The direct superior approach in total hip arthroplasty

ABSTRACT

The direct superior approach is a modification of the minimally invasive posterior approach for total hip arthroplasty which preserves the iliotibial band and external rotators except for the piriformis or conjoint tendon. This review explores the existing scientific evidence on clinical, functional and radiological outcomes in total hip arthroplasty performed using the direct superior approach. The direct superior approach reduces iatrogenic periarticular soft tissue injury compared to the direct anterior approach for total hip arthroplasty. The learning curve for the direct superior approach is 40 operative cases with operative times comparable to those of conventional approaches for total hip arthroplasty after surgical proficiency has been achieved. The direct superior approach provides improvements in pain and short-term functional outcomes after total hip arthroplasty as assessed using the Harris Hip Score. The minimally invasive posterior approach provides comparable pain scores and improved University of California, Los Angeles (UCLA) activity scale functional scores to the direct superior approach at 1-year follow up. Existing studies using plain radiographs have shown that the direct superior approach enables accurate femoral and acetabular implant positioning.

The direct superior approach is a minimally invasive modification of the posterior approach which preserves the iliotibial band and short external rotators except for the piriformis or conjoint tendon during total hip arthroplasty. This article discusses the surgical technique for the direct superior approach, explores how this approach influences postoperative clinical, functional and radiological outcomes, and identifies gaps in the literature for further clinical trials comparing the direct superior approach to conventional approaches for total hip arthroplasty.

Total hip arthroplasty is an effective procedure for relieving pain, restoring function and improving quality of life in patients with end-stage hip osteoarthritis (Barrack et al, 2000; Berry et al, 2003). The surgical approach in total hip arthroplasty is important as it influences postoperative gait, hip stability and muscle function (Poehling-Monaghan et al, 2015). Evolution of the surgical approach for total hip arthroplasty has led to the development of minimally invasive surgery, which is performed through smaller incisions and requires reduced soft tissue dissection compared to more conventional approaches for total hip arthroplasty.

Advocates of minimally invasive total hip arthroplasty report improved patient satisfaction, reduced intraoperative blood loss, decreased hospital stay and improved functional outcomes (Berry et al, 2003). However, some authors remain sceptical, and have raised concerns that minimally invasive surgery may compromise an already well-established and successful total hip arthroplasty procedure (Sculco, 2004). Some studies have shown that minimally invasive total hip arthroplasty may lead to increased risk of complications such as component malposition, femoral shaft fractures, femoral and sciatic nerve palsies, uncontrolled bleeding, increased muscle trauma and death (Fehring and Mason, 2005). Furthermore, implementation of new surgical approaches or implant designs in total hip arthroplasty is associated with learning curves with increased operative times and complication rates until surgical proficiency is obtained (Spaans et al, 2012). Minimally invasive approaches that modify existing conventional approaches familiar to the operating surgeon may lead to more controlled and predictable changes in surgical practice and postoperative outcomes during the progression of the learning curve.

Analysis of joint registry data from the UK, Sweden, and New Zealand has shown that the posterior approach is the most commonly used approach for total hip arthroplasty (Meermans et al, 2017). This approach was first described as a longitudinal proximal femoral incision by Langenback in 1867 and then modified to include a curved caudal extension by Kocher in 1907. The main advantage of the posterior approach is that it preserves the abductor mechanism. However, the posterior approach is associated with increased risk of sciatic nerve injury during dissection, bleeding from the inferior gluteal artery as it leaves the pelvis below the piriformis, and increased risk of dislocation compared to the anterolateral and direct lateral approaches (Masonis and Bourne, 2002).

Several studies have reported on minimally invasive versions of the posterior approach that preserve some of the short external rotators (Penenberg et al, 2008; Roger and Hill, 2012). The direct superior approach is

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one such modification of the posterior approach that preserves the iliotibial band and the short external rotators except for the piriformis or conjoint tendon (*Figure 1*). Conceptually, improved preservation of this periarticular soft tissue envelope may help to reduce postoperative pain, improve functional recovery and better restore native hip biomechanics. Limited dissection through the external rotators may also help to improve postoperative gait and increase hip stability with reduced risk of dislocation (Pellicci et al, 1998). Understanding the potential benefits and additional complications associated with the direct superior approach is challenging as existing studies on this approach have used varying nomenclature to describe the surgical technique, reported on limited functional or radiological outcomes, and included patients with varying follow-up times after total hip arthroplasty.

This article discusses the existing scientific evidence on the direct superior approach with respect to its surgical evolution, operative technique, learning curve, iatrogenic soft tissue injury, postoperative pain and rehabilitation, functional outcomes, accuracy of implant positioning and complications.

Methods

Electronic searches were performed using PubMed, Embase and the Cochrane database for studies relating to the direct superior approach. The following medical subject headings (MeSH) were used to carry out a systematic search of the literature: 'direct superior approach', 'DSA', 'total hip arthroplasty', 'learning curve', 'rehabilitation', 'soft tissue injury', 'functional outcomes', 'clinical outcomes', 'implant positioning' and 'complications'. Articles published in the English language between January 1990 and January 2019 were selected and reviewed for inclusion into the study. The reference lists from the retrieved articles were reviewed for additional articles.

Surgical technique

The direct superior approach is performed with the patient positioned in the lateral decubitus position. The skin incision commences at the posterosuperior border of the greater trochanter, which corresponds to the attachment of the underlying piriformis muscle. This incision is then extended proximally by approximately 10 cm in line with the fibres of the gluteus maximus. The gluteus maximus fibres are spread in line with the fascial incision and the deep gluteus maximus fascia is divided to expose the underlying pericapsular fat. Double-ended retractors are then used to retract the gluteus medius anteriorly and the soft tissue along the posterior border of the proximal femur inferiorly. The pericapsular fat is removed with diathermy.

The plane between the gluteus medius and gluteus minimus muscle is developed and the underlying piriformis and obturator internus tendons identified. A retractor is placed directly under the obturator internus to protect the inferior gemellus muscle below. The piriformis or conjoint tendon are detached as close to their femoral

Figure 1. Intraoperative photograph showing direct superior approach with preservation of the iliotibial band (identified with forceps).

insertions as possible. The capsulotomy starts at the distal, inferolateral aspect of the wound and extends proximally and posteromedially towards the superior acetabular margin. The capsule is elevated subperiosteally to create superior and inferior capsular flaps. The double-ended retractors are then repositioned inside the capsule and the hip is dislocated posteriorly by flexion, adduction and internal rotation.

The femoral neck cut is performed using an oscillating saw at the desired level and the femoral head fragment removed using a threaded Steinmann pin or tenaculum. Angled acetabular retractors are placed over the anterior acetabular rim (inferior margin of the acetabulum) into the ilium between the superior labrum and capsule, and posteriorly into the ischium, which circumferentially exposes the acetabulum (*Figure 2*). The superior and inferior capsular flaps are further elevated subperiosteally and the remaining labrum excised. Medial acetabular wall reaming is initially undertaken using a straight acetabular reamer. This is followed by sequential reaming to the desired size using angled acetabular reamers with an abduction angle of 40° to the transverse plane of the pelvis. The acetabular component is mounted onto a curved cup impacter and inserted into the desired position with the aid of an intraoperative alignment guide to help achieve the desired cup version and inclination.

The leg is then placed into 40° flexion, 40° internal rotation and 40° abduction to visualize the cut surface of the femoral neck. Blunt Hohmann retractors are positioned along the calcar to retract the quadratus femoris and on the anterolateral femoral neck to retract the gluteus medius and minimus muscles. A femoral elevator may then be inserted under the anterior femoral neck to elevate and expose the proximal femur and a box chisel used to remove bone from the posterolateral femoral neck. The femur is then prepared using a rasp and sequential broaching until maximum cortical contact in the mediolateral dimension is achieved. Following acetabular and femoral implant insertion, the hip is relocated and a layered repair of the capsule performed. The obturator internus and piriformis

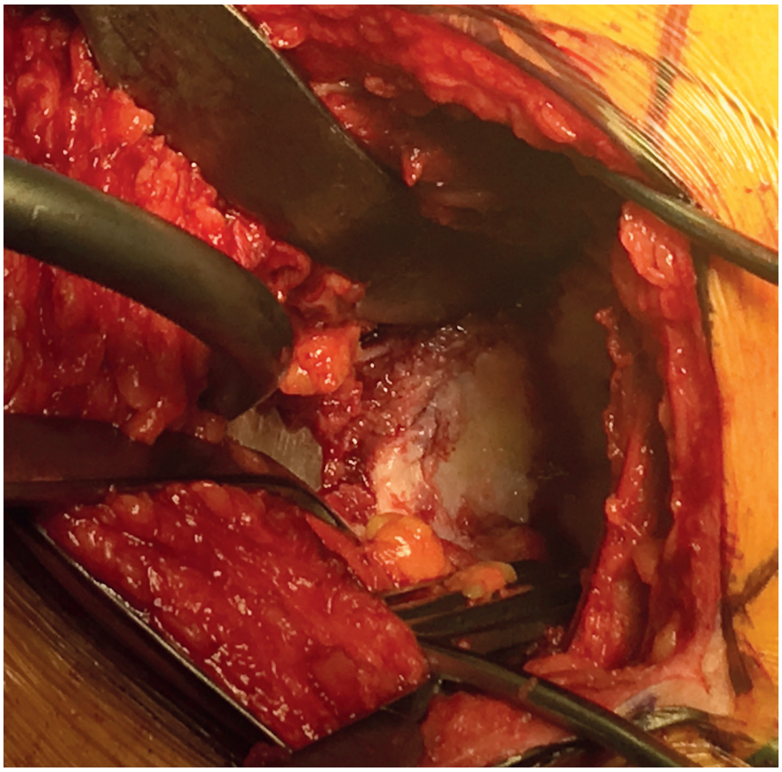

Figure 2. Intraoperative photograph of direct superior approach showing positions of the angled acetabular retractors for circumferential exposure of the acetabular socket.

tendons are repaired directly back on to the femur. The superior gluteus maximus fascia is closed with a running suture. Subcutaneous tissue and skin are closed according to the surgeon's preference.

Learning curve

Minimally invasive approaches for total hip arthroplasty are associated with steep learning curves owing to smaller skin incisions, reduced superficial soft tissue dissection and limited views of the operative field. Understanding the learning curve for a new procedure is important for its safe incorporation into routine surgical practice and appreciating any additional risks or complications during the acquisition of surgical proficiency. Rasuli and Gofton (2015) reviewed outcomes in 49 patients undergoing the direct superior approach for total hip arthroplasty, and found implementation of this procedure was associated with a learning curve of 40 cases for gaining surgical proficiency as assessed with operative times. After this initial learning phase, there was no further reduction in operative times with increasing surgical experience.

The overall mean operative time for the direct superior approach is 55–65 minutes (range 35–90 minutes) and estimated blood loss is 200–340 ml, which is comparable to that reported with the conventional posterior approach for total hip arthroplasty (Penenberg et al, 2008; Roger and Hill, 2012; Meermans et al, 2017). Roger and Hill (2012) reported that in their cohort of 135 patients undergoing the direct superior approach for total hip arthroplasty, two patients from the first half of the study population required revision surgery for suboptimal hip offset leading to leg length discrepancy or hip instability. Surgeons undertaking the direct superior approach must meticulously assess hip biomechanics and leg length discrepancy on-table before definitive selection of final components for total hip arthroplasty. The authors also suggest that surgeons implementing the direct superior approach have reached proficiency in their learning curve with the conventional posterior approach for total hip arthroplasty. This will facilitate intraoperative conversion from the direct superior approach to the posterior approach if required.

Iatrogenic soft tissue injury

Proponents of minimally invasive total hip arthroplasty cite that smaller skin incisions and reduced superficial soft tissue dissection help to limit the postoperative inflammatory response, decrease postoperative pain and enhance postoperative functional rehabilitation (Chimento et al, 2005). The mean length of the surgical incision with the direct superior approach is 8.3–9.0 cm (range 8–15 cm), which is consistent with the minimally invasive posterior approach for total hip arthroplasty (Pellicci et al, 1998; Roger and Hill, 2012).

Amanatullah et al (2016) assessed periarticular muscle injury in eight cadaveric specimens in which the direct anterior approach was performed on one side and the direct superior approach on the contralateral side. The direct superior approach was associated with reduced iatrogenic injury to the gluteus minimus muscle, gluteus minimus tendon, tensor fascia lata and rectus femoris compared to the direct anterior approach. Both approaches were comparable for complete transections through the piriformis and obturator internus tendons, and there was no difference between the two approaches for iatrogenic injury to the gluteus medius muscle, gluteus medius tendon and obturator externus tendon. There remains a paucity of clinical data on how the angled acetabular reamers used in the direct superior approach affect iatrogenic bone injury and periarticular soft tissue trauma and how these correlate to the systemic inflammatory response and long-term patient satisfaction.

Postoperative pain

Residual pain after total hip arthroplasty is a major concern and occurs in up to 40% of patients despite the presence of well-fixed and stable implants (Barrack et al, 2000). Nam et al (2017) retrospectively compared pain scores using pain-drawing questionnaires in 42 patients undergoing the direct superior approach *vs* 196 patients receiving the miniposterior approach for total hip arthroplasty. The authors found that there was no difference in moderate to severe pain over the trochanter, anterior thigh or lateral thigh between the two approaches at a minimum 1-year follow up. In both approaches, residual pain following total hip arthroplasty was prevalent in 17% of patients, which the authors attributed to other aetiological factors such as tendinitis, soft tissue impingement, bursitis or hypersensitivity to metallosis. Mean length of hospital stay following the direct superior approach has been reported as 1.98 days (range 1–3 days), which is comparable to that reported with conventional approaches for total hip arthroplasty (Meermans et al; 2017; Nam et al, 2017).

Functional outcomes

Preservation of the short external rotators improves hip stability and functional outcomes at short- to middle-term follow up (Hedley et al, 1990; Pellicci et al, 1998). Despite this, surgically repaired external rotators fail in 80% of cases after posterior total hip arthroplasty (Stähelin et al, 2004). The direct superior approach offers an opportunity to modify the posterior approach to preserve some of the short external rotators to improve hip stability and optimize functional outcomes after total hip arthroplasty. The direct superior approach improves functional outcomes after total hip arthroplasty as assessed using the Harris Hip Score at 3–14 months follow up (Penenberg et al, 2008; Roger and Hill, 2012).

Nam et al (2017) showed that patients undergoing the miniposterior approach had improved University of California, Los Angeles (UCLA) activity scores compared to those undergoing the direct superior approach at minimum 1-year follow up following total hip arthroplasty. However, this was a retrospective study with different operating surgeons and health-care institutions for each treatment group, and the miniposterior approach included younger and more active patients, which may have affected their perception of pain and reporting of functional progress. Further clinical trials are required to establish if the improved muscle preservation with the direct superior approach translates to any long-term differences in clinical or functional outcomes compared to conventional approaches for total hip arthroplasty.

Accuracy of implant positioning

Accuracy of implant positioning affects hip biomechanics, abductor function, gait, functional outcomes and implant survivorship following total hip arthroplasty (Holleyman et al, 2012). Suboptimal implant positioning may lead to instability, which is the leading complication in both primary and revision total hip arthroplasty within the first year after surgery (Callanan et al, 2011). Surgeons often use 'safe zones' such as those of Lewinnek et al (1978) (5–25° anteversion, 30–50° inclination) to guide optimal implant positioning during total hip arthroplasty (Callanan et al, 2011). Preoperative radiographic templating, intraoperative alignment guides and anatomical landmarks such as the transverse acetabular ligament, acetabular notch and anterior superior iliac spine with the sciatic notch may be used to help guide implant positioning within these predefined safe zones for total hip arthroplasty.

Previous studies have shown that there may be increased risk of implant malpositioning with minimally invasive surgery owing to the limited view of the surgical field and difficulty in identifying appropriate anatomical landmarks (Hassan et al, 1998; Callanan et al, 2011). In the direct superior approach, acetabular bone resection is undertaken using angled acetabular reamers, and therefore assessing the force and direction of acetabular reaming for achieving the planned implant position is more challenging.

Penenberg et al (2008) reviewed outcomes in 250 patients undergoing total hip arthroplasty through the direct superior approach and found acetabular cup positioning within the planned safe zones in 96% of patients and femoral implant alignment within 2° of the planned position in 97% of patients. Roger and Hill (2012) found that in their cohort of 135 patients undergoing direct superior approach, mean acetabular cup abduction angle was 41° (range 21–49°) and mean cup anteversion angle was 21° (range 15–27°). Femoral implant positioning with greater than 2° varus and valgus occurred in 4% and 2% of patients respectively.

Rasuli and Gofton (2015) showed that overall acetabular cup positioning within Lewinnek's safe zones of anteversion and abduction were achieved in 69.4% of patients, which is comparable with conventional approaches for total hip arthroplasty (Hassan et al, 1998; Callanan et al, 2011). Only one patient in the direct superior approach cohort had postoperative dislocation, which required revision surgery with a modular neck and soft tissue repair. This complication was attributed to poor compliance with hip precautions, and plain radiographs showed that both femoral and acetabular implants were within the planned positions. Further trials using computed tomography to assess implant position more accurately and radiosteriometric analysis to evaluate implant stability in the direct superior approach are required to understand how this approach affects accuracy of executing a preoperative surgical plan and long-term implant survivorship in total hip arthroplasty.

Complications

The direct superior approach is associated with low risk of postoperative dislocations, sciatic nerve palsies, deep vein thromboses, pulmonary emboli and wound complications at short-term follow up (Penenberg et al, 2008; Roger and Hill, 2012). Isolated complications reported with the direct superior approach include femoral fractures requiring intraoperative plate fixation or cerclage wiring, inadequate offset and leg length discrepancy (Penenberg et al, 2008; Rasuli and Gofton, 2015). However, there is no existing evidence for an increased risk of complications with the direct superior approach compared to conventional approaches for total hip arthroplasty.

Conclusions

The direct superior approach is a modification of the minimally invasive posterior approach for total hip arthroplasty that preserves the iliotibial band and external rotators except for the piriformis and conjoint tendon. Cadaveric research has shown that the direct superior

KEY POINTS

- The direct superior approach is a modification of the minimally invasive posterior approach for total hip arthroplasty which preserves the iliotibial band and external rotators except for the piriformis or conjoint tendon.
- Cadaveric studies have shown that the direct superior approach reduces iatrogenic injury to the gluteus minimis, tensor fascia lata and rectus femoris compared to the direct anterior approach.
- The direct superior approach has a learning curve of 40 operative cases. After the initial learning phase, operative times with the direct superior approach are comparable to conventional approaches for total hip arthroplasty.
- The direct superior approach is associated with reduced pain, early discharge from hospital, and improved functional outcomes as assessed using the Harris Hip Score at short-term follow up after total hip arthroplasty. The minimally invasive posterior approach provides comparable pain scores and improved University of California, Los Angeles (UCLA) activity scale functional scores compared to the direct superior approach at 1 year follow up.
- The direct superior approach enables accurate femoral and acetabular implant positioning during total hip arthroplasty. Specific complications reported include intraoperative femoral fractures and revision surgery for suboptimal restoration of offset and leg length discrepancy.
- Further studies are required to compare differences in conventional approaches *vs* direct superior approach in relation to patient satisfaction, long-term functional outcomes, accuracy of implant positioning, time to revision surgery and cost effectiveness.

approach reduces iatrogenic periarticular soft tissue injury compared to the direct anterior approach for total hip arthroplasty. The learning curve for the direct superior approach is 40 operative cases with operative times comparable to those of conventional approaches once surgical proficiency is achieved. The direct superior approach provides improvements in pain and short-term functional outcomes after total hip arthroplasty as assessed using the Harris Hip Score. The minimally invasive posterior approach provides comparable pain scores and improved UCLA functional scores compared to the direct superior approach at 1 year follow up. Existing studies using plain radiographs have shown that the direct superior approach enables accurate femoral and acetabular implant positioning. Further clinical studies are required to compare differences in conventional approaches *vs* direct superior approach for total hip arthroplasty in relation to patient satisfaction, long-term functional outcomes, accuracy of implant positioning, time to revision surgery and cost effectiveness. **BJHM**

Conflict of interest: none.

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