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"Table-less" and "Assistant-less" Direct Anterior Approach to Hip Arthroplasty

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Abstract

In recent years, specialized, non-sterile, traction table systems have facilitated Direct Anterior Approach (DAA) hip arthroplasty. To combat the potential downsides of these traction systems, a sterile, intra-operative retractor option has emerged as a means to access the surgical site more easily, minimize soft-tissue trauma, and reduce the degree of required human assistance. This chapter describes the setup, surgical approach, and early results of a retractor system (the Phantom MIS Anterior Hip Retractor system [TeDan Surgical Innovations, Inc. {TSI}, Houston, Texas, US Patent # 8,808,176 B2]), which uses a standard operating table, allows preparation of both lower extremities free in the surgical field, is compatible with fluoroscopy, and aids in both acetabular and femoral exposure, preparation, and implantation. Early outcome data indicates that this system significantly minimizes the need for surgical assistance, while allowing for safe and effective DAA performance, facilitating the procedure for high-volume surgeons and shortening the learning curve for surgeons new to the procedure.

Keywords: *hip arthroplasty, hip replacement, hip reconstruction, direct anterior approach*
Level of Evidence: *AAOS Therapeutic Level IV*

Introduction

Since Keggi's initial introduction of the technique to the United States, many studies have demonstrated the validity of direct anterior approach (DAA) hip arthroplasty using a standard operating table [1,2,3,4]. With more surgeons opting to use the DAA for total hip arthroplasty, technology is affording new opportunities to perform the procedure more efficiently and cost-effectively—without specialized traction mechanisms and with fewer surgical assistants. Benefits of using the standard operating table, as opposed to a traction apparatus, include the ability to prepare the entire operative (and contralateral) limb in the surgical field, improved control and feel of the limb, and and prevention of transmission of excessive, potenitally dangerous forces to the bone and soft tissues. Downsides to using the standard operating table include the need for multiple assistants and difficulties with femoral exposure and preparation, with the potential for additional soft tissue trauma, component

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malposition, and accentuation of the DAA learning curve.

The described technique (Phantom MIS) involves a patented "table-less" approach (use of a standard operating table without a limb traction apparatus), in which a specialized, self-retaining, table-mounted, retractor system facilitates exposure of the femur and acetabulum, while allowing for fluoroscopic visualization and prepping of the entire operative limb and contralateral limb in the field on a standard operating table (TeDan Surgical Innovations Inc., Houston, TX, US Patent # 8,808,176 B2). An evolution of previous table mounted self retaining retractor designs used in general abdominal surgery, this self-retaining retractor system employs the use of stable, adjustable surgical arms with attachable retractors, allowing surgeons to perform the entire procedure on a standard operating table with minimal (or no) additional surgical personnel. The system aims to address obstacles of the DAA, while maintaining "table-less" advantages of decreased expense, decreased storage requirements, compatibility with standard OR equipment, simple mechanics, controlled forces, improved feel, and ability to prep both legs into the surgical field. Subsequent benefits of this system may include decreased soft tissue and bone trauma, improved component positioning, improved limb length symmetry, decreased need for surgical assistance, and potential shortening of the learning curve.

The purpose of this study is to evaluate the clinical results of the Phantom MIS DAA retractor system in 50 cases performed by a single surgeon (DCA) early in the surgeon's learning curve in order to determine if the system is a safe and effective means to facilitate DAA hip replacement by surgeons relatively new to the procedure.

Materials and Methods

SURGICAL TECHNIQUE

Equipment

- A standard operating stable that bends at the knee (Skytron® or similar)
- TSI® Phantom Anterior Retractor System
- Standard fluoroscopy or digital radiography unit (if desired)
- 0–1 surgical assistants
- Standard total hip arthroplasty instruments equipment
  - o Wheatlander retractors, alice clamps, oscilating saw, cork screw, and acetabular / femoral preparation instrumentation

Positioning

- Secure the traditional table's "head" extension piece to the "foot" of the table.
  - o The patient is placed supine with the pelvis centered on the table and with the table's bending joint 3 inches distal to the level of the patient's hip joint

Preparation

- Hindquarter prep on the operative side, the non-operative is prepped to above the knee (alternatively, both hindquarters may be prepped for bilateral cases).
  - o Impervious drapes initially secure the perimeter, both lower extremities are covered with stockinettes, which are then wrapped with Coban.
  - o A traditional hip drape with pouches is passed over both limbs, with a 6-inch slit cut to accommodate non-operative limb (Figure 1a); for bilateral cases, two U-drapes with a central perineal towel can be used (Figure 1b).

Figure 1a. Example of draping for unilateral case

Figure 1b. Example of draping for bilateral case

- The skin is re-prepped with another surgical prep stick, the incision line is marked with the sterile marking pen, and Ioban is placed to completely cover all skin. Outer gloves are then changed.

Retractor System Set Up

- The Yellow Post Clamp (YC) is applied to the non-operative side of the table 12" – 24" proximal to the hip joint, over the sterile drapes. The Trident (T) is placed over the Yellow Post Clamp, directed toward the incision, and locked into place, with the red Trident prong directed toward the patient's head and the blue Trident prong directed toward the patient's foot (Figure 1c). The Blue Elbow (BE) is secured to the distal Trident (blue) prong, and the Yellow Accessory Arm (YA) and Blue Accessory Arm (BA) are then secured to the corresponding middle Trident (yellow) and Blue Elbow attachment points, respectively; these Yellow and Blue Accessory Arms will hold retractors on the side opposite the surgeon.

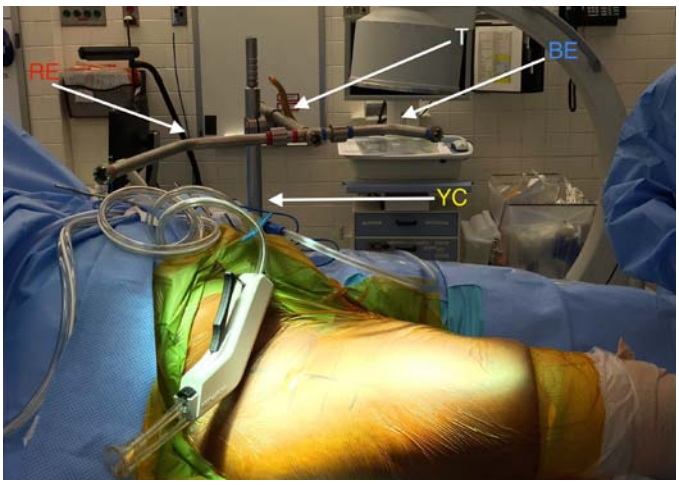


Figure 1c. Yellow Post Clamp and Trident application

- Two options allow a retractor to be placed on the surgeon's side of the incision:
  - o Option 1 (Figure 1d and 1e): The Red Elbow (RE) may be attached to the proximal (red) Trident prong, which then attaches to the Red Accessory Arm (RA). This arm can reach over and hold a retractor on the surgeon's side.

Figure 1d. Option 1: the additional proximal retractor is placed on the non-operative side of the table through the Red Elbow attachment

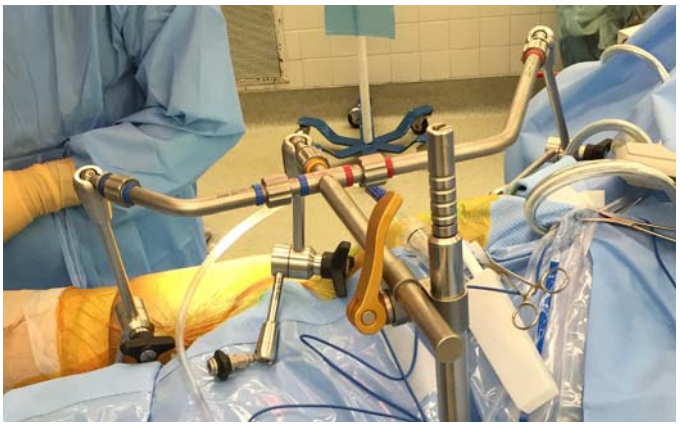


Figure 1e. Option 1: the additional proximal retractor is placed on the non-operative side of the table through the Red Elbow attachment (another view)

  - o Option 2 (Figure 1f): The Purple Post Clamp (PC) is applied to the side rail operative side of the bed, 12" distal to the hip joint, over the sterile drapes. The Ball Joint Angle Arm (JA) is then applied to this mounting post, which then attaches to the Purple Accessory Arm (PA). This arm can hold a retractor of the surgeon's side.

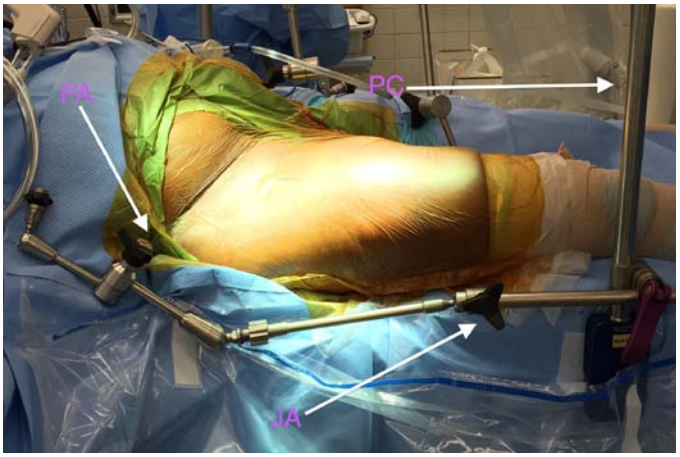


Figure 1f. Option 2: the additional proximal retractor is placed on the operative side of the table through the Purple Post Clamp and Ball Joint Angle Arm

Surgical Approach

- The incision starts 1 cm distal and 2 cm lateral to the anterior superior iliac spine (ASIS) and extends 8–12 cm distally and laterally toward the lateral knee, with the lower extremity in the neutral position (Figure 2a). If the limb is externally rotated during incision, the path will be inadvertently directed medially, and the lateral femoral cutaneous nerve branches will be at risk. The fascia over the tensor fascia lata (TFL) muscle is incised and elevated off of the TFL muscle medially (staying in this sheath protects the lateral femoral cutaneous nerve and allows for easy identification of the interval) (Figure 2b).

Figure 2a. The initial surgical incision

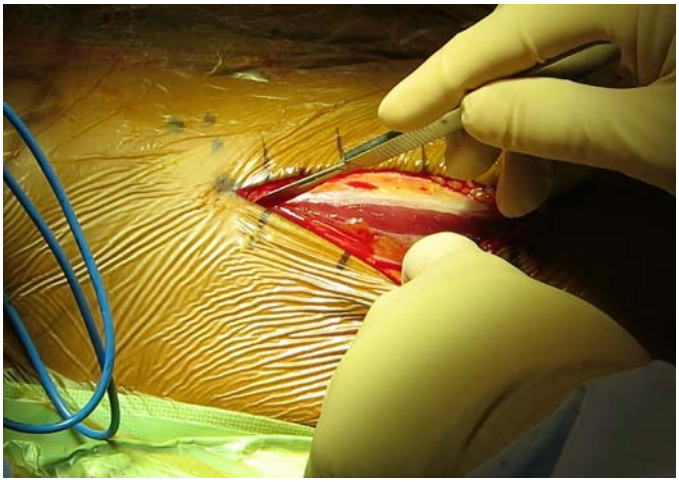


Figure 2b. The approach with entry into the TFL sheath

- o The interval between TFL and sartorius is developed with finger dissection, staying within the TFL sheath, and held open with a self-retaining wheatlander retractor (abducting the hip will loosen the TFL and further open this interval); the lateral femoral circumflex vessels are then identified and ligated (the authors prefer using silk ligature, but electrocautery is also an option) (Figure 2c).

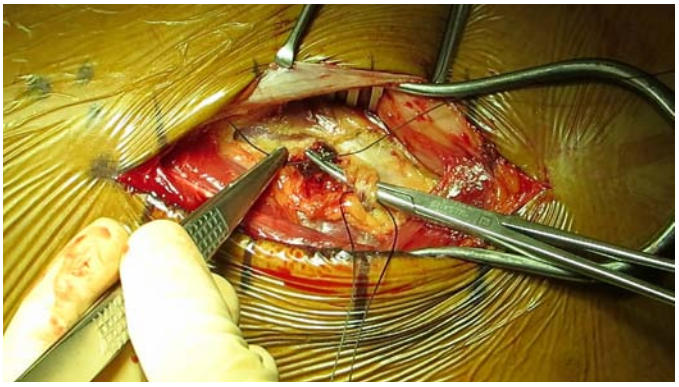


Figure 2c. Exposure of the superficial interval with ligation of the lateral femoral circumflex vessels

- o Medially, a Straight (20º) Hohmann Retractor is placed around the femoral neck, between the medial hip capsule and rectus femoris, and secured to the Yellow Accessory Arm; laterally, a Right-Angled Hohmann Retractor is placed around the femoral neck, between the lateral hip capsule and gluteus medius, and secured to the Red (option 1) or Purple (option 2) Accessory Arm (Figure 2d).

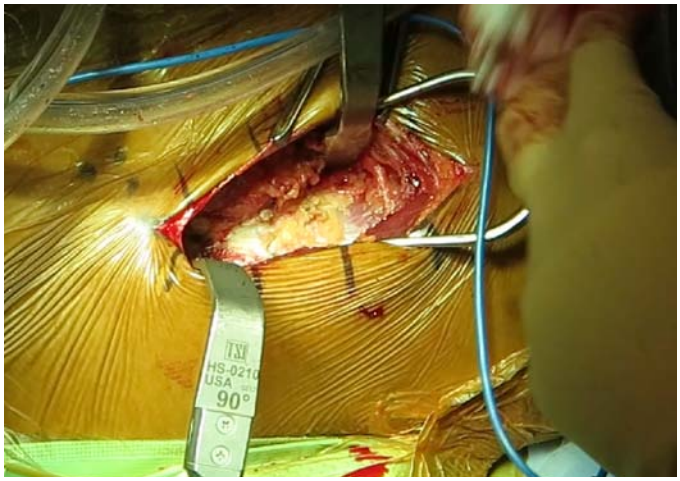


Figure 2d. Exposure of anterior hip capsule

- o The pre-capsular fat is removed, and the indirect head of rectus is elevated medially for capsular exposure; an "I" shaped capsulotomy is performed. The authors prefer to preserve the capsule for lateral coverage / closure; alternatively, the capsule may be resected.

Neck Osteotomy and Femoral Head Extraction

- Medially, a Straight (20º) Hohmann Retractor is placed directly around the medial femoral neck; laterally a Right-Angled or 70º Hohmann Retractor is placed directly around the lateral femoral neck.
- The inferomedial femoral neck capsule is released to the level of the lesser trochanter; palpation of the lesser trochanter, in addition to fluoroscopy, facilitates osteotomy position in accordance with preoperative templating (Figure 3a).
- The oscillating saw is used to create the femoral neck cut. An additional femoral neck cut can be made 5–10 mm proximal to the initial cut, creating an intercalary segment, which can then be removed to allow for easier head extraction.
- The hip joint can be slightly flexed to facilitate delivery of the femur posteriorly. Posteriorly, a Straight (20º) Hohmann Retractor is placed between the posterior femoral head and the femur, carefully delivering the femur further posterior; Anteriorly a Curved (70º) Hohmann Retractor is placed between the femo-

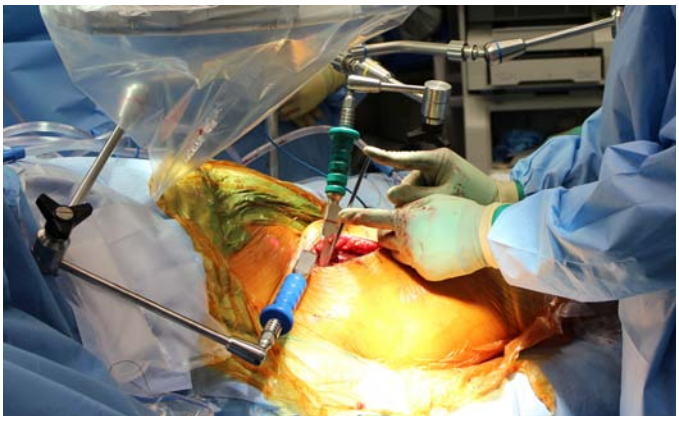


Figure 3a. Exposure of the femoral neck and localization of femoral neck osteotomy

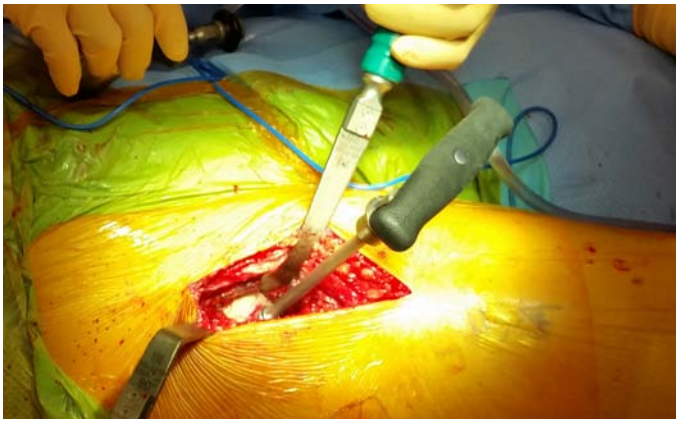


Figure 3b. Removal of the femoral head

ral head and the acetabulum. A corkscrew or threaded Steinman pin is placed into the femoral head through the cartilage or femoral neck cortex (Figure 3b).

- Capsular attachments around the base of the head are released with electrocautery. Careful rotation of the femoral head can facilitate this release. With traction on the head, the ligamentum teres can be identified and transected, facilitating removal. Care is taken with rotation and extraction not to injure the TFL, rectus femoris, or sartorius.

Acetabular Exposure

- A Curved (70º) Hohmann Retractor is placed over the anterior wall of acetabulum, between the anterior wall and iliopsoas (with great care not to over-retract to avoid femoral nerve injury); this retractor is secured to the Yellow Accessory Arm.
- A Curved (70º) Hohmann Retractor is placed between the inferior border of acetabulum (cotyloid fossa) and transverse acetabular ligament (with great care not to over-retract to avoid obturator nerve injury), and secured to the Blue Accessory Arm.
- A Straight (20º) Hohmann Retractor is placed between posterior wall of acetabulum and the femur (with great care to stay close to the bone to avoid sciatic nerve injury), and secured to the Red Accessory Arm (Option 1 [Figure 4a]) or Purple Accessory Arm (Option 2 [Figure 4b]).

Figure 4a. Acetabular exposure using Option 1 (posterior wall retractor is secured from non-operative side of table)

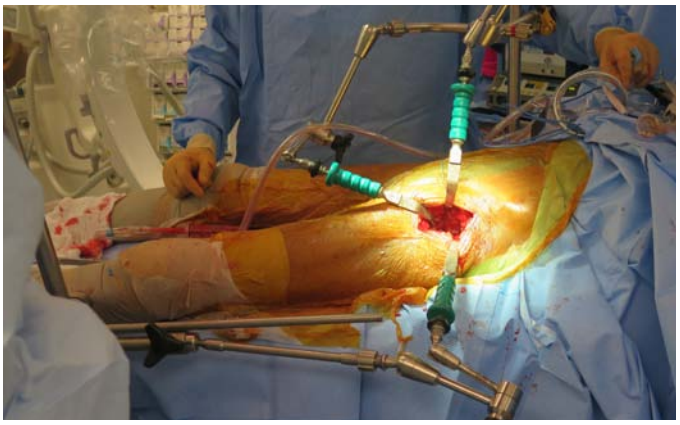


Figure 4b. Acetabular exposure using Option 2 (posterior wall retractor is secured from operative side of table)

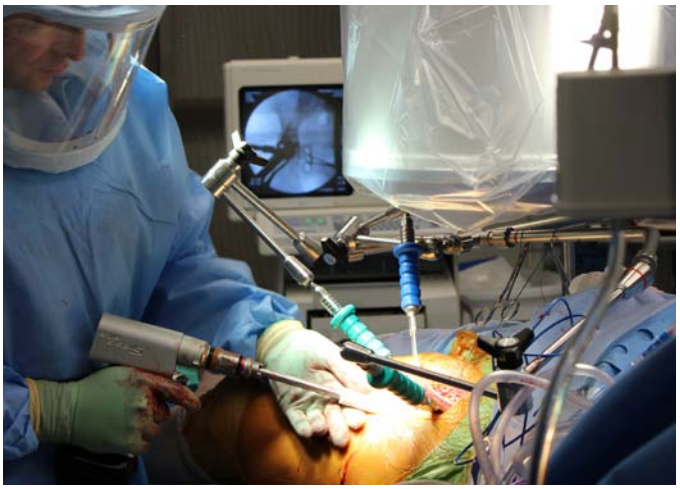


Figure 4c: Acetabular exposure and preparation, allowing fluoroscopy, without any other surgical assistance

- The acetabulum is reamed in usual fashion. The authors prefer to ream to the base of the cotyloid fossa, at 40 degrees of abduction and 20 degrees of antever-

sion, without raising the joint line (closely following native acetabular position); fluoroscopy or digital radiography can be used as a guide, but great care must be taken to assure a true AP pelvis radiographic position when judging acetabular alignment (Figure 4c).

Femoral Exposure

- If not previously placed, the Purple Post Clamp is now applied 12" distal to the hip joint to the side rail of the table, over the sterile drapes, on the operative side of the table; the Ball Joint Angle Arm is then applied to this mounting post, which then attaches to the Purple Accessory Arm, and the Red Elbow and Red Accessory Arm are removed (if previously placed). The Extension Bar is then placed over the Purple Post Clamp.
- The legs of the table are dropped 15–60 degrees (obtaining extension at the hip); the non-operative leg is placed on a well padded sterile Mayo stand. With the limb in the neutral position, the Femoral Hook is carefully placed around the proximal posterior femur from the lateral direction, distal to the vastus ridge, proximal to the gluteus maximus insertion, over (not through) the vastus lateralis, hugging the bone posteriorly. The operative limb is then adducted and externally rotated, keeping the knee straight to decrease anterior soft tissue tension.
- One or two retractors are placed around the medial femoral neck and secured to the Yellow and / or Blue Accessory Arms. A serrated Cobra Retractor or Curved Pointed (double-pronged) Retractor is initially placed over the greater trochanter, between TFL and gluteus medius. The Femoral Hook is attached to the Femoral Lift (FL), which is attached to the Extension Bar (EB) (Figure 5a). The capsule at the lateral femoral neck is removed, and the posterior femoral neck capsule is released. The trochanteric retractor can now be placed between the greater trochanter and gluteus medius, retracting the TFL and gluteus medius, while assisting with femoral elevation.
- The femur is carefully elevated by turning the finger dial on the Femoral Lift (1 click = 1 mm elevation). The posterolateral femoral neck capsule is further released under tension; the conjoined tendon (the gemelli and obturator internus) insertion at the medial greater trochanter is identified and either released fully, released partially, or preserved; the piriformis tendon at the medial tip of the greater trochanter and the obturator externus at the distal medial greater trochanter are preserved (Figure 5b & 5c).

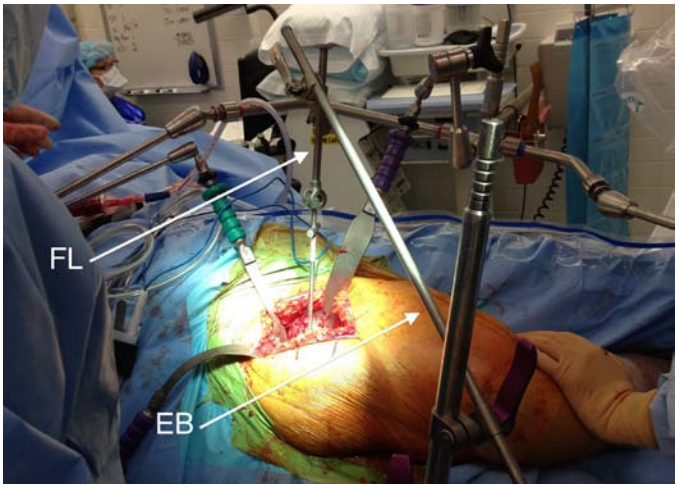


Figure 5a: Femoral exposure and preparation, using the Femoral Lift, without any other surgical assistance

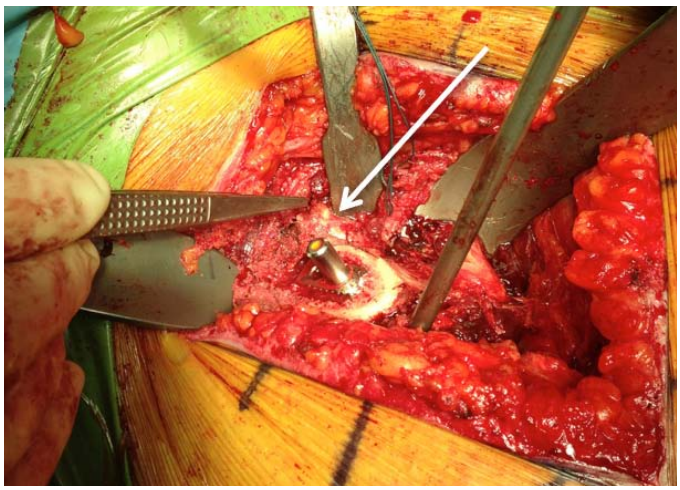


Figure 5b: Exposure of the proximal femur and associated insertions of the oburator internus and superior / inferior gamelli

Figure 5c: Exposure of the proximal femur

- The femur is elevated gradually as careful releases are performed, without excessive tension; the femur is delivered only to the extent necessary for appropriate broach and stem insertion (Figure 5d). Traditional straight broach handles and long femoral stems can be used with this technique (Figure 5e).

Figure 5d: Femoral broaching with double-offset broach handle

Figure 5e: Femoral broaching with standard straight (non-offset) broach handle

Femoral Trialing and Implantation

- Femoral component trialing is then performed. Fluoroscopy or intra-operative digital radiography can verify appropriate implant position. Manual joint reduction with feel of soft tissue tension helps verify appropriate stability. Direct comparison to the prepped contralateral limb allows for consistently reproducible limb length equality (Figure 6a). The hip can be easily taken through a full, unimpeded range of motion in all planes.

Figure 6a: Femoral broach and head trialing with contralateral limb length comparison

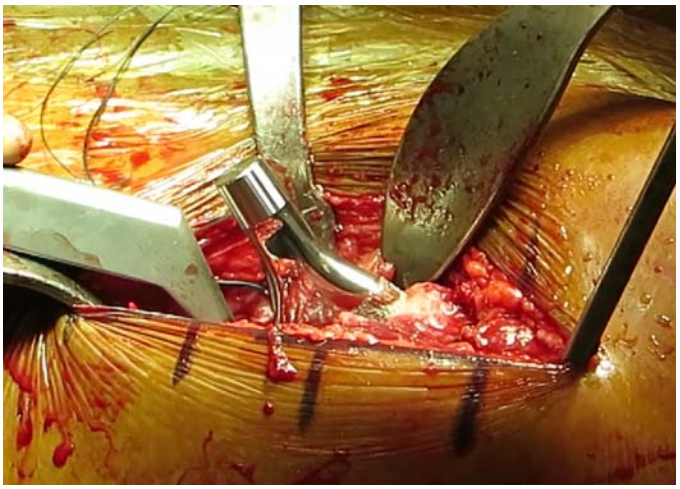


Figure 6b: Femoral stem implantation

- Femoral stem implantation is then performed with standard technique according to the type of stem used (Figure 6b).

Wound closure

- The authors prefer to preserve the hip joint capsule and subsequently close it with interrupted, braided absorbable #1 suture (Figure 7a).

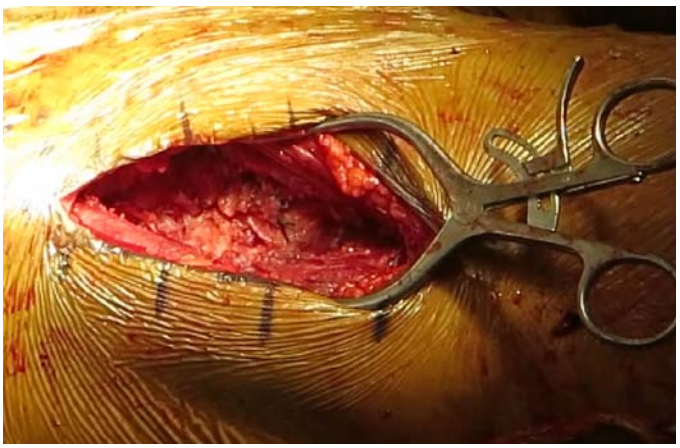


Figure 7a: Preservation and closure of preserved anterior hip joint capsule

- The fascia over TFL is closed with interrupted, braided absorbable #0 suture, with care not to ensnare branches of the LFCN anteriorly.
- The skin is closed with subdermal and subcuticular suture, and the soft tissues remain healthy and untraumatized (Figure 7b). The incision is dressed with incisional sealant (Dermabond® [Ethicon US, LLC, Cincinnati, OH]) in addition to a skin-friendly occlusive antimicrobial dressing (Aquacel® Ag [Convatec, Inc., Skillman, NJ]).

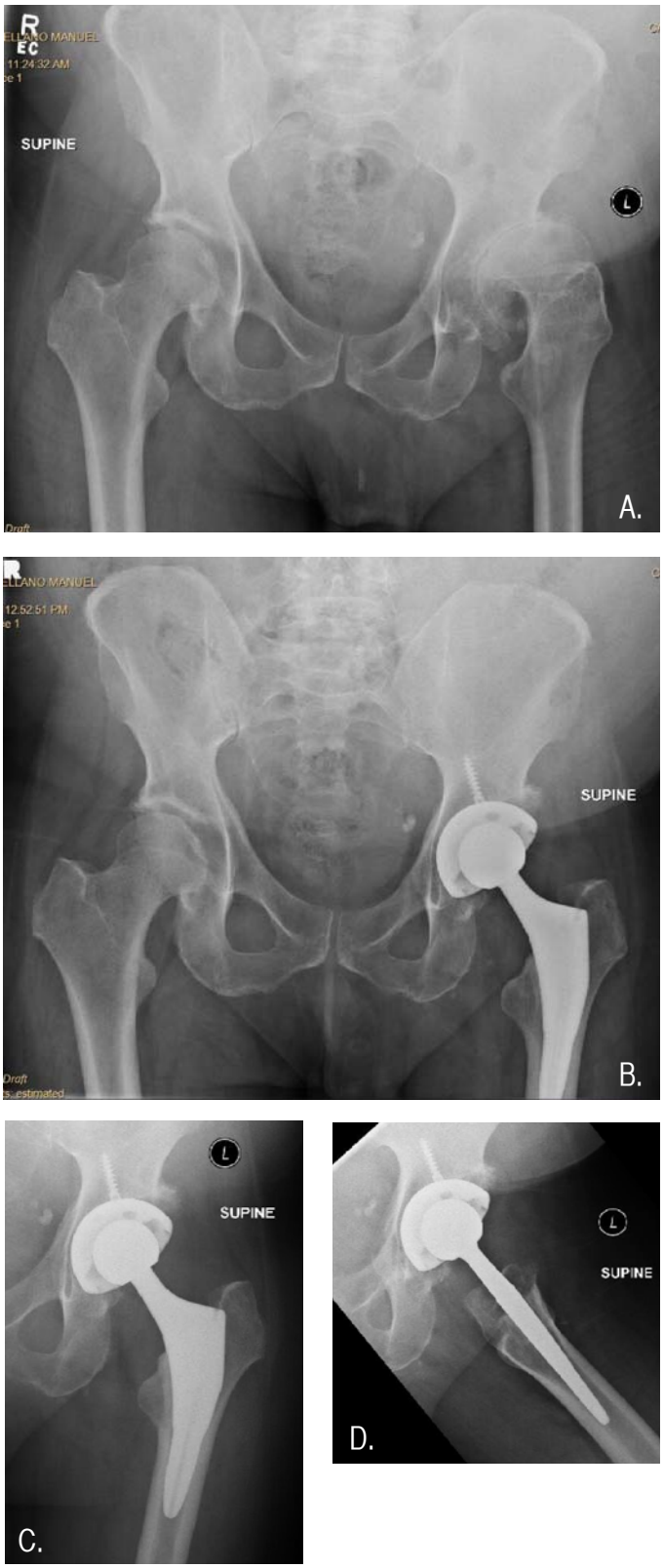
Figure 7b: Soft tissue status and incisional length after completion of the procedure

Postoperative care and rehabilitation

- The patient is treated with protected weight bearing as tolerated with crutches or a front-wheeled walker if a press fit femoral stem is used, or full weight bearing as tolerated with assistive devices only as needed if a cemented femoral stem is used.
- No hip precautions (anterior or posterior) are instituted.
- The sealed, occlusive dressing is left in place and not changed for 7–10 days (patients are allowed to shower).

STUDY DESIGN

Fifty consecutive DAA THA surgeries performed by a single surgeon (DCA), early in the surgeon's DAA learning curve, using the TSI Phantom MIS retractor system on a standard operating table, were retrospectively reviewed. Mean patient age was 67.7 years (range 45–97), with 35 females and 15 males. The underlying pathology consisted of osteoarthritis [23], femoral neck fracture [14], congenital dysplasia [6], avascular necrosis [4], and metastatic carcinoma [3] (Figures 8a-d). Follow up averaged 26.6 months. Thirty-seven of the cases performed were total hip arthroplasties and 13 were hemi-arthroplasties. Thirty-two of femoral stems were press fit, the remaining were cemented, and all cups were press fit. Cases were then evaluated according to outcome measures of surgical time, estimated blood loss, number of assistants used, intra-operative releases, component position, and complications.



Figures 8a-d: Preoperative and postoperative radiographs of one of the study patients (Ortho Development Corporation, Inc., Draper, UT)

Results

Surgical time averaged 116.3 minutes (range 79–180), and estimated blood loss averaged 223 cc (range 50–600),

without use of transexamic acid or pro-coagulants. The mean number of surgical assistants was 0.9 per case, with 5 (10%) of the cases using no assistant. Length of stay averaged 2.9 days (range 1–5).

With regard to intra-operative femoral releases, partial conjoined tendon release was performed in 15 cases and complete release in 32 cases; three cases were performed with no release of the conjoined tendon. Thirty-seven of 50 cases (74%) were performed without any piriformis release; the remaining cases involved partial piriformis release in 8, and complete piriformis release in 5.

Absolute radiographic limb length discrepancy averaged 0.2 mm (0–3.5 mm). Mean radiographic coronal femoral stem alignment was 0.13° with respect to neutral (range 0° [neutral]–2° [varus]). In four cases (8%), the stem rested in 1° varus, and in 1 case (2%), the stem rested at 2° varus. The remaining stems (90%) rested at 0° (neutral) coronal alignment (including the last 25 cases). Mean acetabular abduction angle was 39.8°, and in 36 of 37 THA cases (97%), the cup fell within the 35° – 45° range. In one case early in the series, the acetabular abduction angle was 50° (case # 15).

With regard to complications, there were no dislocations (0%) and no infections (0%). There was one intra-operative non-displaced proximal femur fracture early in the series (case #9) in a patient with severe osteoporosis using press fit femoral stem. This patient was still allowed to bear weight as tolerated without restrictions immediately, and healed without limp or any problems. The patient's contralateral hip was replaced later in the series (case #50) using cemented femoral stem, with no complications. There was one case of femoral stem subsidence at 3 months postoperatively in a patient with severe osteoporosis and neuropathy, in which a press fit femoral stem was used and immediate weight bearing was allowed. This case was treated with revision, without further problems. There was one case of lumbosacral plexopathy, diagnosed by neurology consultation as secondary to epidural hematoma caused by traumatic spinal block, which resolved spontaneously without intervention. One patient who underwent cemented hip hemiarthroplasty for femoral neck fragility fracture sustained a Vancouver C periprosthetic fracture of the distal femur (12 cm distal to the femoral stem tip) 6 months after surgery. The patient was treated successfully with percutaneous plate fixation and healed without further complication or disability.

Discussion

DAA to hip arthroplasty carries many distinct advantages, which are balanced by difficulties with femoral exposure [5]. Given the technical challenges, a distinct and possibly lengthy learning curve has been well described with regard to surgeons newly adopting the procedure [6,7]. In attempt to combat these challenges, traction-based table systems have emerged to facilitate the approach. These "table" systems certainly improve the ease of the procedure, but carry downsides of excessive forces, expense, space requirements, need for additional operative personnel, and complex mechanics requiring maintenance. Therefore, the "table-less" technique to DAA has re-emerged as a viable option, addressing traction-related concerns, but carrying downsides of difficulties with femoral exposure and implantation, potential soft tissue trauma, and need for multiple assistants.

The Phantom MIS technique of "table-less" DAA consists of a table mounted retractor system with a femoral lift assembly applied to a standard operating table, aiming to maintain "table-less" advantages, while minimizing the downsides. The ability to prepare both lower extremities in the surgical field allows for direct clinical limb length comparison and minimizes limb length discrepancy, as evidenced by the close symmetry of limb lengths seen in this study. Preparing both extremities also facilitates the "feel" of reduction and assessment soft tissue tension, allowing complete, passive joint range of motion; this ability helps improve appropriate implant choice during trialing. The system's self-retaining retractor features free up the hands of surgical assistants to do other more meaningful work during the case, and make the procedure possible even if no surgical assistant is available, as evidenced by 10% of the cases in this study performed without any surgical assistant (other than the scrub technician). As personnel costs increase and implant surgery reimbursements decrease, this decreased reliance on additional operating personnel may become a distinct advantage.

The manual femoral elevation system exposes the femur well, while providing controlled forces and feel of tension, which may decrease soft tissue trauma, nerve stretch, and fracture risk, which was demonstrated by the well-positioned femoral implants and low complication rates seen in this study. The system also allows for cemented femoral stem implantation. The unparalleled acetabular exposure, while still allowing use of fluoroscopy, facilitates cup positioning, as evidenced by the consistent, appropriate acetabular shell position in this series. The low dislocation rate (0%) seen in this study may be in part attributable to the stability conferred by the DAA approach, and also the lack of excessive releases, preservation and repair of the anterior joint capsule, and appropriate implant position, which are all facilitated with the Phantom MIS system. This sys-

tem can also be applied to traction tables in order to minimize the need for assistance and to aid with exposure in these cases. Additional advantages of the system include attachable, small, cold LED lights that illuminate the deep surgical field, further improving the ease of the surgery. Any retractors with a hole at the proximal handle tip can be used with the system, and custom retractors of any sort can be easily manufactured and applied.

Conclusion

A specialized hip retractor system (Phantom MIS) affords surgeons the opportunity to perform DAA procedures on a standard operating table with limited assistance. This system offers many potential benefits when compared to traction-related technique, including decreased expense, decreased storage requirements, compatibility with standard operating equipment, simple mechanics, controlled forces, improved feel, decreased reliance on additional personnel, and ability to prep both lower extremities into the surgical field. The systems allows for incorporation of the best of both "table" and "table-less" techniques, while maintaining the benefits of each. Traditional hip arthroplasty principles still apply, and careful attention to technique and respect for soft tissues and bone is always required. A retrospective review of surgeries using the Phantom MIS Hip Retractor system demonstrates that the system can be safely and effectively applied to the DAA procedure, even early in a surgeon's learning curve. The series indicates that DAA for hip arthroplasty with a standard operating table was greatly facilitated with this specialized retractor system, requiring only a single assistant, and even allowing for the procedure to be performed without any surgical assistance. The Phantom MIS retractor system technique facilitates appropriate DAA hip arthroplasty outcomes, with apparent shortening of the learning curve, while minimizing potential complications.

Disclosure Statement

One or more of our authors have disclosed information that may present potential for conflict of interest with this work. For full disclosures refer to last page of this journal.

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