fractures sustained while preparing the femur through hook elevation or broaching [8••]. Four calcar fractures occurred, two of which were treated with cerclage wiring, while the other two were treated with protected weight bearing. There were additionally 3 greater trochanter fractures and 2 femoral shaft fractures at the distal extent of the femoral component requiring extension of the field and cerclage wiring. These were reported to occur during broaching, false reaming routes through the femoral cortex, or with elevation of the femur with the hook [8••, 9•]. Sequential release when necessary of short external rotators piriformis and obturator internus can help avoid excessive tension and fracture as described by Matta et al. Despite these intraoperative proximal femur fractures, the authors reported no complication in recovery for the patients attributed to these fractures. There is also potential for distal fractures as a result of the traction device. Matta et al reported 3 ankle fractures and Sariali et al reported 1 ankle fracture, presumed to occur due to the significant external rotation force placed with traction table use if applied solely at the foot and ankle [8••, 9•].

The sentiment of the authors describing proximal femur fractures using the direct anterior approach is that the fracture rate is inversely related to the experience of the surgeon. For example, Sariali et al reported 21 femoral neck fractures, 7 false femoral reaming routes, and 1 greater trochanter fracture, all of which occurred in first 250 cases of 1764 total cases [9•]. Similarly, Jewett et al in their report of 800 THA, had 19 trochanteric fractures (2.3%), fifteen of which occurred early in the series, and 3 femoral shaft perforations (0.37%), all of which occurred early [6•]. Woolson et al reported 2 femoral shaft fractures, 14 proximal femur or greater trochanter fractures during 247 cases performed by community surgeons without formal training in the technique with a reduction in serious complications occurring after the first 30–50 cases [11•]. In summation of the literature review, a significant case volume of up to 200 cases seems necessary to reliably reduce the complication rate for several of the authors initially reporting on this technique. The authors of this technique guide report no intraoperative fractures using the direct anterior approach on a fracture table for total hip arthroplasty. In agreement with the authors of the earlier reports, surgeon feel for the degree of tension being applied to the femur during exposure for broaching and component position is paramount in avoiding iatrogenic fracture. The advances in the technique as described within this guide and the referenced reports should allow a safer experience and reduce the length of the learning curve for surgeons adopting this technique.

Table 2 Reported incidence of dislocations following anterior total hip with a fracture table

Authors	Number of THA	Dislocations	Dislocation rate
Siguier et al	1037	10 (2 revisions)	0.96%
Matta et al	494	3 (no revisions)	0.61%
Sariali et al	1764	27 (2 revisions)	1.5%
Jewett et al	800	7 (1 revision)	0.88%
Woolson et al	247	0	0%
Mast et al	294	1 (no revision)	0. 34%
Olson (author's series)	61	0	0
Total	4697	48	1.0%

Limp

This technique is thought to promote early postoperative ambulation and recovery due to the lack of muscular release involved, and therefore post operative [2, 9•, 10•, 11•]. Specifically, the hip abductors remain intact, avoiding the risks of patients developing a trendelenburg limp post operatively. The above studies on the anterior approach did not report any incidence of limp in uncomplicated patients. Occurrence of limp was observed in patients who sustained a larger greater trochanter fracture intraoperatively, though. This was reported by Jewett et al, for example, and not felt by the authors to hinder the patient's post-operative function [6•].

Heterotopic ossification

No significant heterotopic ossification was reported in the available studies. Mast et al reported nothing more than Brooker grade 1 ossification [7•]. Siguier et al and Sariali et al reported no significant HO observed [9•, 10•]. A review by Barton et al commented that HO or myositis ossificans has been noted within the Tensor fascia lata and rectus femoris [5]. Aside from a palpable mass in the wound, the occurrence of HO has not caused detriment to the patient or required reoperation.

Neuropraxia

The authors have reported relatively minor neuralgias post operatively of the femoral nerve, femoral cutaneous nerves, or peroneal nerve. Most of these were stated to have resolved spontaneously [6•, 7•, 8••, 11•]. Pudendal nerve palsy, which is considered a risk of traction table procedures due to the perineal post, has not been reported in series of direct anterior approach for total hip arthroplasty.

Revision

Revision arthroplasty for loosening was reported for standard reasons, infection, dislocation as discuss above, and component loosening. The authors of Woolson et al, related a revision rate of 3% in no more than 29 months follow up in their retrospective review of 247 THA [11•]. These were performed using the direct anterior fracture table technique by community orthopaedic surgeons who did not have significant training prior to converting their THA practices to this approach. The revisions included 2 Girdlestone resection arthroplasties for deep infection. Three other patients required revision within one year postoperatively for loosening and femoral component subsidence related to proximal femur fracture. The authors report at time of manuscript preparation, 5 more patients were facing impending revision for radiographic subsidence. Jewett et al reported 10 revisions in 800 cases (1%), 7 of the 11 for deep infection [6•]. The others were revised for femoral fracture (2) and dislocation (1). No revisions were performed for aseptic loosening in their series. Siguier et al reported 3 revisions were performed for septic loosening and additional 3 were performed for aseptic loosening of 1037 cases (0.6%) [10•]. We have had one infection requiring revision.

Infection

Infection rates were generally low, with a cumulative deep infection rate of 0.5%. In addition to deep joint infection, Jewett et al reported 37 wound complications in 800 cases (4.6%) [6•]. 24 were deemed to be noninfectious dehiscence, with the remaining 13 diagnosed as wound infection all requiring irrigation and debridement. None of these developed deep infection. The authors postulated this high rate of wound complication may be due to the difference in skin thickness over the anterior proximal thigh and tension imparted at that site from the hip flexion crease which they postulate could negatively affect wound healing in that site relative to wounds over the lateral or posterior hip. No other authors reported similar issues.

In comparison to these data from the available literature on direct anterior approach using a fracture table, data from what many consider the gold standard, the posterior approach for total hip arthroplasty are regarded as preserving hip abductor function, but typically are associated with higher dislocation rates. A review by Masonis and Bourne reported a dislocation rate of 2.0% for posterior approach when performing posterior soft tissue repair, versus 3.95% without soft tissue repair [3]. Kwon et al performed a meta-analysis and found the posterior approach entails a dislocation rate of 0.49% with posterior repair and 4.5% without repair [12•]. A Cochrane Database review of posterior approach by Jolles et al (Cochrane Database 2006, Issue 3) showed dislocation rate of 1.3%, heterotopic ossification of 9%, and nerve injury in 2% of patients [2]. Trendelenburg gait was noted in 8%. Therefore, the direct anterior approach has a very favorable complication rate profile relative to the posterior approach which theoretically maximizes patient function postoperatively.

A potentially important factor is the need to use broaches and femoral components with offset built in to allow placement through the exposure provided in this approach. Therefore, not all hip prosthesis systems are available to the surgeon with this approach.

Conclusion

The anterior approach for total hip replacement has gained popularity recently. The use of the fracture table allows for realtime assessment of component positioning with fluoroscopy. The table facilitates the procedure through assistance with positioning. As with all techniques, the skill and experience of the surgeon are critical to the success of the procedure. This represents another advance in surgical technique to lessen morbidity of hip replacement surgery.

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