Modified Posterior Approach to the Hip Joint

K. Mohan Iyer
Editor

Second Edition

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To the memory of my respected teacher

(Late) Mr. Geoffrey V. Osborne

I have written this dedication with a very heavy mind full of fond memories for my late respected teacher, Mr. Geoffrey V. Osborne, without whose constant encouragement and freedom I could not have written this book. These teachers are extremely rare to spot these days where the turmoil of daily life *overtakes one's ambitions, duties, and career aspirations. I have a remarkable store of personal and academic memories of him, with whom I spent four long years at the University of Liverpool, UK, during which I rarely looked upon him as my teacher, as he was more of a close friend and father to me during all those years.*

He inspired me with his approach and knowledge of orthopedics, that is unforgetable, and I would not have followed his footsteps, had it been for him. I just have hallucinations that he is very much present there and I am sharing with him the joy of being in India. He was a patron of the Indian Orthopedic Association, and he patiently listened when I presented my original research on the hip joint, done in Liverpool, with my respected teacher and late Dr. Rasik M. Bhansali who was the chairman at the Conference of the Association of Surgeons of India in December 1982.

and loving thanks to

My wife, Mrs. Nalini K. Mohan
My daughter, Deepa Iyer, MBBS, FRCP (UK), FAFRM (RACP)
(1. Honorary Adjunct Assistant Professor/ Bond University, Queensland
2. Senior Lecturer/Griffith University and University of Queensland)
My son-in-law Dr. Kanishka B.
My son, Rohit Iyer, B.E. (IT)
My daughter-in-law, Deepti B. U.
My grandsons Vihaan and Kiaan
My grandchild Nisha Iyer

Foreword

I am pleased to write this Foreword to Dr. K. Mohan Iyer after 8 years in the 2nd edition of this book titled *Modified Posterior Approach to the Hip Joint* which has been accepted for publication by Springer Nature (Switzerland) since I wrote the foreword in its 1st edition 8 years ago.

The surgery for the hip joint has evolved considerably in different parts of the world. This evolution dates back to as early as 1883 and is still developing in many parts of the world. Dr. K. Mohan Iyer started with his research in 1981 and is seen in many textbooks of repute such as

1. *The Year Book of Orthopaedics 1982*—Mark B. Coventry, pp. 371–373.
2. *Campbell's Textbook of Operative Orthopaedics*, 12th edition by S. Terry Canale and James H. Beaty, p. 331. He had also given me a Foreword for my book *The Hip Joint* (1st edition) as seen on his website at kmohaniyer.com.
3. *Surgery of the Hip*, Elsevier, Mosby/Saunders, Volume 2, by Daniel J. Berry and Jay R. Lieberman, p. 269.
4. *The Adult Hip (Lippincott-Raven)* (1998), Volume 1, Callaghan, Rosenberg and Rubash, pp. 700–701, 718.
5. *The Hip* by Richard A. Balderston. Lea & Febiger: My original work has been quoted on page 90.
6. *Surgery of the Hip Joint* by Raymond G. Tronzo: Ref. no. 187: (p. 333): Fractures of the Hip in Adults: My original research on the Hip Joint has been quoted.
7. William J. Hozak, Martin Kirsmer, Michael Hogler, Peter M. Bonutti, Franz Rachbauer, Jonathan L. Scaffer, William J. Donnelly (Editors).

His original work (1981) is also referred to in this book *Total Hip Arthroplasty*, Arch Orthop Trauma Surg 102:225–229 at reference no. 24 (pp. 115–229). The Foreword by William J. Hozak for his book *The Hip Joint* (2nd edition) as seen on his website at kmohaniyer.com.

It has reached a new dimension to include in the 2nd edition

1. Posterior Approach to Hip Joint
2. Southern Posterior Approach of the Hip

3. Direct Anterior Approach to the Hip Joint
4. Principles of the Anterior Approach for Total Hip Arthroplasty
5. Anterior Minimally Invasive Surgery
6. Direct Anterior Approach to the Hip Joint
7. Direct Anterior Approach for Total Hip Arthroplasty.

This second edition also has a furthur reference reading section given by all seven contributory authors at the end of their respective chapters.

The best part of his research is its feasibility in Third World countries when it can be done in an indigenous way as shown in detail in Chap. 7 of this book.

It is my pleasure to be able to write this Foreword to the 2nd edition being published by Springer Nature (Switzerland).

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Von Büren, Orthopädische Chirurgie
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Switzerland

Preface

The evolution of my research done (Modified Posterior Approach to the Hip Joint) in 1981 with Dr. Martin A. Elloy, Ph.D., University of Liverpool, UK, is the basis of this book. I had done this at a time when dislocations were frequently reported in literature those days.

In the beginning in Chap. 1 of the manuscript, the description of the Posterior Approach(C) had been written by Dr. Ahmed Zaghloul, lecturer at Orthopedic Department Mansoura University, Mansoura University Hospitals, Mansoura University, Egypt, only for this book being published by the publisher Springer Nature, Switzerland AG.

Another additional version of the traditional Posterior Approach is also given in Chap. 2 by Kemal Şibar, Affiliation: Ankara Etlik City Hospital and Alper Öztürk, Ankara, Turkey.

Professor John O'Donnell; Direct Anterior Approach to the Hip Joint in Chap. 3 by John O'Donnell from my book *Hip Joint in Adults: Advances and Developments* (permission of publisher taken).

Alessandro Geraci; Orthopedic Department, CaFoncello Hospital, Treviso, Italy, from the publication of my book *The Hip Joint* (2nd edition) in Chap. 4 (permission of publisher taken) of this book.

Hiran Amarasekera (Warwick); Hip Preservation Fellow, University Hospitals of Coventry and Warwickshire, UK, Research Fellow at Warwick Medical School, UK, in Chap. 5.

There is a new additional chapter on DAA written Kirubakaran Pattabiraman, Assistant Professor, Department of Orthopedics, JIPMER, Puducherry, India, with Prof. Thomas Mullner, on Minimally Invasive Joint Surgery—Total Hip Replacement. This chapter has been published in detail by another publisher.

DAA by Ahmed Saad, Karthikeyan P. Iyengar, Rajesh Botchu, and Callum McBryde (Direct Anterior Approach to the Hip Joint) by Calllum McBryde in Chap. 6.

Dr. Deepak Gautam, Consultant Joint Replacement and Director of Orthopedic Disciplines, Medicover Hospital, Navi Mumbai and former—Assistant Professor of Orthopedics at AIIMS, New Delhi, India (new additional chapter) in Chap. 7

elaborates a method of doing the DAA on a plain table without the use of any leg holder which is extremely useful in Third World countries.

I am also very thankful to Jenny Rompas and Stanford Chong, Directors and Publishers, Jenny Stanford publishing, Singapore, for their permission to include Chapter 17 (Direct Anterior Approach to the Hip Joint by John O'Donnell) from my book *The Hip Joint in Adults: Advances and Developments* and Alessandro Geraci from my book *The Hip Joint* (2nd edition).

I am also thankful to Dr. Rajesh Botchu, Consultant Musculoskeletal Radiologist, The Royal Orthopedic Hospital, Birmingham, UK, for helping me out in Chap. 6.

Above all my grateful thanks to Melisa Morton [Executive Editor Clinical Medicine], Elizabeth Pope and Ram Prasad Chandrasekar for their invaluable help in this manuscript.

Also my thanks to Vishnu M. G., project Manager at Straive, Chennai – India for his patience in the production of my book titled Modified Posterior Approach to the Hip Joint.

Above all I highly appreciate the help of my son, Mr. Rohit Iyer, in the presentation and publication of this book.

Bengaluru, Karnataka, India

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Introduction

The PA is the most commonly used surgical approach for THA worldwide. There have been several iterations of the PA since it was first described by von Langenbeck in 1874 where he mentioned that all 11 posterior approaches have been described when all either divide the short external rotators or pass between them (Moretti and Post 2017, von Langenbeck 1874). Numerous surgical approaches to the hip joint have been described over the years. Each approach offers certain advantages as well as has its own unique limitations. Access is the key for success; it is essential for the surgeons to be aware of the different surgical approaches in order to deal with variable complex clinical situations. Most new approaches are based on older approaches which have been modified to a specific purpose or for a specific reason. The approach is based on the access needed, the potential for complications, the purpose for which it is needed along with the experience of the surgeon. The primary aim is to maintain the primary blood supply to the femoral head from the medial femoral circumflex artery and its ascending branches. In total hip arthroplasty, disruption of the ascending branches is of no consequence, while in hip resurfacing or osteotomy, the anterior, anterolateral, lateral, or medial approaches are more preferred in order to prevent osteonecrosis of the femoral head. The lateral approaches, which require osteotomy which have a significant nonunion rate, should also be taken into account. Overall, the surgical approaches to the hip may be broadly classified as: anterior, anterolateral, lateral, posterior, medial, lateral subtrochanteric, and proximal femoral shaft. The most commonly used approaches for THA (Moretti and Post 2017) include posterior approach (PA), direct lateral approach (DLA), and direct anterior approach (DAA):

(A) Direct Anterior Approach

Internationally, this approach is gaining popularity in the hip arthroplasty community. Advocates of this approach consider its advantages to be the muscle-sparing nature of its internervous intervals, earlier restoration of gait kinematics, and low dislocation rates. The direct anterior approach can be performed with or without the use of a specialized table or fluoroscopy.

The procedure begins by positioning the patient supine on a specialized traction table. Both feet are firmly secured to boots attached to lever arms that permit positioning of each lower extremity and applying traction to either limb. The perineal post located between the legs stabilizes the patient on the operating room table and provides a point of counter-traction.

The surgical incision begins 2–4 cm lateral to the anterior superior iliac spine of the pelvis. It is then carried distally and laterally for about 8–12 cm at 20° from the sagittal plane of the patient toward the lateral aspect of the patient's ipsilateral knee. The lateral femoral cutaneous nerve (LFCN) is identified, transposed medially, and protected.

After protecting the LFCN, the fascia overlying the tensor fascia latae (TFL) is incised, and a plane is then developed between the TFL and sartorius. The surgeon will then encounter the interval between the rectus femoris and gluteus medius. A Charnley hip retractor displaces the rectus femoris medially and the gluteus medius laterally to expose the anterior joint capsule of the hip. After coagulating or suture ligating the ascending branch of the lateral femoral circumflex artery, a Mueller retractor is placed inferior to the femoral neck, and a capsulotomy is performed. The joint capsule is incised along the length of the femoral neck from the acetabulum to the intertrochanteric line.

Gentle traction is then applied to the operative limb. Mueller and Hohmann retractors are placed intracapsularly around the femoral neck. A reciprocating saw is used to make a femoral neck osteotomy. The femoral head is then removed with a corkscrew. The osteotomy can be repeated, and the resultant napkin ring of bone is removed to increase the ease of removing the femoral head.

Once the femoral head is removed, traction is released and the leg is externally rotated to improve exposure for acetabular preparation. The Charnley hip retractor maintains exposure medially. Placement of the final acetabular component is facilitated by the use of an offset inserter handle to minimize soft tissue injury. Intraoperative fluoroscopy is used to optimize component anteversion and inclination.

Femoral preparation can be difficult owing to limited proximal femoral exposure with this approach. The operative limb is carefully placed in a position of extension, adduction, and external rotation to improve the accessibility of the proximal femur. Overly forceful external rotation can result in soft tissue injuries to the knee and ankle as well as intraoperative fracture. A specialized bone hook is then inserted around the posterior aspect of the femur just proximal to the insertion of the gluteus maximus tendon. This bone hook can be used manually to elevate the proximal femur anteriorly. In the subset of patients in whom the femur cannot be sufficiently mobilized anteriorly, sequential release of the conjoint tendon and piriformis can also improve mobilization of the femur. Rarely, a release of the anterior 1–2 cm of the origin of the TFL off the iliac wing may be required. An offset femoral broach handle eases access to the proximal femur during preparation. Trialing can be combined with intraoperative fluoroscopy to assess leg length and offset. Femoral anteversion is identified based on the posterior cortex of the proximal femur or by using the femoral epicondyles as a reference point. Once the final implants are in situ and the hip is reduced, implant positioning is verified with fluoroscopy, and the stability of the construct can be assessed out of traction.

(B) Hip Direct Lateral Approach (Hardinge, Transgluteal)

Majority of Canadian orthopedic surgeons prefer the Hardinge approach as it gives sufficient exposure to the proximal femur and acetabulum with an extremely low rate of dislocation as reported in the literature.

This is not in the true internervous plane, but is in the intermuscular plane because it (1) splits gluteus medius distal to innervation (superior gluteal nerve) and (2) the vastus lateralis is also split lateral to innervation (femoral nerve).

The anesthesia varies between general anesthesia and spinal with the patient positioned in the either lateral or supine position. The incision starts 5 cm proximal to tip of greater trochanter which is longitudinal being centered over tip of greater trochanter and extends down the line of the femur about 8 cm. The superficial dissection splits the fascia lata and retract anteriorly to expose tendon of gluteus medius and thus helps to detach fibers of gluteus medius that is attached to fascia lata using sharp dissection. The deeper dissection involves splitting of the fibers longitudinally at the middle of the greater trochanter which does not extend more than 3–5 cm above the greater trochanter thus preventing any injury to the gluteal nerve. It is also preferable to extend incision inferiorly through the fibers of vastus lateralis in order to develop an anterior flap containing the anterior aspect of gluteus medius from the anterior greater trochanter with its underlying gluteus minimus and the anterior part of vastus lateralis which then requires a sharp dissection of muscles of bone or lifting small fleck of bone. This thus exposes the anterior hip joint capsule. It is then advised to follow the dissection anteriorly along greater trochanter and onto femoral neck which leads to capsule when the gluteus minimus needs to be released from anterior greater trochanter. There are two structures at risk here, namely (1) the superior gluteal nerve which runs between gluteus medius and minimus 3–5 cm above greater trochanter and is protected by putting a stay suture at the apex of gluteal split and (2) the femoral nerve which is the most lateral structure in neurovascular bundle of anterior thigh. Some surgeons perform a capsulectomy to facilitate dislocating the hip. The surgeon then dislocates the femoral head by externally rotating and flexing the hip and knee. The foot is then placed in a sterile bag anteriorly when Hohmann retractors are positioned around the femoral neck, allowing the surgeon to safely perform a femoral neck osteotomy using an oscillating saw. Completion of the femoral neck osteotomy then provides access to the proximal femur and the acetabulum which is then prepared by externally rotating the leg with the knee in extension. Thereafter, retractors are placed anteriorly, posteriorly, and inferiorly to visualize the acetabulum completely. After trialing and final component placement, the anterior flap (gluteus medius, gluteus minimus, anterior capsule, and anterior vastus lateralis) is repaired to its anatomic position and closed as one layer with a combination of interrupted and running sutures. The fascia lata, ITB, and gluteus maximus are then closed with either interrupted or running sutures followed by routine closure of the subcutaneous tissues and skin.

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Chapter 1
Posterior Approach to Hip Joint

Ahmed Zaghloul

This description of the Posterior Approach had been written by Dr. Ahmed Zaghloul, lecturer at Orthopaedic Departmemt Mansoura University, Mansoura University Hospitals, Mansoura university, Egypt only for this book being published by the publisher Springer Nature, Switzerland AG.

1.1 Introduction

Surgical approach is dissection via tissue planes employing the anatomical mastery to minimize the degree of dissection needed and delimiting the dangers to neurovascular structures. An exemplary surgical approach to the hip joint should obey internervous and intermuscular soft plans to minimize soft tissue harm, aiming to provide an adequate corridor to both acetabulum and proximal femur.

Besides, the ideal approach should grant proximal and distal extensions if required. The deep anatomical location of the hip joint coupled with the close proximity to important neurovascular structures, give surgical approach a matter of some difficulty and complexity (Rathi and Khan 2015).

Diverse surgical corridors to the hip joint have been depicted. For clarity and accuracy of description, a classification system that systematically describes these approaches was proposed by Duncan and Herman. It is based on the relationship of the corridor to the gluteus medius (in front, behind, or through it), the number of incisions used (single or multiple), and whether the approach trans or intermuscular. The posterior approach (PA) is classified as a single-incision, posterior trans muscular approach that divides the external rotators (Hozack et al. 2018).

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1.2 History

The PA is one of the frequently practiced approaches to the hip (Hoppenfeld et al. 2009). An up to date worldwide survey of surgeons proposes that the PA is the commonest adopted surgical approach for total hip arthroplasty (THA) internationally (Chechik et al. 2013).

In 1874, Bernhard von Langenbeck first described this approach in his treatment of war wounds and infections of the hip and termed it “the longitudinal incision to the hip” (Langenbeck 1874). In 1907, Kocher added a modification to Langenbeck’s approach by continuing the incision caudally. He declared that “it is a further development of Langenbeck’s method by the oblique incision” (Kocher 1902). Thenceforward, thirteen other modifications and variations of this approach have been delineated (Gibson 1950; Moore 1959; Mehlman et al. 2000; Tonzo 1984). A well-known variation to the PA was proposed by Alexander Gibson in 1950. He bettered the exposure of hip joint by adding the release of gluteus medius and minimus muscles, the two main hip abductors (Gibson 1950). All of these versions are broadly named posterolateral approach and the recent PA is mostly similar to Moore’s approach (1957). Austin Talley Moore is largely credited by popularization of PA during his work with femoral prosthesis what he named “The Self Locking Metal Hip Prothesis” (Moore 1959). The incision in this classic, utilitarian, extensile, PA extends from the posterior superior iliac spine (PSIS) to the posterior border of the greater trochanter (GT), and then extends 10–13 cm distally along the femoral shaft axis (McGann 2007).Moore named it “Southern Approach” partially as he transferred the skin and maximus incisions more posteriorly and inferiorly and also as he practiced in one of the southern states of America (Osborne 1986). This approach offers very spacious exposure to the posterior capsule, posterior acetabular wall, ischium, and GT, and can be extended to include the entire femur while preserving the abductor muscles. From the time of its initial description, numerous modifications and mutations were proposed to involve different placement and size of the skin incision, preferential detachment of the short external rotators, posterior capsular repair and potential preservation of femoral head blood supply (Iyer 1981; Hedley et al. 1990; Shaw 1991; Pellicci et al. 1998; Ko et al. 2001; White et al. 2001; Suh et al. 2004; Tsai et al. 2008; Kwon et al. 2006; Sculco et al. 2016; Kizaki et al. 2018; Barrett et al. 2019).

1.3 Indications and Contraindications

The PA to the hip with its multiple modifications and permutations are suitable for any operation which needs perfect access for the acetabulum, the proximal femur, or both of them. According to the size of the incision, it allows for narrow or extensible access for vast majority of hip procedures such as primary or revision

THA, hemiarthroplasty, hip resurfacing arthroplasty, resection arthroplasty, osteochondral grafting, surgical dislocation of the hip, removal of intra-articular loose bodies, drainage of intra-articular sepsis, treatment of proximal femoral or acetabular osteomyelitis, tumor resection, fixation of posterior acetabular and posterior column pelvic fractures, open reduction of posterior hip dislocations, hip arthrodesis and neurolysis of the sciatic nerve (Hoppenfeld et al. 2009; Foran and Valle 2015; Modaine 2010).

Moreover, PA can be simply extended more distal in case of periprosthetic fractures, where exposure to the whole shaft of femur may be needed or in cases where an extended trochanteric osteotomy (ETO) is necessary (Hoppenfeld et al. 2009; McGann 2007; Foran and Valle 2015; Modaine 2010). Generally, there are no contraindications to this approach (Meftah et al. 2015). However, some relative contraindications exist including anterior column fractures, previous anterior approach to the hip and patients at high risk for dislocation after THA (e.g., neurologic disorder, Parkinson disease, noncompliance, dementia) (Srinivasan et al. 2015).

1.4 Surgical Anatomy

1.4.1 Bony Landmarks

The palpation of the hip joint and its structures is actually challenging and a little bit tricky. This is attributed to bulky muscles and a variable amount of subcutaneous fat covering the joint (Harty 1984). However, there are some bony landmarks of the pelvis and femur that give hand during performing the PA to the hip. The principal palpable osseous landmarks over the posterior aspect of the pelvis and hip are enumerated in Table 1.1.

The anterior–superior iliac spine (ASIS) represents the most anterior limit of the iliac spine and is the site of attachment to sartorius muscle and inguinal ligament. The iliac crest curves posteriorly and ends at the posterior superior iliac spine (PSIS) towards which the skin incision is curved (Harty 1984). The GT, with its prominent tubercle (Innominate Tubercle) located in its posterosuperior edge, is laterally protruding, easily palpable and establishes a milestone while performing PA (Kielbasinski Podlaszewska et al. 2017). The GT, over which the skin incision is centered,

Table 1.1 Bony landmarks over posterior hip and pelvis

Bony landmarks over posterior hip and pelvis
• Anterior superior iliac spine (ASIS) • Iliac crest • Posterior superior iliac spine (PSIS) • Innominate tubercle of greater trochanter (GT) • Ischial tuberosity (IT)

is the site of attachment of five structures (Gluteus medius, Gluteus medius, Piriformis, Conjoined Tendon and Obturator externus) (Hoppenfeld et al. 2009). The Ischial Tuberosity is a large bony prominence lying posteriorly on the descending ramus of the ischium. It marks the lateral boundary of the *pelvic outlet* (https://en.wikipedia.org/wiki/Pelvic_outlet). Precise orientation to ASIS and IT is very crucial to understand acetabular quadrant system helps the surgeons to identify the location of intrapelvic neurovascular structures in relation to fixed reference points inside the acetabulum (Wasielewski et al. 1990).

1.4.2 Osteology

The normal acetabulum owns specific orientations, determined by horizontal abduction angle of about 42° and the anteversion angle ranging from 10–15° sagittally. This geometry with the normal antetorsion of the femur of about 12° this will enable hip flexion up to 90° before occurrence of femoroacetabular impingement. These anatomic characteristics should be taken into consideration while performing THA (Prescher et al. 2021). The inside acetabular surface reveals important surgical landmarks while performing THA. These landmarks include anterior and posterior brims, the acetabular fossa (Fossa Acetabuli or Fovea Centralis) and the transverse acetabular ligament (TAL).

The anterior and posterior brims give a hand determining adequate acetabular component size, inclination and anteversion. As a general rule, reaming one quarter of the acetabular diameter is secure. In another words, reaming a size 56 acetabulum to a size 70 is quite sufficient while preserving about 75% of the cross-sectional bone of the anterior and posterior columns. Overreaming the acetabulum during THA may create a pelvic discontinuity, render the columns incompetent, hinder optimum circumferential hoop stresses while press-fitting the acetabular component into an undersized acetabulum. In addition, it may reduce the attainable bone depths delimiting the screw purchase necessary to augment acetabular component fixation (Kusuma et al. 2013).

The fovea (Fossa Acetabuli) is a rough depression devoid of hyaline cartilage lying at the center of acetabulum. It is the deepest part of acetabulum, its floor (base) is very thin having several nutrient canals (Prescher et al. 2021). The foveal floor acts as a landmark to the maximal extent where the acetabular reaming can reach medially. It is essential to identify the base of fossa acetabuli in cases having large obscuring medial or central osteophytes. Inability to clear these osteophytes with precise reaming medially will end with lateralization of acetabular cup. Additionally, medialization beyond this level should be avoided (Wasielewski et al. 2015). Natural or iatrogenic defects in the base of fovea are hazardous when implanting cemented cups forming an irregular and creepy cement bulge known as “transacetabular cement cone” (Heller et al. 1996).

Anatomically, TAL is a strong double-layered ligament crossing the acetabular notch, functionally acts as a tension band wiring construct, that can limit the expanding of the acetabular margins in loading and pathologically in cases of severe degenerative amendments the ligament may be totally ossified (Löhe et al. 1996). During THA it provides a landmark of the most inferior margin of the acetabulum specifically in dysplastic hips and prevents the inferior wandering of the acetabular reamers when the superior acetabular bone is sclerotic. In contrast, if TAL is completely ossified it will force acetabular reamer in superior direction in cases in which the superior acetabular bone is osteopenic (Wasielewski et al. 2015).

The femur (thigh bone) is the largest and strongest bone in human bodies. It is mostly cylindrical throughout its length with anterolateral bowing in its midportion. The proximal metaphysis (Femoral Neck) makes an angle ranging from 125 to 135° in relation to diaphysis, this angle is known as femoral neck shaft angle (NSA). Additionally, the neck is anteverted (externally rotated about the long axis) by about 15–20° with respect to a tangent to the posterior surface of both femoral condyles. In almost all hips, the femoral head center lies at the same level of the tip of the GT, increasing the NSA puts the femoral head center at a higher level in relation to the tip of GT resulting in coxa valga. In comparison, a decreased NSA will result in coxa vara (Zaghloul and Mohamed 2018).

Moreover, the distance from the femoral head center to the lateral surface of GT (Medial Offset) varies apart from changes in NSA. However, patients with increased NSA lean to possess less offset, while those with decreased NSA own more offset. All these variations must be taken into consideration during THA using femoral components with nearly equal offsets and NSA. The femoral canal configuration and extent of bowing are clinically relevant as they may create problems with cementless stems, especially long stems with fixed proximal geometry. Not only must cementless stems fit the anterior–posterior and medial–lateral dimensions of the canal, they also should maximize the endosteal contact down the length of their porous coating (Kim and Yoo 2016).

1.4.3 Muscular Anatomy

The muscles overlying the posterior aspect of the hip joint are divided into deep and superficial layers. Henry described the outer layer as the “deltoid” muscle of the hip, similar to the deltoid of the shoulder. This layer includes the gluteus maximus, the fascia lata, and the tensor fascia lata, which together form the outer sheath of the hip musculature (Henry and Henry 1970). The deep layer encountered during the PA is formed of the short external rotators (SERs). From cephalad to caudad, they include the piriformis, the superior gemellus, the obturator internus, the inferior gemellus, the obturator externus, and the quadratus femoris. The musculotendinous insertions of the gluteus medius and minimus insert at the tip of the greater trochanter and are not disturbed during the posterior PA to the hip.

Conjoined tendon is formed by tendons of superior gemellus, the obturator internus, the inferior gemellus, from proximal to distal, before its insertion in antero-superior aspect of GT. There are multiple connections between tendons of SERs, gluteus medius and joint capsule. Detailed knowledge of this anatomy and the effects of their preservation or release have a pivotal role during PA in order to optimize this exposure while minimizing muscular damage (Solomon et al. 2010).

1.4.4 Neurovascular Anatomy

Neurovascular structures relevant to the PA to the hip leave the pelvis to reach the hip via the sciatic notch. The piriformis tendon defines the pathway for the neurovascular anatomy of the hip. Ten structures enter the hip through the sciatic notch, passing above or below the tendon to supply their given muscles.

The sciatic nerve reaches the hip beneath the piriformis tendon and travels distally between the superficial (gluteus maximus) and deep (SERs) layers of the hip. Throughout the PA to the hip, it is typically shielded by the posterior soft tissue flap but may be injured by errant posterior retractor placement, during surgical reduction and dislocation of the prosthesis, repair of posterior soft tissue (capsule and SERs) or excessive leg lengthening (Bryan et al. 2013). Likewise, the femoral nerve and vessels are also at risk of indirect injury, usually from anterior acetabular retractor placement. In placing the anterior retractor, care must be taken to hug the bony anterior wall and avoid impinging soft tissue between the retractor and the anterior walls of the acetabulum (Foran and Valle 2015).

The inferior gluteal nerve (IGN) and artery leave the pelvis beneath the piriformis tendon to reach the hip providing the neurovascular supply to the gluteus maximus. Because they enter the muscle almost immediately, they remain well medial and are not encountered during a routine posterior approach to the hip. The branches of inferior gluteal artery are inescapably injured during gluteus maximus splitting. Hence, careful dissection is essential for identification and coagulation before they are avulsed (Prescher et al. 2021). Its main trunk is rarely encountered while performing PA for THA. But if injured, it will retract into the pelvis causing acute and drastic bleeding. In this condition, an extraperitoneal approach to the pelvis may be required to control the internal iliac artery, which is the feeding branch to the inferior gluteal artery.

The superior gluteal nerve (SGN) and artery reach the hip upon the piriformis to supply the gluteus medius and minimus muscles. Although not frequently encountered during the posterior approach to total hip arthroplasty, the superior gluteal artery and nerve tether the gluteus medius and minimus musculature to the ilium, preventing complete mobilization of these muscles and limiting exposure of the ilium. Injury to the superior gluteal nerve may result in denervation of these muscles, ending with abductor muscle dysfunction and Trendelenburg gait. Injury to the superior gluteal artery can result in brisk pelvic bleeding and is difficult to control because the artery may retract into the pelvis during injury, making identification and ligation difficult and necessitating a trans-abdominal extraperitoneal approach to ligate internal iliac artery (Bryan et al. 2013).

1.5 Surgical Technique

A combination of familiarity, versatility, and reproducibility with the PA likely makes it the routinely used approach while performing hip arthroplasty. A Step-by-Step description of implementing THA through PA will be summarized.

Step I: Patient Positioning

- The patient is placed in the lateral position with the affected side uppermost and the pelvis is secured in a neutral position as a tilted or rotated pelvis may end with inappropriate positioning of the acetabular components.
- All bony prominences should be well-padded and axillary rolls placed in the downside axilla and the down leg to prevent undue pressure on the brachial plexus and peroneal nerve in the dependent extremities during surgery.
- The pelvis is fixed utilizing well-padded hip positioners on the sacrum posteriorly and the pubis and/or iliac crests anteriorly. Alternately, bean bags can be utilized. Using the floor as an external reference, care is taken to ensure that the gluteal crease is parallel to the floor. Additionally, the anterior superior iliac spines may be palpated and interspinous line should be perpendicular to the floor (Fig. 1.1).

Fig. 1.1 Lateral decubitus position. The patient is placed in the lateral position with the affected side uppermost and the pelvis is secured in a neutral position. All bony prominences should be well-padded to prevent undue pressure on the brachial plexus and peroneal nerve in the dependent extremities during surgery

- After double skin preparation, the involved limb is draped freely to facilitate dislocating the hip and to permit maneuverability of the limb during surgery (Fig. 1.2).

Step II: Skin Incision

- Start by identifying the GT, abduction, adduction and rolling of the hip by the assistant will give hand palpating the GT.
- With the hip flexed approximately 45 degrees, a straight incision (8–20 cm) is made over the posterior one third of the GT. Preferably, one third of the incision should be placed proximal to the tip of the GT and two thirds should be distally placed along femoral diaphysis (Fig. 1.3).
- If the hip can't be flexed, curve the incision proximally towards Posterior Superior Iliac Spine (PSIS) (parallel to underlying fibers of gluteus maximus muscle). This incision can be extended both proximally and distally for extensile exposure of the acetabulum and femur.
- Adequate size and position of the incision will provide better minimize soft tissue injury is required to visualization of anatomic landmarks, proper component positioning and minimal soft tissue injury. Too anteriorly placed incision renders the retraction of the posterior flap arduous, especially in obese or muscular patients. Too posteriorly placed incision makes the sciatic nerve at risk.

Fig. 1.2 The involved limb draping after double skin preparation to permit maneuverability during surgery

Fig. 1.3 Skin incision is made over posterior one third of greater trochanter (GT) with one third of the incision is placed proximal and two thirds distal to the tip of GT

- Incise the skin with a number-10 blade in plane directly perpendicular to skin in order to create sharp skin edges not flaps.

Step III: Superficial Dissection:

- After skin incision, the subcutaneous tissues and superficial fascia are dissected using a knife or electrocautery with cauterization of subcutaneous vessels to create one subcutaneous plane directed towards the middle of the GT in the anteroposterior plane till reaching fascia lata (Fig. 1.4).
- Frequent palpation of GT is crucial to confirm an accurate plane or simply you can follow the anterior margin of skin incision especially in obese or muscular patients. As, too much anterior or posterior placement of incision will impede the access to both acetabulum and proximal femur.
- Once the fascia lata is identified, a Cobb elevator can be utilized for gentle clearance of the remaining subcutaneous tissue so as to expose the fascia without creating large flaps.
- Incise the fascia lata on the lateral aspect of the femur to uncover the vastus lateralis. Lengthen the fascial incision superiorly in line with the skin incision and split the fibers of the gluteus maximus by blunt dissection.
- Splitting the muscle inevitably crosses the vascular plane (Inferior Gluteal vessels). So, gentle blunt splitting is recommended to pick up, coagulate, and

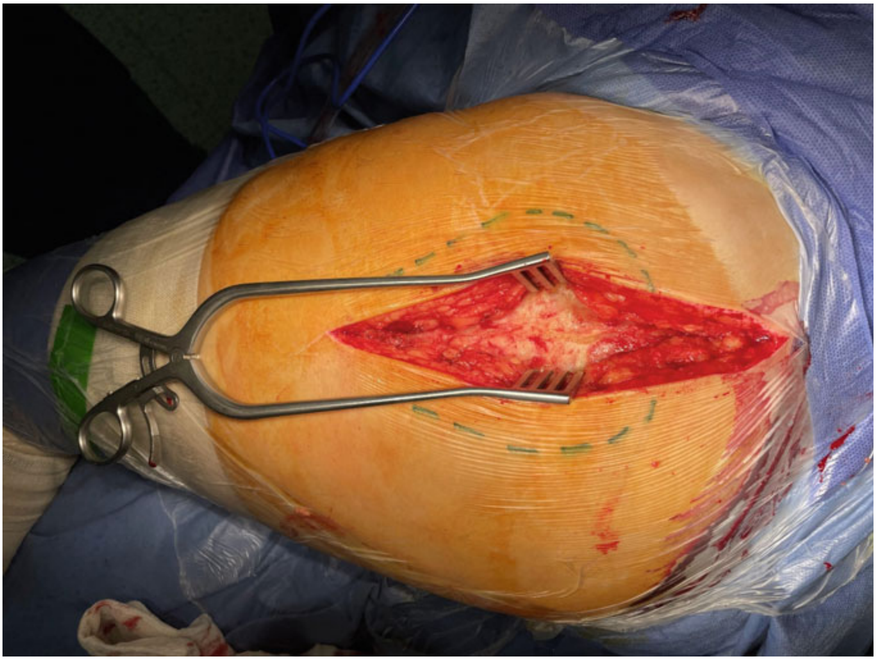

Fig. 1.4 Superficial dissection is done using a knife or electrocautery through subcutaneous tissues and superficial fascia with cauterization of subcutaneous vessels creating one plane till reaching fascia lata

cut the crossing vessels before they are stretched, avulsed and retracted into the muscle (Fig. 1.5).

- Ideally, splitting of about 5 cm of gluteus maximus is sufficient to allow generally appropriate access to both the acetabulum and proximal femur. More proximal dissection will increase the risk of injury to the IGN or artery resulting in muscle denervation or brisk bleeding respectively.
- Two self-retaining retractors are used at proximal and distal angles of the incision beneath the fascia lata with one limb placed first on the posterior flap (where the sciatic nerve is at risk if the retractor is placed to deeply) and then the other limb on anterior flap (Fig. 1.6).

Step IV: Deep Dissection:

- Surgeons may use index finger and thumb to sweep 360° under fascial incision to break up bursal adhesions.
- Incise the GT bursa as anterior as possible using scissors or electrocautery and reflect it posteriorly by pressing using lap pad in hand with careful identification and cauterization peribursal vessels (Fig. 1.7).
- If this is severely inflamed of fibrosed, it could be completely excised. Then, fatty tissue is removed to clearly expose the back of GT (Fig. 1.8).

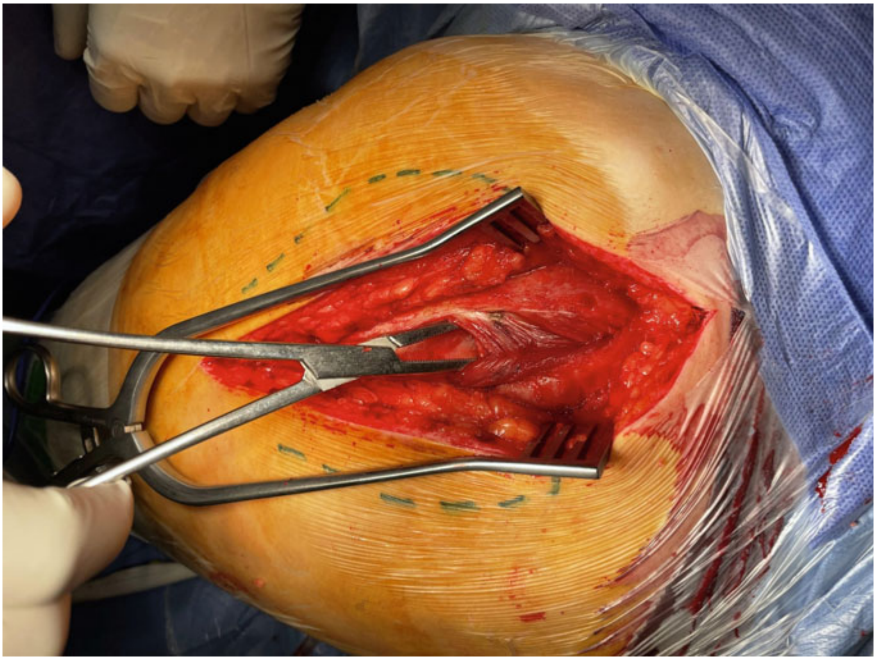

Fig. 1.5 Incising the fascia lata in line with skin incision with gentle blunt splitting the gluteus maximus to pick up, coagulate, and cut the crossing vessels before they are stretched, avulsed and retracted into the muscle

- Exposure is enhanced by putting the hip in extension and maximal internal rotation and the knee in 90° flexion. This also allows for teasing of the fat surrounding the sciatic nerve, thereby minimizing the risk of iatrogenic nerve injury.
- The gluteus medius, piriformis and remaining SERs (superior gemellus, obturator internus, inferior gemellus and quadratus femoris) are identified. The piriformis muscle is identified as a taught, firm, band-like structure attached to piriformis fossa at the upper edge of GT (Fig. 1.9).
- A plane is created above the piriformis tendon using a Cobb elevator and a bent Homan retractor is put above the piriformis and below the gluteus minimus and medius, avoiding vigorous retraction as this can harm the abductor muscles and magnify the risk for heterotopic ossification.
- The subsequent exposure of the hip joint can be done
- with either one layer in complex primary or revision cases or two layers in primary cases.
- Taking down the hip capsule and the SERs as one layer in the shape of a "7" is done with a cautery by starting from the posterior-superior aspect of the acetabulum to the piriformis fossa and is continued inferiorly along the posterior aspect of the femoral neck to the posterior-inferior part of the femoral neck, creating a single

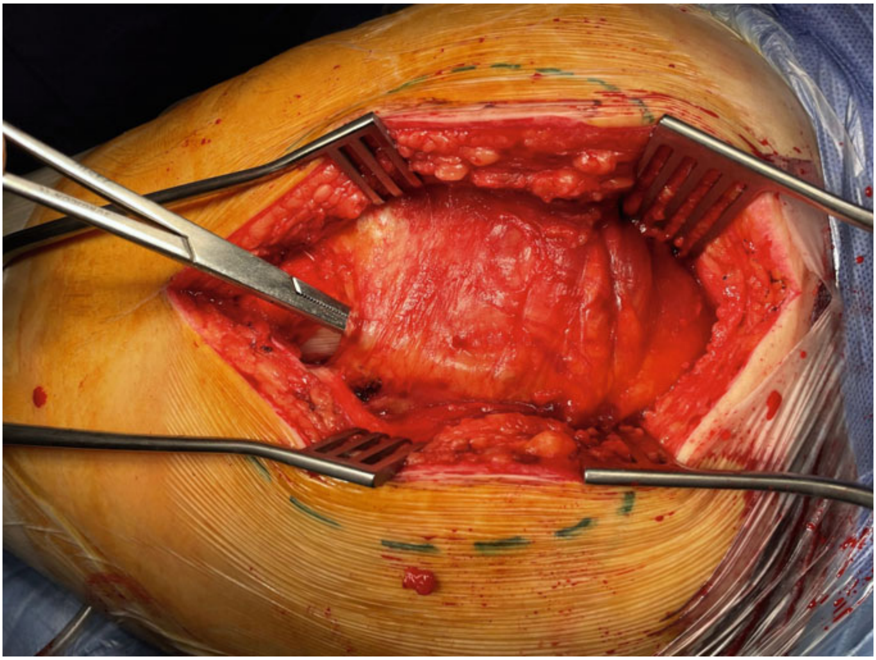

Fig. 1.6 After placement of two self-retaining retractors at proximal and distal ends beneath the fascia lata the trochanteric bursa is identified

conjoint-myocapsular sleeve attached to the acetabulum tagged with two or three large gauge nonabsorbable sutures for later repair (Fig. 1.10).

- Alternatively, the two-layer approach involves taking down the piriformis tendon and the external rotators first and tagging them with sutures, followed by a separate capsulotomy in the previously mentioned manner to expose the underlying femoral head.
- Ideally, on tagging these structures, the needle must be directed from posterior to anterior in order to avoid injury to sciatic nerve. Once tagged, the capsule and rotators could be reflected posteriorly to shield the sciatic nerve and to improve the exposure of acetabulum.
- Distally the quadratus femoris may be spared from dissection or the proximal one third may be released. Care must be taken when dissecting the proximal quadratus, because the medial femoral circumflex artery may be cut and may retract, causing troublesome bleeding. Slowly cauterizing the quadratus during this dissection helps avoid this problem or simply dissecting the muscle as near as possible to the bone.
- At this point, the femoral head, neck, and posterior wall are visualized and the hip can be dislocated. If hip dislocation is difficult, it is often due to residual

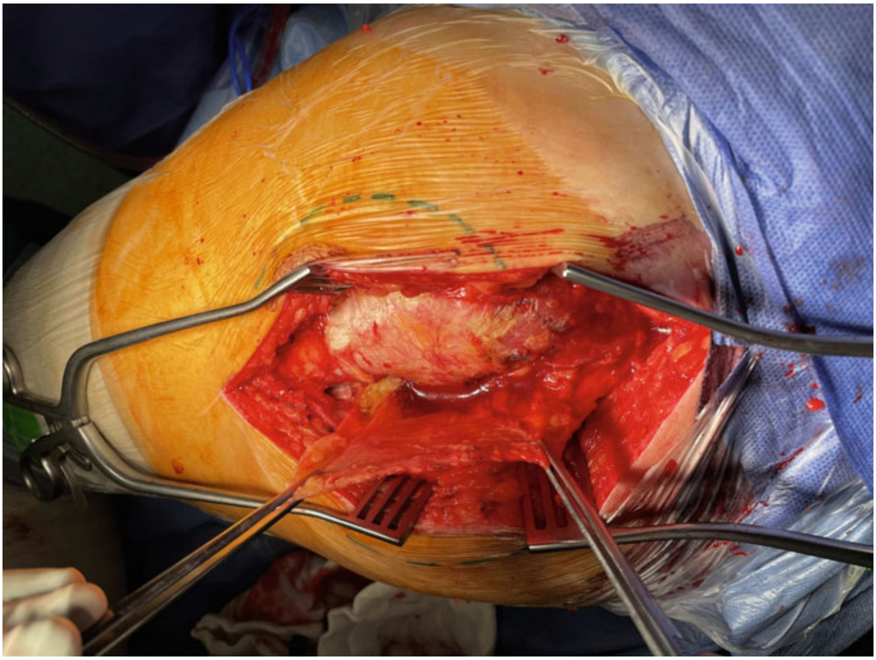

Fig. 1.7 Incising the trochanteric bursa as anterior as possible using scissor or electrocautery and reflecting it posteriorly by pressing using lap pad in hand with careful identification and cauterization peribursal vessels

inferior capsular attachments to the posteroinferior femoral neck (Zona Orbicularis). Complete detachment of this inferior capsular reflection will permit hip dislocation without resistance.

- Occasionally in hips that are stiff, or when extensile exposures are required, the rest of quadratus femoris and tendon of the gluteus maximus may need to be released to allow mobilization of the femur anteriorly for the acetabular exposure and distally for restoration of limb length discrepancy.
- Care should be taken when the gluteus maximus tendon (femoral insertion) is released, because the sciatic nerve traverses just below the tendon and the first perforator branch of the profunda femoris artery may be encountered during the release and should be identified and coagulated.
- The hip is then dislocated by flexion, adduction, and internal rotation then put again in extension and internal rotation. The femoral neck cut is made perpendicular to the neck at a level based on preoperative templating, using an oscillating saw with two Hohmann retractors anteriorly and posteriorly to protect the surrounding soft tissues and GT. The cut neck should be left a few millimeters more than predicted to allow for templating measurement errors. Excess bone can be removed after femoral broaching using a calcar reamer (Fig. 1.11).

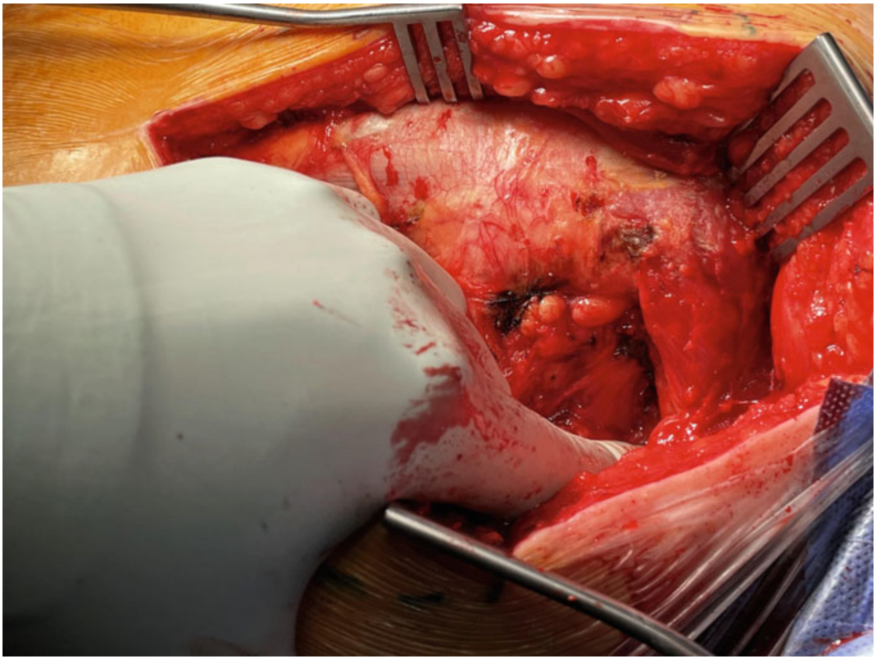

Fig. 1.8 Dissection of fat pad covering the back of greater trochanter is an essential step needed for adequate exposure and protection of the abductors

Step V: Acetabular Exposure

- The posterior approach allows excellent visualization of the acetabulum but requires anterior translation of the femur in front of the acetabulum. This is achieved by the use of an anterior retractor placed at the level of the anterior inferior iliac spine or approximately at the 3 o'clock position.
- Care should be taken when placing this retractor to ensure that it stays in direct contact with the anterior pelvis. Aggressive placement can put the femoral artery and nerve at risk. Slight hip flexion and external rotation of the hip will allow for anterior translation of the femur and circumferential exposure of the acetabulum.
- A posteriorly based Hohmann retractor placed at the level of the Ischium and the posterior column holds the capsule and external rotators away from the acetabular rim and enhances visualization,but it should be placed intracapsular posterior to the labrum.
- Another Hohmann retractor is placed inferiorly just distal to the transverse acetabular ligament to allow visualization of the floor of the acetabulum, and finally a Steinmann pin or retractor is placed superiorly retracting the gluteus medius to improve visualization of the superior aspect of the acetabulum (Fig. 1.12).
- The labrum is removed and any soft tissue remnants of the ligamentum teres and pulvinar are excised to allow visualization of the medial wall of the acetabulum.

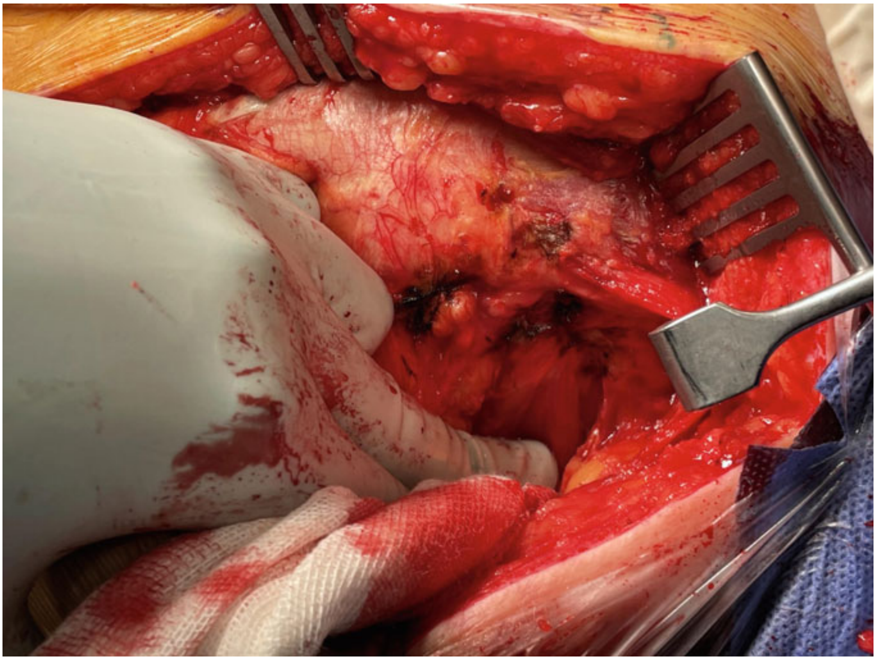

Fig. 1.9 A retractor is placed deep to gluteus minimus and medius to expose piriformis tendon and short external rotators

The foveal artery (a branch of the obturator artery) is cauterized at this step. The acetabulum then can be prepared with hemispherical reamers with excellent visualization of the entire acetabulum.

Step VI: Femoral Exposure

- To expose the femur, the hip is flexed, internally rotated, and adducted; a skilled assistant can determine the ideal combination of these positions to facilitate visualization. Typically, the leg should be flexed until positioned in line perpendicular to the floor, internally rotated to move the greater trochanter out of the way and adducted to minimize impingement on the posterior skin flap.
- A Mueller-type femoral neck elevators femoral is typically placed on the anterior (deep) surface of the femoral neck, and another retractor is placed medially to view the calcar region; this allows for unhindered placement of the stem and provides an accurate check for femoral anteversion.
- A box osteotome is used to create a lateral and a slight posterior entry point to align the femoral prosthesis along the neutral axis of the femur and avoid varus mal positioning of the stem. Then femoral reaming or broaching is completed under direct visualization of the femoral anatomy to the proper size in the desired anteversion (Fig. 1.13).

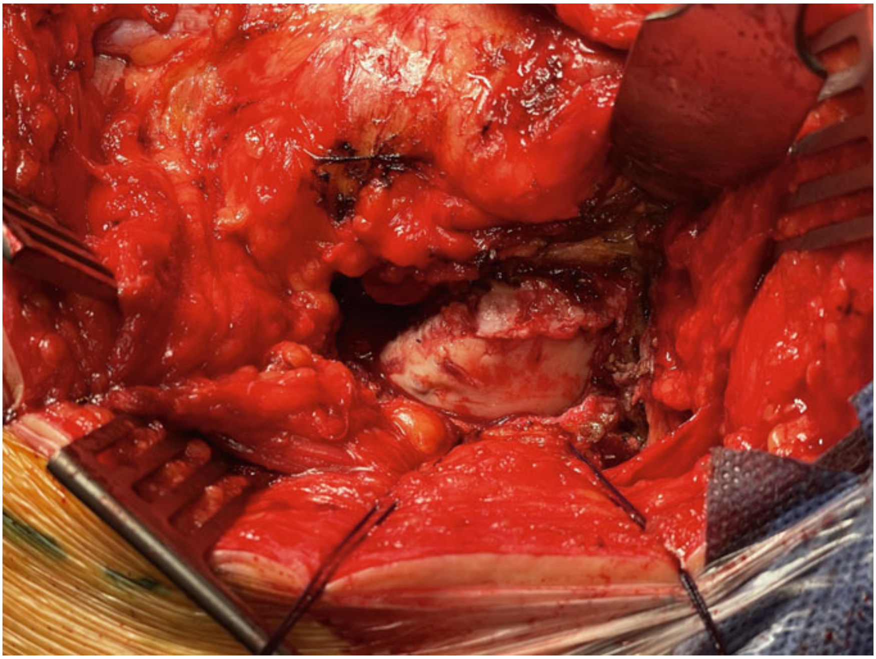

Fig. 1.10 The posterior capsule and SERs are dissected as one layer in the shape of a "7" from proximal to distal and tagged with nonabsorbable sutures

Step VII: Trial Reduction

- A trial reduction is performed to assess leg length, offset, and hip stability. Routinely, leg length is assessed then hip stability is tested in the following sequence:
  - The hip is positioned in maximal extension and maximal external rotation to assess the neck impingement against the posterior edge of the liner.
  - Then flexed 45° and maximally adducted (position of sleep) to assess femoral head subluxation.
  - And then flexed 90° in neutral abduction to assess degree of internal rotation performed without dislocation; usually 45° is accepted.
  - Additionally, the combined anteversion of the femoral and acetabular components is checked using the coplanar test by bringing the femur into slight abduction and from 30–45° of internal rotation (Fig. 1.14).
  - Soft tissue tension should be tested. The anterior capsular tension is checked by passive external rotation which should bring the proximal femur to within one finger breadth from the ischial tuberosity. The Ober test is used to check the length and tightness of the tensor fascia lata and iliotibial band. Also, the shuck test involves telescopic distraction of the femoral head from the acetabulum, which should only allow for a few millimeters of translation.

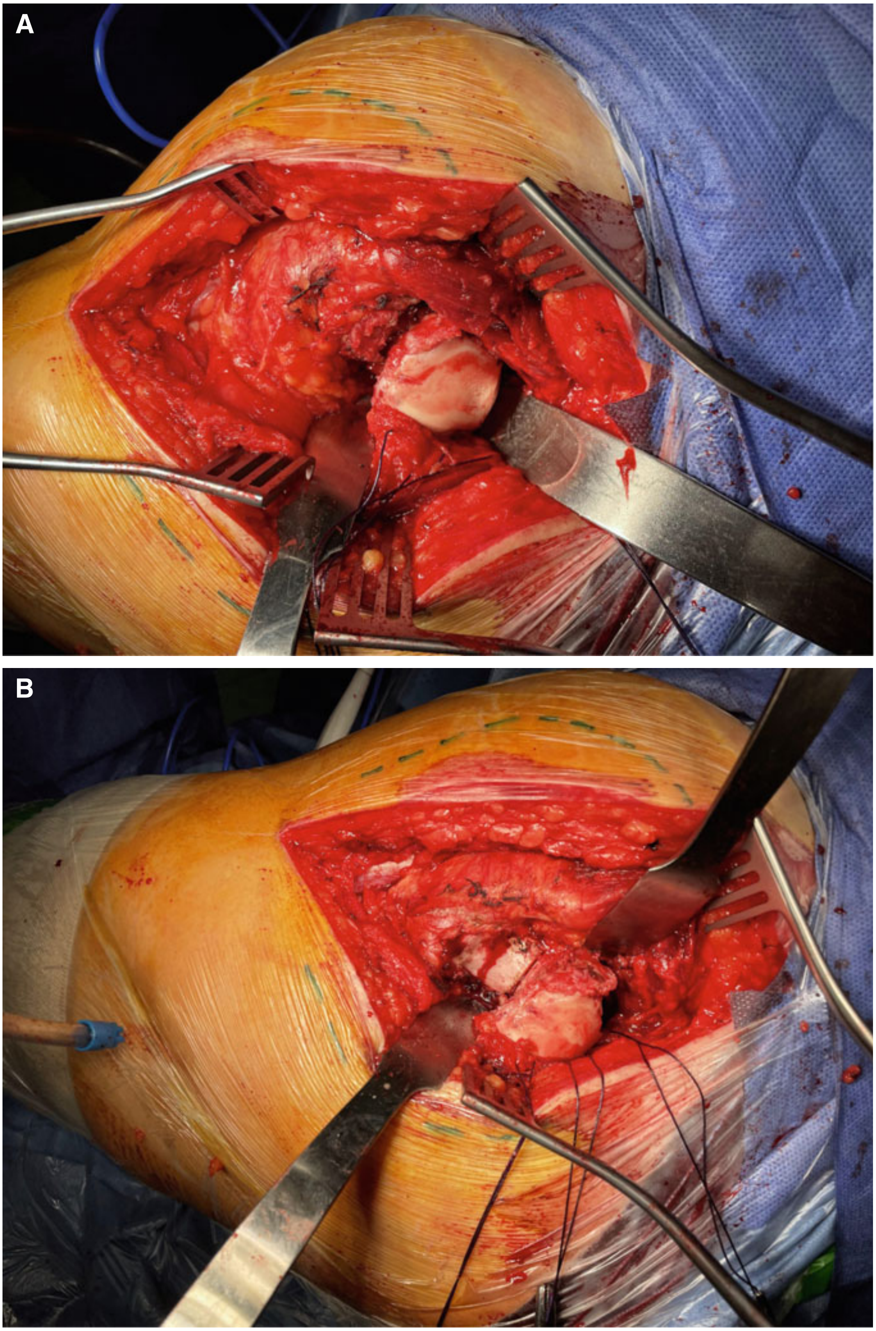

Fig. 1.11 (A, B) The hip is dislocated posteriorly (A), and retractors are placed around the femoral neck to protect the surrounding soft tissues and grater trochanter during neck osteotomy (B)

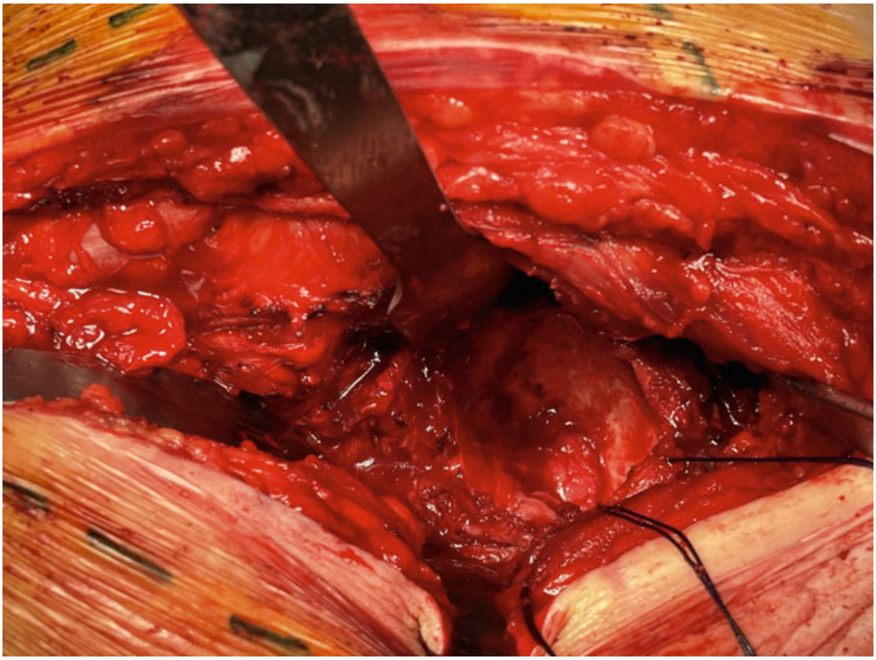

Fig. 1.12 Adequate placement of retractors (3 o'clock, 9 o'clock, superiorly and inferiorly at transverse acetabular ligament) provides circumferential 360° visualization of the acetabulum

– If the stability test results are unacceptable, then various combinations of neck length, hip offset, head diameter, and liner options can be trialed. Also, the anterior soft tissue and iliotibial band may be released as required to adjust the soft tissue tension.

Step VIII: Soft Tissue Repair and Wound Closure

- In preparation for wound closure, hemostasis is achieved, irrigation with a Betadine solution of 3.5% is performed for 3 min (Brown et al. 2012) then the wound is washed with copious amounts of saline solution.
- Periarticular injections using a combination of local anesthetic and corticosteroid are given. They have been shown to significantly decrease postoperative pain and narcotic requirements (Parvataneni et al. 2007; Maheshwari et al. 2009).
- After final femoral component placement, injection of the deep soft tissues is performed including the anterior capsule, iliopsoas tendon, and gluteus medius and minimus insertion sites. After reduction, superficial injection is performed in the iliotibial band, the gluteus maximus and the subcutaneous tissue.
- An extended posterior soft tissue repair is performed. The quadratus femoris is repaired to its insertion using a nonabsorbable suture, along with repair of the gluteus maximus insertion. The SERs and posterior capsule are then repaired to the trochanteric fossa, very close to their insertion, through two drill holes using

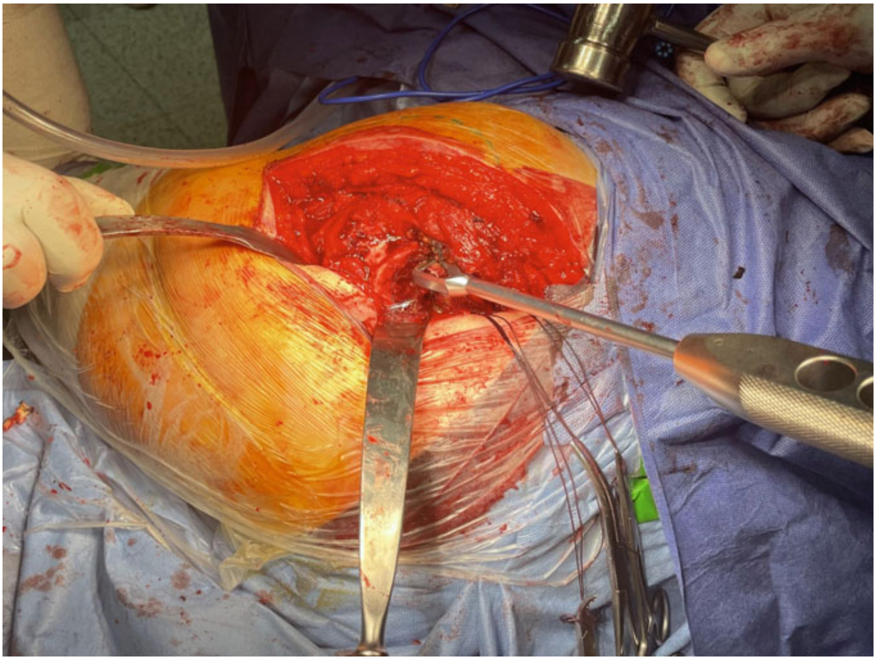

Fig. 1.13 A Mueller-type femoral neck elevator is typically placed on the anterior (deep) surface of the femoral neck and Hohmann retractor is placed medially to view the calcar region then a box osteotome is used to create a lateral and slightly posterior entry point at the femoral neck the neutral axis of the femur

2 mm drill bit, approximately 2 cm apart. Alternatively, the sutures can be passed trans osseous by direct electrocauterization of the needle to facilitate its passage through the bone.

- A nonabsorbable suture is passed through the superolateral portion of the posterior capsular flap and the piriformis tendon. A second nonabsorbable suture is passed through the inferolateral portion of the capsule and the conjoint tendon (Ranawat et al. 2011; Sioen et al. 2002) (Fig. 1.15).
- The sutures are passed through the drill holes and tied with the leg in slight external rotation and neutral abduction to bring the femur close to the posterior structures and to take tension off the flap. The interval between the superior border of the piriformis and gluteus minimus is closed with absorbable sutures to complete the posterior soft tissue sleeve (Ranawat et al. 2011; Sioen et al. 2002) (Fig. 1.16).
- Capsular closure can also be achieved through direct capsule to capsule closure but this requires preservation of some anterior capsule at the time of capsulotomy. This closure has the benefit of being "tension free" that is less affected by the increased tension created with hip internal rotation and flexion.
- A drain is inserted deep before closure of fascia lata in order to drain the haematoma, decreasing its size and lowering the incidence of infection. Then,

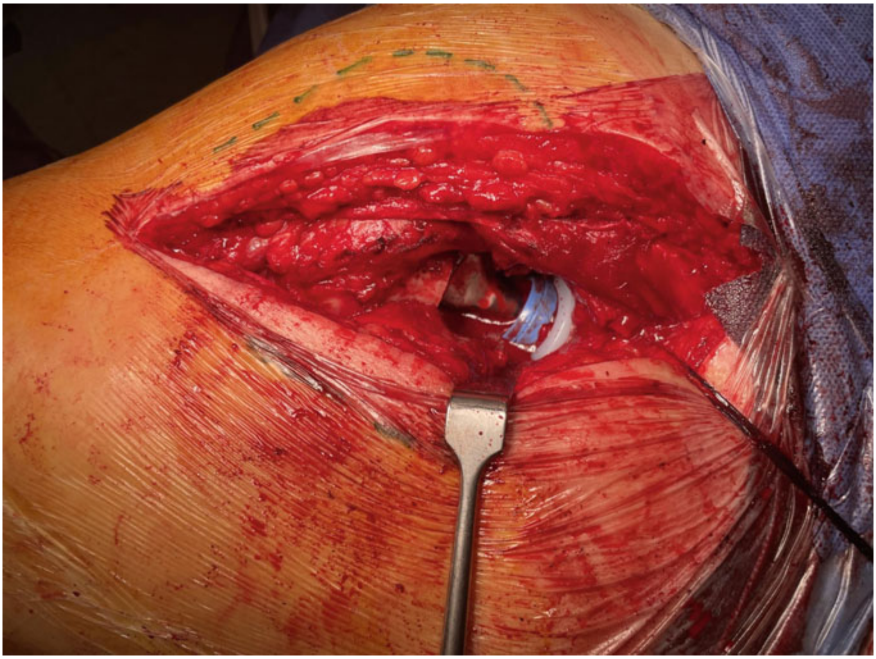

Fig. 1.14 The Coplanar test. It is used to check the combined anteversion of both acetabular and femoral components by putting the femur in slight abduction and from 30 to 45° of internal rotation

the fascia is securely closed with interrupted, continuous Vicryl sutures to attain a watertight closure.

- The remaining superficial soft tissues and subcutaneous layer are closed with either Vicryl or PDS sutures. A running Monocryl suture or staples are used to approximate the skin and sterile dressing is applied. An abduction pillow is applied and the patient is shifted securely to bed.
- The drains should be removed 24 h after the surgery, as they do not reduce the size of the haematoma after this period and can even increase the risk of infection (Drinkwater and Neil 1995; Sørensen Sørensen and 1991; Erceg and Becić 2008; Rowe et al. 1993).

1.6 Dangers and Complications

No agreement has been concluded on the ideal surgical approach for every patient. Although, the PA to the hip offers an adaptable option that can be utilized to handle most issues faced while performing primary and revision THA. Its ability to be freely transformed to an extensible exposure makes it a fundamental element of the armamentarium of any arthroplasty surgeon (Bryan et al. 2013).

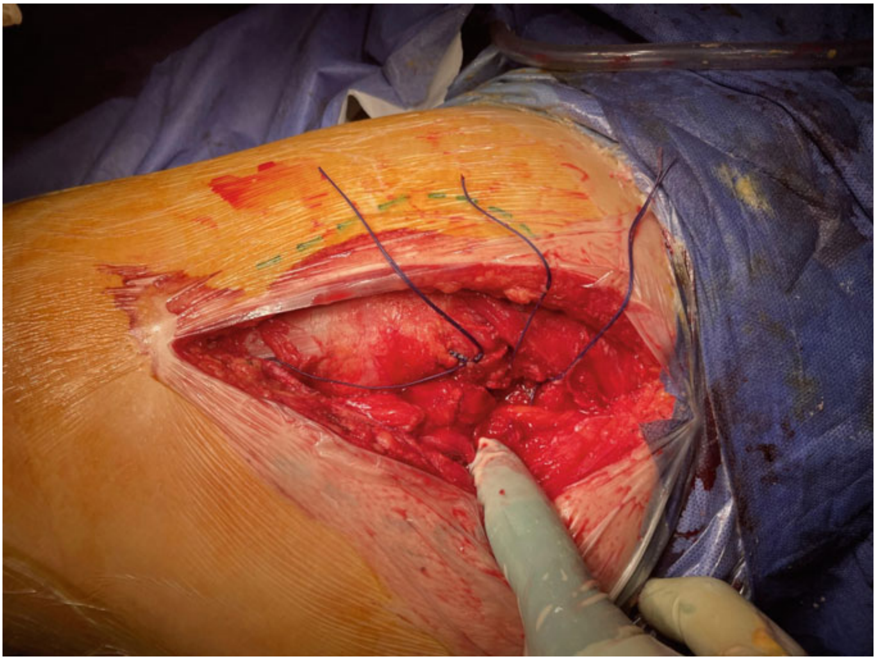

Fig. 1.15 The capsular flap, piriformis and conjoined tendon are repaired through bone tunnels within the trochanteric fossa with direct repair of quadratus femoris to its insertion

It is reported to be associated with a slightly lower risk of heterotopic ossification, abductor insufficiency, intraoperative femoral fracture, SGN palsy, and neurapraxia of the lateral femoral cutaneous nerve (LFCN) compared with the anterior or direct lateral approaches. On the other face of the coin, the PA is coupled with a slightly higher risk of dislocation and sciatic nerve injury in comparison with the anterior or direct lateral approaches (Hozack et al. 2018).

1.6.1 Nerve Injury

Nerve injury is a potentially disastrous complication. Nerve injury can occur under several circumstances, including direct trauma during dissection or placement of devices, such as wires or acetabular screws, retraction, thermal injury from methyl methacrylate, compression due to hematoma, leg lengthening and component positioning. The nerves at risk include LFCN, SGN, femoral nerve and sciatic nerve. Commonly injured nerve during PA is sciatic nerve and femoral nerve to less extent. Injury to the sciatic or femoral nerves causes the most dysfunction but are uncommon (Schmalzried et al. 1991).

Fig. 1.16 Final deep closure. The interval between the superior border of the piriformis and gluteus minimus is closed with absorbable sutures to complete the posterior soft tissue sleeve

Generally, the rate of sciatic nerve injury after THA is 0.1–1.7% (Schmalzried et al. 1991; DeHart and Riley 1999; Oldenburg and Müller 1997; Farrell et al. 2005). The risk of sciatic nerve injury has been shown to be significantly higher in PA versus other anteriorly or laterally based approaches, likely due to the nerve's proximity to the surgical field with this approach (Farrell et al. 2005). A thorough knowledge of the anatomic course of the sciatic nerve, careful posterior retractor placement, and minimizing undue stretch on the nerve (such as what occurs with excessive limb lengthening in THA or with the intraoperative position of flexion, internal rotation, and adduction during femoral preparation) will help minimize direct and indirect injury to the sciatic nerve. Careful placement of the anterior acetabular retractor; avoiding trapping soft tissue between the anterior retractor and the anterior wall will help to minimize femoral nerve injury (Foran and Valle 2015).

1.6.2 Instability and Dislocation

Hip instability and dislocation are common and potential complications occurring after THA through PA. Dislocation rates for the PA reported in the literature vary from 1 to 5.3% (White et al. 2001; Kwon et al. 2006; Chiu et al. 2000; Jolles and Bogoch

2006; Ho et al. 2012; Sierra et al. 2005; Goldstein et al. 2001). Although recent literature has demonstrated improved stability and decreased dislocation rates with careful reconstruction and repair of the posterior capsule and SERs utilizing several techniques (Kwon et al. 2006; Sierra et al. 2005; Pellicci et al. 2009; Tripuraneni et al. 2016; Kumar et al. 2014; Khan et al. 2007).

Randomized prospective data on dislocations is lacking, but several meta-analyses and large retrospective comparative studies have demonstrated stability superiority with the anterior based approaches versus PA (Kwon et al. 2006; Sheth et al. 2015; Berry et al. 2005; Higgins et al. 2015; Masonis and Bourne 2002; Tsukada and Wakui 2015). In addition, many variables other than surgical approach affect the rate of dislocation; these include patient factors, implant design and femoral head size. These variables make it difficult to ascertain the sole influence of approach on dislocation (Peters et al. 2007; Lachiewicz and Soileau 2006; Hedlundh et al. 1996; Berry 2001; Sanchez-Sotelo and Berry 2001).

Therefore, accurate selection of prosthesis, proper implantation technique with meticulous repair of the posterior structures are essential elements to reduce the dislocation rate.

1.6.3 Intraoperative Femoral Fractures

Intraoperative femoral fractures can be a catastrophic complication resulting in increased duration of surgery, difficult postoperative mobilization due to weight-bearing modifications, prolonged functional recovery and poor patient outcomes.

The incidence of femoral fractures associated with PA is very low. There is a paucity of literature examining the rate of intraoperative fracture risk with PA. For instance, Nakata et al. reported 1.0% of GT fractures with PA (Nakata et al. 2009). Additionally, in a direct comparative study conducted by Malek and his colleagues, a significantly more femoral fractures with direct anterior approach (DAA) (6%) over PA (0%) were demonstrated (Malek et al. 2016).

1.6.4 Infection

Infection is a rare but known complication following THA. Generally, multiple studies documented an incidence of 0.2%–1.2% after primary THA (Phillips et al. 2003; Pulido et al. 2008; Pugely et al. 2015). On the basis of literature, there are minimal data available directly comparing infection rates between the different approaches. Some retrospective studies found no significant difference in deep infection rates between the approaches. However, a recent study conducted by Christensen and his colleagues documented a greater number of wound complications with the DAA compared to PA (Malek et al. 2016; Namba et al. 2012; Christensen et al. 2014).

1.6.5 Muscle Damage and Abductor Dysfunction

Because PA is not a truly muscle sparing, one major concern often cited against is muscle damage. It requires the splitting and release of some muscles like gluteus maximus and SERs. A recent study conducted by Bergin and his colleagues supported this claim by reporting significantly higher levels of serum creatine kinase postoperatively in PA patients compared to DAA patients following the procedure as well as cumulatively 2 days after THA. The other acute phase reactants including; creatine kinase (CK), interleukin-6 (IL-6), tumor necrosis factor (TNF)-α and interleukin-1 (IL-1) did not change significantly between the groups (Bergin et al. 2011).

However, a cadaveric study by Meneghini and his colleagues compared the degree of muscle damage in PA and DAA and concluded that there is considerable damage to varying muscles surrounding the hip in both groups and no group was superior to another on gross analysis. This study quantified the visual evidence of muscle tearing, cut fibers, or maceration as a percentage of total muscle size (Meneghini et al. 2006).

Recently, a randomized controlled trial from China in 2017 have coupled the basic science and clinical findings when comparing PA and DAA regarding the degree of muscle damage (Zhao et al. 2017). This study measured laboratory values of inflammatory markers in addition to pain scores, functional scores, and hospital parameters such as length of hospital stay. They reported much muscle damage in PA as measured by inflammatory marker on postoperative days 1–4 and higher pain scores at 72 h. Although, at mid-term, there was no significant difference between both groups when looking at 6-month Harris hip scores and University of California, Los Angeles (UCLA) activity scores.

Finally, a major superiority of PA is the preservation of abductor mechanism. As, any abductor dysfunction can lead to pain, prolonged rehabilitation, postoperative limp, Trendelenburg gait and patient dissatisfaction following THA. This approach stays posterior to and thus preserves the abductor muscles. Multiple studies have reported improved abductor muscle strength with less limping during the initial postoperative period with the PA in comparison with anterolaterally based approaches (Mihalko and Whiteside 2004; Downing et al. 2001).

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Chapter 2
Southern Posterior Approach of the Hip

Kemal Şibar and Alper Öztürk

A similar version [Southern Approach] of the Posterior Approach has also been written by Kemal Şibar and Alper Öztürk Ankara Training and Research Hospital and Ankara Etlik City Hospital, Turkey.

The Southern Posterior Approach of the Hip.

2.1 Introduction

Approaches to the hip joint can be broadly classified as anterior, anterolateral, lateral, medial, anteromedial, posterolateral or posterior depending on their location at the hip joint (Calandruccio 1992). The most reported approaches to the hip joint in arthroplasty are the posterior and the lateral ones (Chechik et al. 2013). The posterior approach is the most common and practical of those used to expose the hip joint. It was first described by von Langenbeck (1874) in 1874 and popularized by Moore (1959), it is often called the Southern approach.

Each approaches have unique advantages as well as disadvantages. With the posterior approach, fast, easy and safe access to the hip joint is provided. However, posterior approach has been shown to be associated with higher dislocation rates than others (Lindgren et al. 2012). Recent repaired, dislocation rates drop down (Kwon et al. 2006).

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2.2 Technique

The patient is placed in the true lateral position with the affected hip uppermost. It is very important that the pelvis is in a neutral position (Fig. 2.1). Incorrect positioning of the pelvis may result in improper application of the acetabular component. It is important to protect all bony prominences of the lower extremities (lateral malleolus, proximal fibula, greater trochanter) with pads to avoid possible skin problems and nerve palsies.

With the hip flexed 90°, a straight incision is made over the posterior aspect of the greater trochanter. The greater trochanter should remain at the proximal 1/3 point of the incision (Fig. 2.2). After the skin incision, superficial tissues dissected till reaching fascia lata. Subcutaneous vessels should be cauterized at this stage. After that, the fascia is incised on the lateral aspect of the femur to uncover the vastus lateralis. The fascial incision is than lengthened proximal in line with the skin incision by splitting the fibers of the gluteus maximus via blunt dissection. Thus, providing adequate access to the acetabulum and proximal femur. Blunt dissection should be performed gently. In this way, the crossed arteries and veins can be found and cauterized before they avulsed.

Two retractors are used at the incision beneath the fascia lata with one on the posterior flap and then the other one on anterior flap. Then, the trochanteric bursa appears. The bursa can be excised or, as far as possible, cut from the anterior and taken between the sciatic nerve and the posterior retractor. Underneath is the posterolateral of the hip joint and femur. It should be remembered that the sciatic nerve leaves the pelvis through the greater sciatic notch and proceeds through the short external

Fig. 2.1 Patient positioning for posterior hip approach

Fig. 2.2 Hip position and the skin incision

rotator muscles. The sciatic nerve can be easily noticed on the short rotator muscles. Care should be taken when using the posterior retractor to avoid possible sciatic nerve injury.

The affected limb is taken to internal rotation, increasing the tension of the short rotator muscles and providing a surgical working area further away from the sciatic nerve. The gluteus medius, piriformis and remaining short rotator muscles are identified (Fig. 2.3). The piriformis muscle is identified as a hard, band-like structure attached to piriformis fossa at the proximal part of the greater trochanter. Stay sutures could be inserted into the piriformis (and, if possible, other short rotator muscles) just before the attachment point at the greater trochanter. Then, the short rotator muscles are detached from their insertion and the capsule is exposed (In some cases the proximal part of the quadratus femoris may rarely need to be split to fully reveal the posterior aspect of the joint capsule). The capsule can be incised longitudinally, H-shaped or T-shaped, depending on the surgeon's preference. Hip joint dislocation

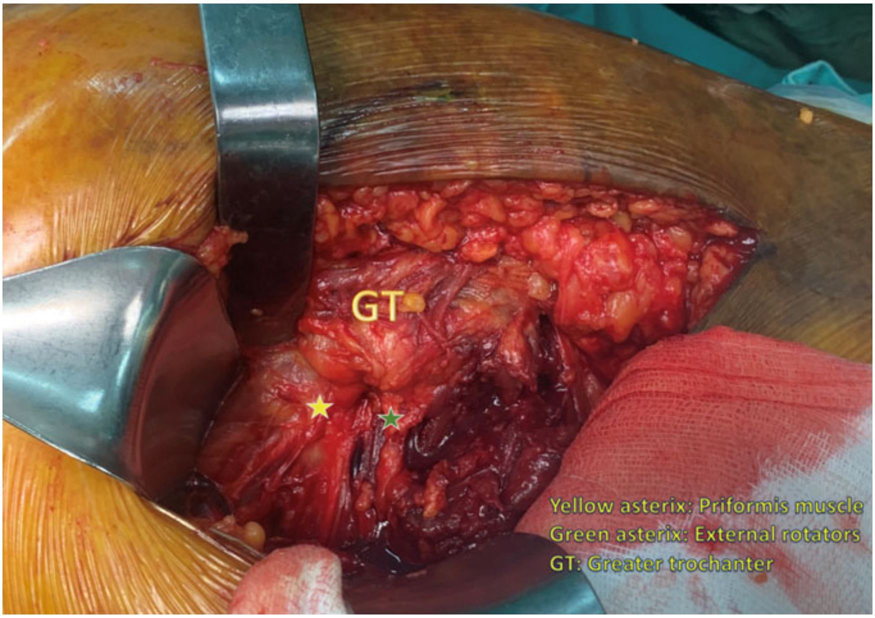

Fig. 2.3 External rotator muscles identified in posterior hip approach

following the capsule incision is achieved by flexion and internal rotation. Femoral head and neck exposed.

2.3 Closure

After hemostasis is achieved, irrigation with a povidone iodine solution and saline solution is performed for 5 min. Strong evidence supports the use of a periarticular injection with a long-acting local anesthetic and corticosteroid to reduce postoperative pain and opioid consumption (Hannon et al. 2022). An extended posterior soft tissue repair is performed. The short rotator muscles and posterior capsule are repaired to the trochanteric fossa, very close to their insertion, through two drill holes approximately 2–3 cm apart. A nonabsorbable suture is passed through the superolateral portion of the posterior capsular flap and the piriformis tendon. A second nonabsorbable suture is passed through the inferolateral portion of the capsule and the other short rotators. The sutures are passed through the drill holes and tied with the leg in slight external rotation and neutral abduction to bring the femur close to the posterior structures and to take tension off the flap. The interval between the superior border of the piriformis and gluteus minimus is closed with absorbable sutures to complete the posterior soft tissue sleeve. A drain is inserted deep before closure of fascia lata in order to drain the hematoma, decreasing its size and lowering the incidence of infection. Then, the fascia is securely closed with interrupted, continuous absorbable sutures to attain a watertight closure. The remaining deep and superficial soft tissues are closed with either Vicryl or PDS sutures. A running Monocryl suture or staples are used to approximate the skin and sterile dressing is applied.

2.4 Dangers and Complications

Instability following total hip replacement is one of the most common complications for the revision surgery. It's reported to be 0.2–7% for primary hip replacements (Patel and Potts 2007). Although the dislocation rates after posterior approach reported to be higher when compared to the anterior approach (Miller et al. 2018), many authors reported similar dislocation rates by repairing the joint capsule and external rotators after posterior hip approach (Kim et al. 2008). Heterotrophic ossification is another complication following posterior hip approach, and higher rates of heterotrophic ossification is reported when compared with anterior hip approach (Newman et al. 2016). Prophylaxis for heterotrophic ossification via radiotherapy or indomethacin is recommended for patients undergoing hip surgery through posterior approach. Other dangers related to this approach can be listed as, sciatic nerve injury, superior–inferior gluteal artery injury and injury to the femoral vessels.

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Von Langenbeck B. Ueber die Schussverletzungen des Huftgelenks. Archi Klin Chir. 1874;16:263–339.

Chapter 3
Direct Anterior Approach to the Hip Joint

John O'Donnell

However there are a few limitations of Anterior hip replacement as follows: (1) Obese or very muscular people. (2) It is a technically demanding surgery with a steep learning curve for this procedure and (3) The anterior incision provides a restricted view of the hip joint, making it a technically demanding procedure.

There are certain disadvantages of Anterior Hip Replacement: such as (1) Potential risk of nerve injury such as lateral cutaneous femoral nerve. (2) There may be wound healing issues usually mild and self-limiting.

The direct Anterior Approach can be performed in one the following ways: such as (1) DAA using a fracture table or (2) DAA using a leg positioner-ARCH Leg Positioning System: Straightforward Alternative to Specialized Surgical Tables-the ARCH system is a free-standing unit that is compatible with any standard OR table and is easily transported for use in multiple operating rooms.

These specialized tables, while useful for many, can have some disadvantages such as: (a) These tables are expensive. (b) These tables also require a trained assistant to manipulate the leg rather than leaving the control of the limb in the hands of the surgeon. (c) They exert tremendous forces and may even cause trochanteric fractures or rarely ankle fractures or traction nerve palsies because of them and (d) The size of the table may be large to fit into a regular operating room.

The use of a regular operating room table for the direct anterior approach has certain advantages as below:

(a) It requires no additional equipment and may be performed in any size operating room. (b) It allows easy patient positioning and permits simultaneous bilateral procedures. (c) Direct comparison of leg lengths and range of motion/stability assessment are easily performed since the limb is draped free. (d) The surgeon maintains control

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GRUNDRISS
DER
CHIRURGIE
VON
DR. C. HUETER,

Zweite sorgfältig durchgesehene Auflage
VON
PROF. DR. HERMANN LOSSEN

II. BAND.
SPECIELLER THEIL.
ERSTE ABTHEILUNG.
Die chirurgischen Krankheiten des Kopfes.
MIT 108 ABBILDUNGEN.

LEIPZIG,
VERLAG VON F. C. W. VOGEL.
1883.

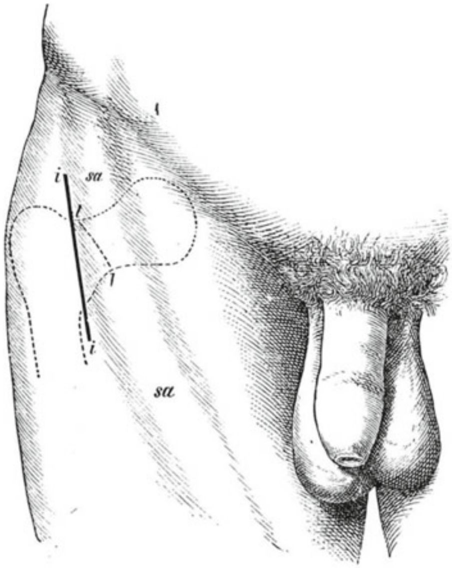

Fig. 3.1 Hueter's original publication ("Courtesy of Medacta"). [Courtesy: Fig reproduced with the kind permission of Jenny Stanford Publishing after it had been published in Hip Joint in Adults Advances and Developments by Pan Stanford Publishing which has been renamed as Jenny Stanford Publishing from 1st April 2019 onwards]

of the limb making iatrogenic fracture less likely. (e) The table is positioned with the base of the table toward anesthesia and the head of the bed moved to the foot. (f) It permits enough room for fluoroscopy and positions the patient so that the break in the table can facilitate extension of the hip and (g) The patient is positioned so that the gluteal fold is at the break in the table, which is then used as a fulcrum to elevate the femur.

The direct anterior approach to the hip joint was first described in *Der Grundriss der Chirurgie* (*The Compendium of Surgery*) in 1883 by German surgeon Dr Carl Hueter (Hueter 1883). The approach is through the interval between the sartorius and rectus femoris anteriorly and the tensor fascia lata (TFL) (Fig. 3.1).

The approach is through the interval between the Sartorius and Rectus femoris anteriorly, and the Tensor Fascia Lata posteriorly. It is the only commonly used approach which is both intermuscular and internervous (Fig. 3.2).

It was originally described for resection arthroplasty of the hip.

The approach was developed and enlarged by Marius Smith-Petersen, a Norwegian-American, in 1917, and is often still referred to as a Smith Petersen approach in the English speaking world (Smith-Petersen 1917). He used the approach to treat many hip conditions, including hip impingement. He also used the approach for the first hip arthroplasties- the Vitallium-mold arthroplasty.

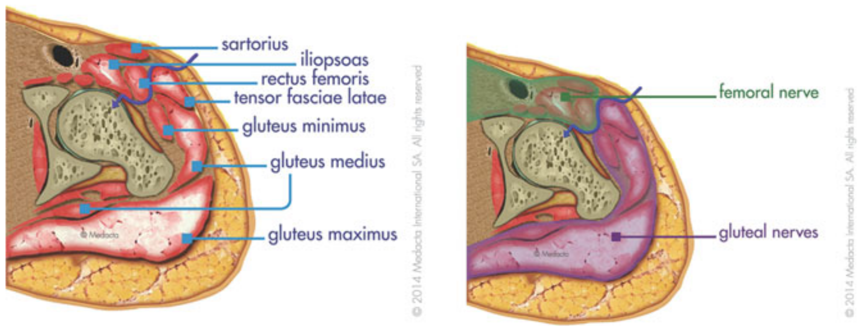

Fig. 3.2 The approach is both intermuscular and interneural ("Courtesy of Medacta"). The blue line is the line of the approach, passing between the Rectus femoris and Sartorius, innervated by the Femoral nerve, and the TFL and Gluteal muscles, innervated by the Gluteal nerves. [Courtesy: Fig reproduced with the kind permission of Jenny Stanford Publishing after it had been published in Hip Joint in Adults Advances and Developments by Pan Stanford Publishing which has been renamed as Jenny Stanford Publishing from 1st April 2019 onwards]

The same approach was used by the Judet brothers in France in 1950 for hip hemiarthroplasty (Judet and Judet 1950), and later total hip replacement, and Wagner in Germany for resurfacing.

However, its popularity went into temporary decline following on from the work of Charnley.

The technique of the Judet brothers utilised a modified traction table. Today many surgeons continue to use a leg positioner, but others have modified the technique so that the surgery is performed on a standard operating table.

Our Technique of Direct Anterior Approach THR using a leg holder.

This operation is very much easier if performed with instruments which are made specifically for the direct anterior approach. They will include appropriate retractors and offset acetabular reamers and femoral broaches.

We use a combined spinal anaesthetic and general anaesthetic, which allows excellent operating conditions, minimises the risk of DVT, and aids post anaesthetic recovery.

We use pre-operative skin washes, and pre-, and post-operative antibiotics (a total of 3 doses) to minimise infection risk.

DVT prophylaxis typically consists of the use of an intra-operative pneumatic foot pump on the non-operated leg, and post-operative bilateral foot pumps for the first night. We use aspirin, but only use anticoagulants in higher risk patients. Patients commence early mobilisation as soon as the spinal anaesthetic effect has ceased.

All patients receive Non-Steroidal Anti-inflammatory medication for prophylaxis against heterotopic bone formation, unless there is a contra-indication.

Fig. 3.3 Patient positioned for right total hip replacement ("Courtesy of Medacta"). [Courtesy: Fig reproduced with the kind permission of Jenny Stanford Publishing after it had been published in Hip Joint in Adults Advances and Developments by Pan Stanford Publishing which has been renamed as Jenny Stanford Publishing from 1st April 2019 onwards]

The patient is positioned supine as shown (Fig. 3.3). Care is taken to pad the foot on the operated leg. The non-operated leg lies free. The leg holder is not critical, but it allows improved hip extension, rotation control, and mild traction, which all make the operation easier.

The operation is then carried through all the routine steps till the end when a Charnley curette to first pass along the calcar and enter the femoral canal. The curved, blunt end minimises any risk of femoral perforation. Standard femoral broaching is then undertaken.

Additional soft tissue local anaesthetic injections can be performed at this stage.

After insertion of either trial components, or the actual prosthesis, standard methods are used to check leg length and hip stability (Fig. 3.4).

We have found the Anterior Approach to the hip provides excellent access to the hip, and allows early patient mobilisation with great safety, and it is extremely well accepted by patients. It can be readily extended, and is suitable for both primary, and revision hip replacements.

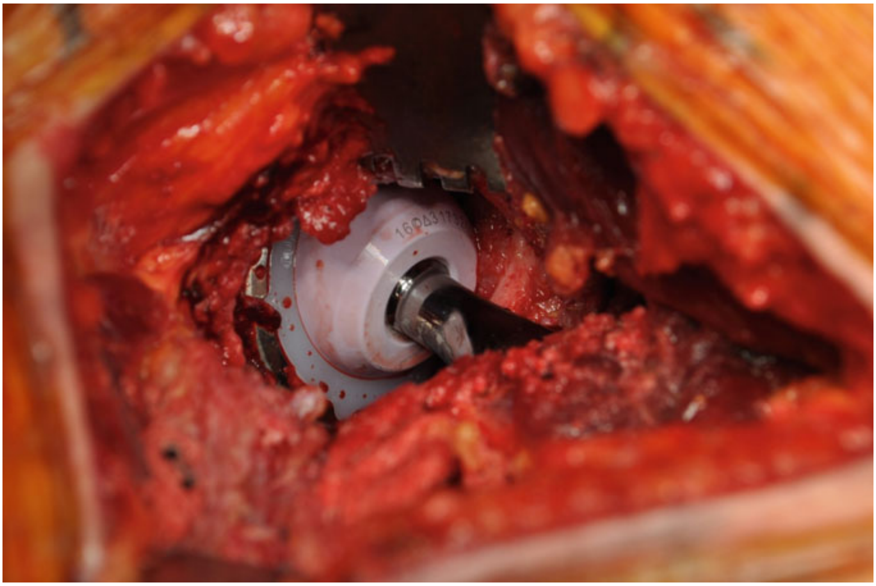

Fig. 3.4 All components in place("Courtesy of Medacta"). [Courtesy: Fig reproduced with the kind permission of Jenny Stanford Publishing after it had been published in Hip Joint in Adults Advances and Developments by Pan Stanford Publishing which has been renamed as Jenny Stanford Publishing from 1st April 2019 onwards]

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Chapter 4
Principles of the Anterior Approach for Total Hip Arthroplasty

Alessandro Geraci

Hip prosthetic surgery today offers solutions aimed at saving the bone patrimomy and respecting muscles and tendons in order to reduce complications and reduce recovery times. The goal of hip replacement surgery is to eliminate the pain often caused by a degenerative disease such as arthrosis, restore good range of motion and allow the patient to carry out his/her daily activities in the gradual functional recovery. The anterior approach to the hip uses two internal nervous planes: superficial and deep. The deep plane passes between the rectus femoris and the tensor of the fascia lata and the gluteus medius. The anterior approach to the hip is a way that uses the anterior region of the hip to be able to attack the joint. The real counter-indication to this technique is a major deformity of the patient's acetabulum or femoral neck, which can make it difficult to manoeuvre the limb during surgery.

The goal of hip replacement surgery is to eliminate the pain often caused by a degenerative disease such as arthrosis, restore good range of motion and allow the patient to carry out their daily activities in the gradual functional recovery.

The anterior approach route, in association with dedicated instruments, allows hip replacement with a minimally invasive approach, opening and not removing the muscle fibers. The anterior approach was first described in 1881 by Huetor (1883) who was a German Surgeon and an assistant to Langebeck. There after in 1917, Marius N Smith-Peterson wrote this in JBJS as Smith-Peterson access (Smith-Petersen 1917). Peterson and Judet used the approach for surgical access to Hip Replacement (Judet and Judet 1950). Judet in 1980s improved upon this access by developing a traction bed which helped in moving the lower limb during surgery (Judet and Judet 1985). Thereafter Matta et al. (2005), Laude (2006), and Moreau

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(2018) pecfected this to make it less difficult and invasive. The main landmark is the anterior superior ilac spine which was desxribed by Lesur and Laude (2004).

4.1 Surgical Technique

The anterior approach to the hip uses two internal nervous planes: superficial and deep. The more superficial plan does located between the sartorius muscle (innervated by the Femoral nerve), placed medially, and the tensor muscle of the fascia lata (pertaining to the Gluteus Superior nerve), placed laterally. The deep plane passes between the rectus femoris (Femoral nerve) and the tensor of the fascia lata and the gluteus medius (Superior Gluteus Nerve).

The anterior approach to the hip is a way that uses the anterior region of the hip because it is an easily accessible bony landmark. The anterior region of the hip is low in fat, which facilitates the surgical approach. The surgeon using postero-lateral or direct lateral approach to the hip encounters considerable fat in obese subjects, making surgical maneuvers more difficult Fig. 4.1.

The patient is positioned supine on the table surgery (Figs. 4.2, 4.3 and 4.4).

The femoral preparation is carried out by the use of the traction table. To facilitate this surgical approach, dedicated surgical instruments are used which improve the working of the femur and the acetabulum, like curved femoral broach handles and curved acetabular reamers (Fig. 4.5).

Fig. 4.1 The obese subject has no fat in the anterior region of the hip. [Courtesy:fig reproduced with kind permission from Alessandro Geraci]

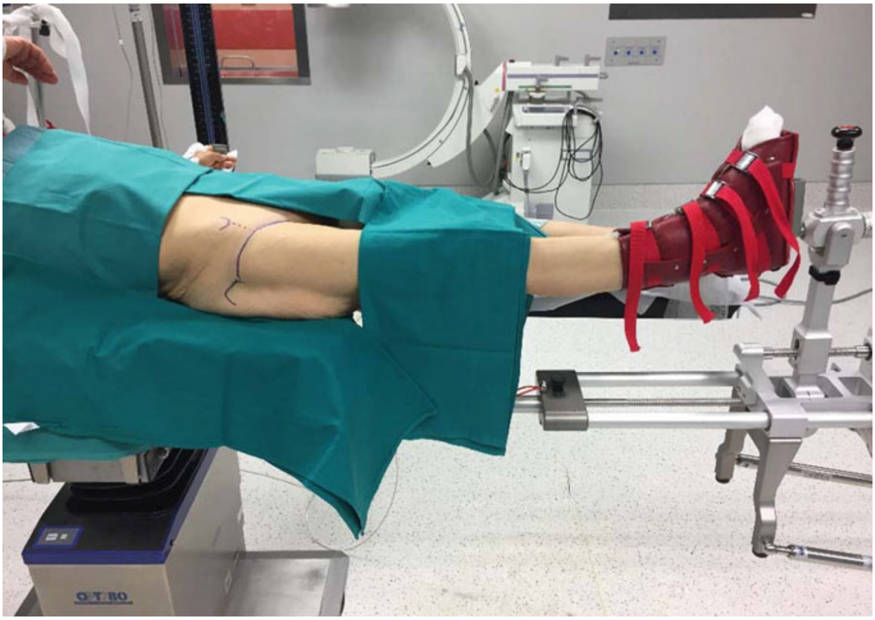

Fig. 4.2 An operating table with dedicated traction for the anterior approach to the hip. [fig reproduced with kind permission from Alessandro Geraci]

The advantage of the anterior approach is that the normal gait is not dependent on tendon healing, since no tendons have been removed and repaired, as they have in the direct lateral approach and posterolateral approach. This is not a particular technique but a ‘surgical philosophy’, consisting in a maximum respect for soft tissues and bone, including reduction of operative invasiveness and the use of minimally invasive surgical solutions.

I had done a few cases in Hemiarthroplasty only [without using a fracture table] in selective patients which is not ideal and enough to write this chapter which has a *difficult learning curve* and *specialised surgical skills* with *special instruments* including a special operation table for this type of Surgery.

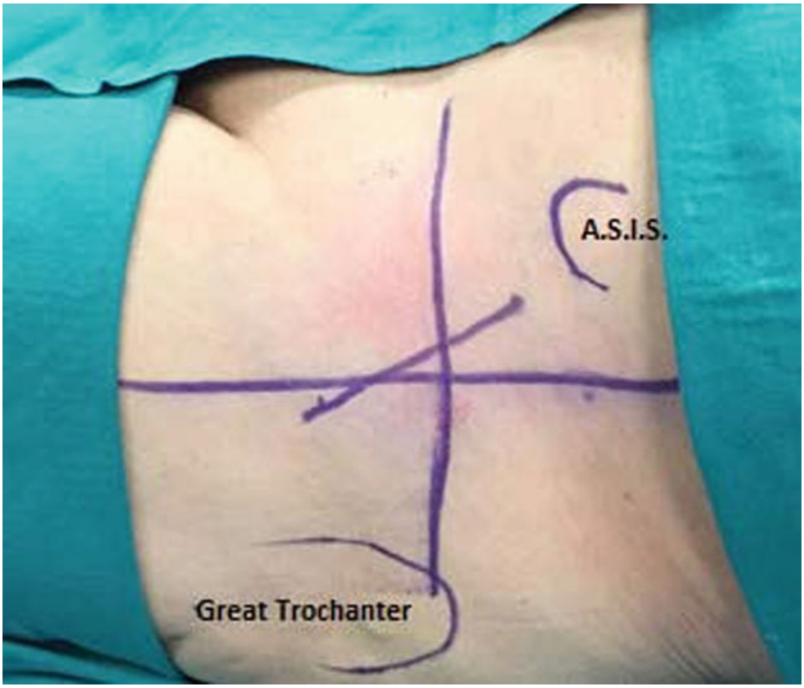

Fig. 4.3 The important points of the iliac crest, greater trochanter, and the anterior superior iliac spine are first marked. The skin incision begins 2 cm distal and 2 cm lateral compared to the superior anterior iliac spine and extends lengthwise for about 7 cm pointing to the fibular head. [fig reproduced with kind permission from Alessandro Geraci]

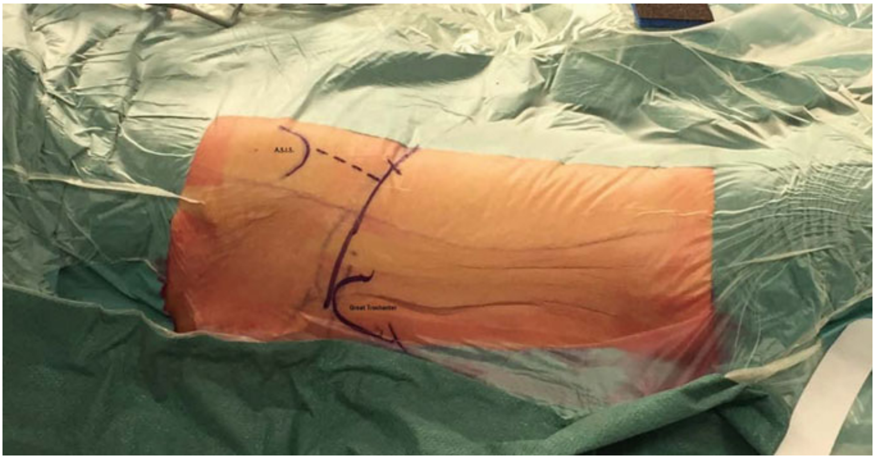

Fig. 4.4 The "bikini" variant described by Leunig et al. (2018), has the incision at the level of the inguinal skin fold, groove highlighted flexing the hip, and extends two-thirds laterally e for one third medial to the anterior iliac spine upper with oblique course. [Courtesy:fig reproduced with kind permission from Alessandro Geraci]

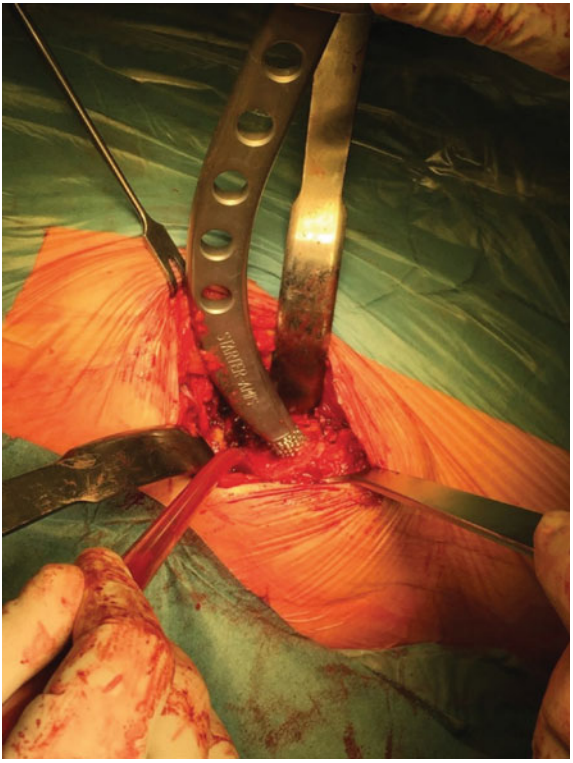

Fig. 4.5 Curved femoral broach handles. [Courtesy:fig reproduced with kind permission from Alessandro Geraci]

4.2 Conclusion

1. The anterior approach has a slight advantage when it comes to early recovery and degree of muscle damage.
2. Infection is a problem with all approaches, but wound complications are most troublesome with the anterior approach.
3. The classic postero lateral or direct lateral approach to the hip in addition to being violent for the tissues around the hip joint, can encounter a significant adipose tissue which makes the surgical process more difficult and/or slow.
4. Overall, it can be said that each approach has its advantages and disadvantages. In line with this, the American Academy of Orthopaedic Surgeons (AAOS) guidelines state that there are no clinically significant differences related to surgical approach for patients undergoing primary total hip replacement.
5. In the end, a surgeon's skill and experience are by far the most important factors.

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Chapter 5
Anterior Minimally Invasive Surgery

Hiran Amarasekera and Dakshini Egodawatte

Abstract Total hip arthroplasty has been one of the most successful orthopaedic procedures over the past 30 years. Currently, several surgical approaches for hip arthroplasty have been defined; these include the anterior, the lateral and the postero-lateral approaches. In literature the advantages and disadvantages of each surgical approach have been documented and which approach will be chosen depends on the experience of the surgeon. This chapter will focus on anterior minimally invasive surgery (AMIS). This surgical approach follows an inter-muscular and inter-nervous plane to reduce the risk of injury to muscles, tendons, vessels, and nerves. This review will discuss the history, technique, tricks and pitfalls of AMIS procedure that reduces anatomical invasiveness and blood loss and speeds up the functional recovery of the patient.

Keywords Hip replacement · AMIS · Anterior approach · Minimally invasive hip surgery · Hip preservation surgery

5.1 Introduction

5.1.1 Background

The hip joint a ball and socket joint covered by strong muscles is situated deeply in pelvis and can be approached almost in any direction (Figs. 5.1 and 5.2; Amarasekera 2013).

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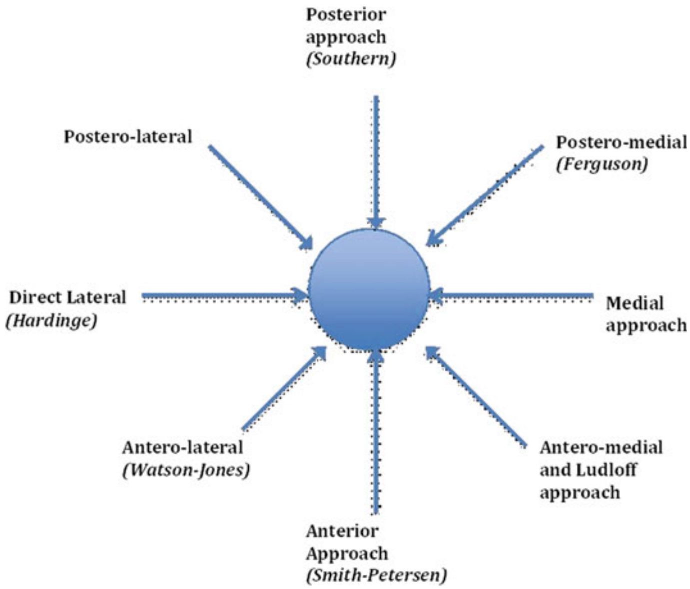


Fig. 5.1 Different approaches to the hip (Hunter 1986)

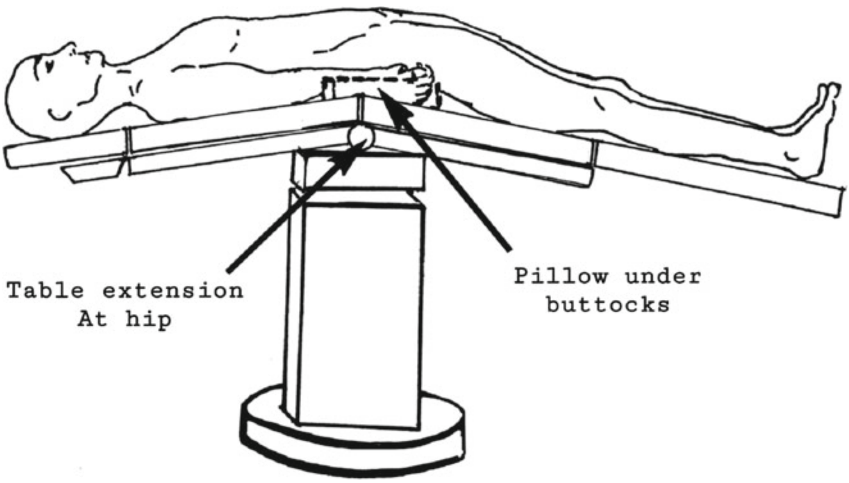


Fig. 5.2 Table and supine position with sand bag under operating side buttock

However out of the many approached described commonest used approaches for arthroplasty has been posterior (Hunter 1986), antero-lateral (Watson-Jones 1936) and anterior approaches (Smith-Petersen 1949). Different approaches have been popular during different times in history of orthopaedics depending on instrumentations, implants, surgeon's preference and training and patients active life styles, early return to working and need to achieve high range of motion with minimal risk of dislocation.

5.1.2 History

Hueter initially described the direct anterior approach in 1881 (Rachbauer et al. 2009) describing the Hueter as a key landmark in the approach. It was later popularized by Smith-Peterson in 1917 (Smith-Petersen 1917) in early 50s direct anterior approach (DAA) was a popular mode for hip arthroplasty. In 1950 two French surgeons Judet and Judet reported this as a successful approach for hip replacement (Judet and Judet 1950) and later O'Brien published case series of total hip arthroplasty done via the anterior approach (O'Brien 1955). However with the introduction of Charnley's low friction arthroplasty in late 50 the this approach fell out of favour among the orthopaedic surgeons giving way for the posterior approach to come in to vogue (Charnley 1970; Charnley 1970; Charnley and Cupic 1973).

Through out this approach has been popular for other surgeries mainly for paediatric hip surgery such as developmental dysplasia, hip biopsy, and drainage of septic arthritis.

5.1.3 Resurgence of the Approach

With increasing life expectancy, ageing population, increase demand for physical activity and early return to work more and more surgeons have planned minimally invasive approaches to the hip. With a clear inter nervous plane without any requirement for muscle detachment stability being maintained with minimal dislocation rates (Tsukada and Wakui 2015; Sariali et al. 2008) and new instrumentation and devices being developed minimally invasive direct anterior approach has gained popularity among the arthroplasty surgeon since the last few decades. Interests appear to be rapidly growing and gaining increasing popularity among arthroplasty surgeons with modern concepts of hip preservation, minimally invasive hip surgery, hip resurfacing, in a population with a high active life style, demanding early return to work or sports activities.

5.1.4 Key Advantages and Disadvantages of the Approach

The key advantages of the approach include the ability to directly access the hip through the true internervous planes with minimal on no muscle dissection leading to early recovery and higher functional rates. The approach also preserves the blood flow to the hip joint as the posterior structures are not damaged thus making this a popular approach in hip preservation surgery and surface replacement of hip joint (Amarasekera 2012) However the steep learning curve, poor cosmetic scar, lack of specialised instrumentation made the approach less preferred by orthopaedic surgeons in last few decades. At present these issues have been addressed with specific training courses, cadaveric run in cadaveric skills labs and development of specific instruments (Paillard 2007; Oinuma et al. 2007).

5.2 The Approach

5.2.1 Indications and Contraindications

Given the proper training and after gaining experience with the use of the correct instrumentation and selecting the ideal patient most hip surgeries can be performed through most approaches. In modern day practice indications key indications for the approach in modern day practice still remain to be most paediatric surgeries, hip preservation surgery, surgical dislocation of the hip, open osteo-chondroplasty, arthrotomy for drainage or biopsy, total hip replacement and in experiences centres revision hip arthroplasty (Nogler et al. 2012).

However contraindications and caution when selecting the patients and surgeries remain. Obesity a BMI > 40 are a contra indication as it increases wound infection, rates.

5.2.2 Anatomy

The approach uses the Hueter interval (Figs. 5.3 and 5.4).

The skin incisuion is between Tensor fascia latae and sartorius. Key anatomical landmark is the anterior superior iliac spine (ASIS) felt as a bony prominence at the anterior most point of iliac crest. The sartorius and the inguinal ligament originate from here. Tensor facia latae (TFL) originates just below and lateral to ASIS along with the gluteus medius. The femoral vessels and nerve are medial to sartorius a key point to remember that too medial dissection will put these structures at risk. Lateral cutaneous nerve of the thigh (LCNT) begins from the lower end of lumbar plexus emerging laterally to the psoas major and crossing the illiacus. Then it runs near the ASIS running laterally through the muscular lacuna under the inguinal ligament crossing over the sartorius and enters the thigh. The nerve divides to anterior and posterior branches and supplies the skin over the antero lateral part of the thigh and the skin over the gluteal region.

The rectus femoris muscle originates from two heads, the straight head from the anterior inferior iliac spine and the reflected head from the anterior lip of acetabular and the hip joint capsule.

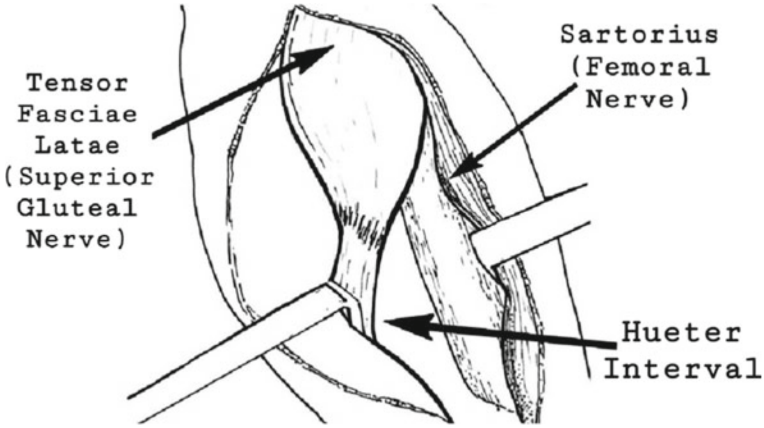
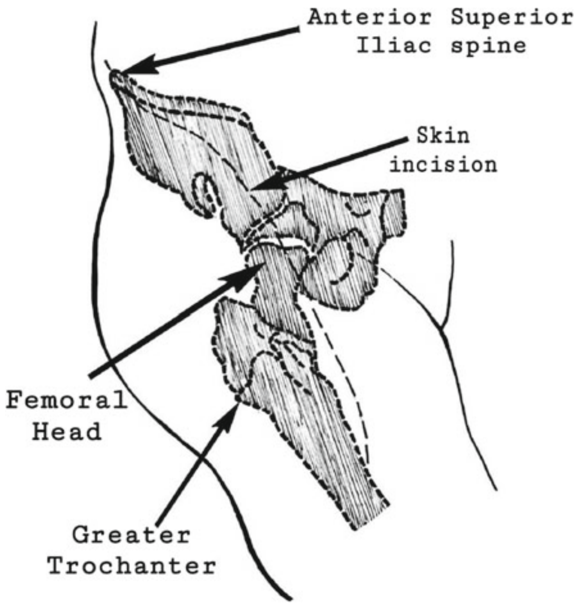


Fig. 5.3 Superficial dissection showing the Hueter interval

Fig. 5.4 Skin incision: note the traditional incision runs from 2-cm inferior and posterior to ASIS



Gluteus medius originates from the gluteal surface of ilium runs antero medially and inserts to the oblique ridge on the lateral surface of greater trochanter. This along with gluteus minimus forms the abductor complex. The approach uses internervous muscle plane between superior gluteal nerve and the femoral nerve. (Figs. 5.5 and 5.6).

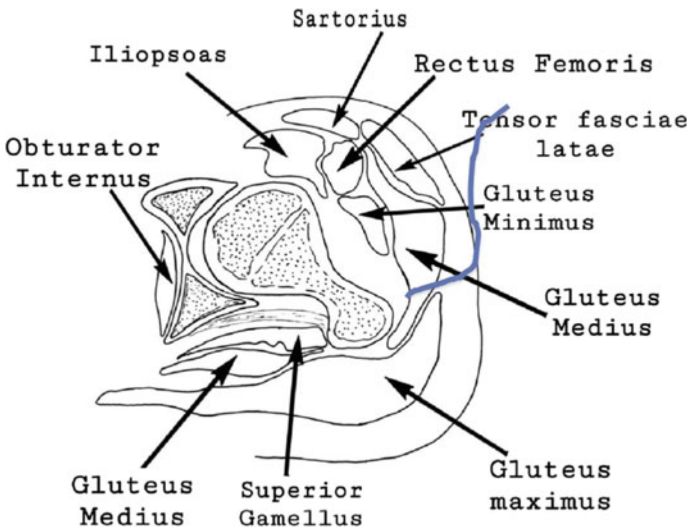


Fig. 5.5 Deep dissection showing clear inter nervous plane

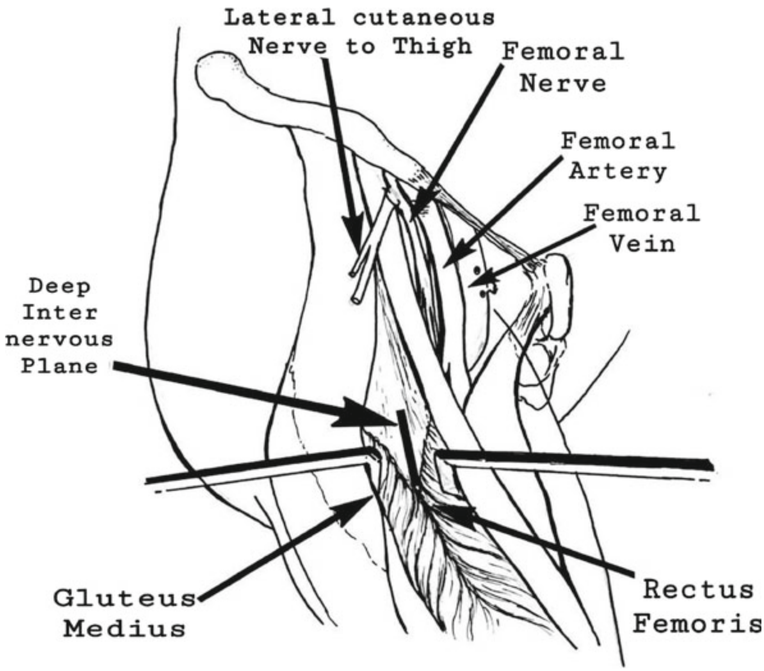


Fig. 5.6 Transverse section of the thigh (dissection and tissue planes marked in blue)

5.2.3 *The Traditional Approach*

1. Position: The patient is placed in the supine position with a sand bag placed under the buttock of the operating side as it helps to identify the muscle planes easily.
2. Incision: The incision lies along a line drawn along the anterior half of the iliac crest towards ASIS and curving downwards in a slight lateral direction heading towards the outer border of the patella.
3. Approach: Initially the gap between the tensor fascia late and sartorius is identified facilitated by external rotation of the limb, which tenses the muscles. Care should be given to protect the LCNT that passes across sartorius. Once retractors are placed deep dissection is done medially to TFL identifying the rectus femoris in the deep layer. Lateral margin of the rectus femoris identified and an interval between it and the gluteus medius is developed. Rectus femoris can be detached from the origin if needed. The retractors are gently placed between the muscles taking care not to damage the femoral neurovascular bundle. The joint capsule is seen through this interval.
4. Muscle planes Inter nervous plane: Both in superficial and deep layers the inter-nervous plane lies between the femoral and the superior gluteal nerves. Superficially medially bound by the sartorius (femoral nerve) and laterally bound by TFL (superior gluteal nerve) and deep layer medially bound by rectus femoris (femoral nerve) and laterally gluteus medius (Superior gluteal nerve), this is considered a true inter nervous plane.
5. Capsule Arthrotomy: Depending on the surgery the capsular arthrotomy can be done as a straight line, vertical, triangular or any preferred way (Fig. 5.7).

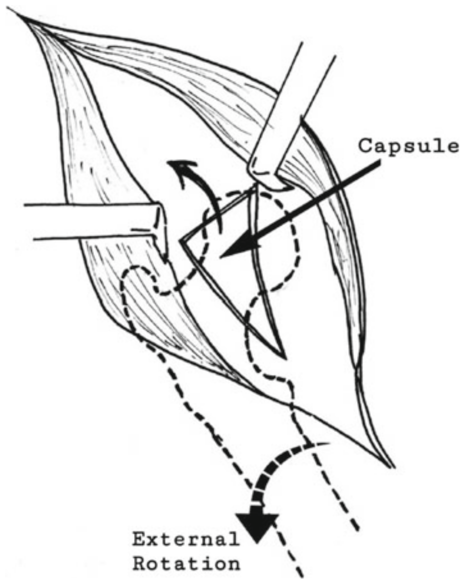


Fig. 5.7 Capsulotomy and dislocation of head

6. Dislocation: The head is dislocated by gentle traction, external rotation and adduction and external rotation.
7. Surgical procedures: Once the hip is approached many surgical procedures can be carried out, arthrotomy, drainage, surgical dislocation, and preservation surgeries such as osteo-chondroplasty, biopsy, Paediatric surgery such as DDH, osteotomies, combine pelvic and acetabular procedures, Total, partial or surface hip replacements few of the common and popular procedures done through this approach.
8. Closure: The tissue planes are closed in layers as there are no tendons or muscles re attachment needed.

5.2.4 Modifications, New Instrumentations and Minimally Access Approach (Rachbauer 2006)

1. Incision: Modern operating tables can be extended at the mid trunk level to enhance the position created by a sand bag placed under the buttocks. Some surgeons prefer to use both as it gives better presentation of the capsule anteriorly.
2. Approach: The mini incision anterior approach or the minimally invasive approach utilizes small 6–7 cm incision starts 2 cm posterior and 2 cm inferior to ASIS running around 2 cm below the greater trochanter (Rachbauer and Krismer 2008).
3. Muscle planes Internervous plane: These are respected as per the traditional approach.
4. Capsule Arthrotomy: This remains a surgeon's preference decided based on the procedure itself.
5. Closure: Stepwise layers of closure are advocated with function and cosmesis kept in mind.

5.2.5 Rehabilitation Protocol

As in all approaches rehabilitation plays a key role in early recovery early return to work and early return to sport. Functional recovery is believed to be faster than in any Approach (Rodriguez et al. 2014; Zhang et al. 2018) and development of a standard protocol for rehab is s mandatory. Even though these may change from institution to institution or surgeon to-surgeon, and the surgical procedure, by and large the principles remain the same. Basic principle in rehabilitation following THR through anterior approach is outlined below.

Once the general recovery following surgery is passed the patients are put on full weight bearing mobilization ideally from day 1.

ROM (range of motion exercises) gait training, day to day activities such as walking, climbing stairs, are achieved within first three days and the patient is discharged. Within the 0–2 weeks gait training, quadriceps and muscle strengthening and core strengthening exercises are started.

3–6 weeks further ROM muscle strengthening including abductors adductors and core body workouts are developed. Patients can return to work within 2–4 weeks depending on the work.

From 7 to 12 weeks further gait training is continued within specific concentration of muscle groups.

Sport activities are started during this period and full return to sports can be achieved as early as 12 weeks.

5.3 Complications

Apart from the general complications that are common to all surgical approaches around the hip such as damages to neurovascular structures, bleeding, deep vein thrombosis pulmonary embolism certain specific set of complications that are unique to this approach.

Higher rate of wound complications (Jahng et al. 2016; Watts et al. 2015) and superficial wound infection is been reported. One main reason is anterior thigh area being covered by skin folds in obese patients. Poor scar is another complications as the approach cuts across the Langer's lines. Dislocation rates are believed to be low capered to traditional approaches such as the posterior (Tsukada and Wakui 2015).

Damage to lateral cutaneous nerve of the thigh (LCNT) that can lead to loss of sensation around anterior thigh some times leading to meralgia paresthetica (Barton and Kim 2009).

Going too medially medial to sartorius run the risk of damaging femoral vessels and nerve, this can be avoided by staying lateral to sartorius and keeping to the correct tissue plane (Fig. 5.4) some times the retractors it self can damage these structures rather than the dissection it self. Carefully placing retractors is key to avoid this, especially if a retractor comes out re placing it should be done by the surgeon him self. These are high usually within the learning curve and with experience these can be avoided.

In hip preservation surgeries and resurfacing femoral neck fracture is a keep complication that leads to failure of the procedure (Kreuzer et al. 2011). Cautiously dislocating the hip mastering the technique, and using customized implants (Khemka et al. 2018) will help to reduce this complication.

5.4 Pearls and Pitfalls

Steep learning curve is probably the single most reason many orthopaedics surgeons have been hesitant to perform this approach over the years. However with present day demand this may be an essential approach where all hip surgeons are expected master. To avoid steep learning curves at present there are many cadaveric courses other training materials and many training programs available throughout the word. Special instruments including retractors, guide wires broach handles (Zachary et al. 2014) reamers along with operating tables have been developed (Wayne and Stoewe 2009).

It is essential to avoid too medial dissection and to stick to the correct tissue planes to avoid damaging the femoral vessels and nerve. Careful handling of instruments, training or minimally invasive techniques, using special tables will help to avoid all these complications.

Even though the mini incision is shorter both traditional and mini incisions do not respect Langer's lines and achieving a cosmetically acceptable scar has been a challenge. Some surgeons have developed a more cosmetically accepted bikini incision to overcome this (Faldini et al. 2017).

5.5 Conclusions

Direct anterior approach seems to have evolved over the years and has return to modern orthopaedic practice gaining rapid popularity among orthopaedic surgeons in this decade. Many reasons such as modern patients demands, active life styles development of modern instruments, demand for minimally invasive techniques, and more hip preservation work carried out in young adult hips have all contributed for this resurgence. However it is worth noting that to achieve successful results, training in specific procedures reduces steep learning curve, familiarizing with modern instrumentation, are key to success. In modern day all hip surgeons, should know this approach or need to learn the basic concepts as more and more open hip procedures are done through this approach.

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Chapter 6
Direct Anterior Approach to the Hip Joint

Ahmed Saad, Karthikeyan P. Iyengar, Rajesh Botchu, and Callum McBryde

6.1 Introduction

Hip replacement surgery is a common procedure that is performed to relieve pain and improve function in patients with severe hip joint disease. In recent years, the direct anterior approach (DAA) has gained popularity among orthopaedic surgeons as a less invasive technique for hip replacement surgery. The direct anterior approach involves accessing the hip joint through an incision at the front of the hip, rather than through an incision at the side or back of the hip. This approach allows the surgeon to work between the muscles and tissues, rather than splitting them or detaching them, as is required in other approaches.

The potential benefits of the direct anterior approach include faster recovery, reduced pain, reduced risk of dislocation, and improved cosmesis.

However, the technique requires specialized training and expertise, and may not be suitable for all patients. This chapter will provide an overview of the direct anterior approach to the hip joint, including the history of the technique, surgical technique and instrumentation, patient selection, and outcomes. The current evidence is presented on the benefits and limitations of the direct anterior approach and includes a discussion on the controversies and ongoing debates surrounding this approach.

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The information provided in this chapter will be valuable for Orthopaedic surgeons, trainees, and fellows who are interested in learning about the direct anterior approach to the hip joint, as well as for patients who are considering hip replacement surgery and want to learn about their surgical options.

6.2 Background

The history of the direct anterior approach (DAA) to the hip dates back to 1881, when German Surgeon Carl Hueter first described it as an internervous muscle-sparing approach primarily used for reducing congenital hip dislocations (Rachbauer and Kain 2009). Since then, various modifications have been made to the approach, with published techniques in the literature. American surgeon Marius Smith Peterson is recognized for developing and efficiently using the approach, pioneering its use in hip arthroplasty (Smith-petersen and Larson 1947). The approach gained wider recognition in the 1980s when Light and Keggi published their series specifically describing the technique for hip arthroplasty procedures (Light and Keggi 1980). In 1985, the Judets' approach, which utilized a traction table, was also described (Judet and Judet 1985). Despite the successive modifications and refinements of the DAA, the basic principles and concept of the technique have remained the same over the years. Given its early success and the growing interest in minimally invasive and tissue-sparing methods for total hip arthroplasty, the popularity of the DAA has surged among adult reconstruction fellowships and hip arthroplasty surgeons over the past decade. While the DAA is not the preferred approach used by UK fellowship-trained arthroplasty surgeons, it is a common approach across Western Europe, particularly in countries such as the Netherlands and Belgium, where it is the primary approach (Peters et al. 2022).

6.3 Considerations for DAA

6.3.1 Learning Curve

The DAA is a technically demanding surgical approach, even in the hands of experienced surgeons, and is associated with a significant learning curve. Although there is no established consensus on the exact number of cases required to achieve proficiency, several studies have suggested that performing between 60 and 100 cases can lead to reduced operative times and rates of postoperative complications (Patel et al. 2019; Stone et al. 2018; Garbarino et al. 2021; Goytia et al. 2012). Importantly, these studies highlight the need for a well-structured training program to support the development of surgical skills, which should be regularly assessed and supervised by experienced trainers.

6.3.2 Advantages of the Direct Anterior Approach

Multiple studies have proposed several advantages of the DAA. Alongside the desire to perform minimally invasive arthroplasty approaches, the DAA is muscle sparing, and advocates of this approach have cited reduced levels of post-operative pain, hospital length of stay, and expedited rehabilitation (Zhao et al. 2017; Putananon et al. 2018; Martin et al. 2013; Alecci et al. 2011; Barrett et al. 2013) (Table 6.1).

Pain, Rehabilitation & Hospital Length of Stay

The purpose of the DAA is primarily to avoid muscle and nerve damage whilst ensuring the ability to accurately position the components of a hip replacement. The development of an intermuscular plane for insertion of THA components allows this. It has been demonstrated that this corresponds with an overall decrease in post operative pain. Pain, however, is a subjective experience confounded by both patient and anaesthetic factors. This makes it difficult to measure. Most pain measurement tools are comprised of pain assessment questionnaires (such as the VAS or Harris Hip Score), patient reported outcome measures (PROMS), or through direct observation of patient behaviours. Advocates of the DAA have demonstrated a significant decrease in postoperative pain levels, using the latter assessments, during the early days following a THA in comparison to other surgical approaches.

Length of hospital stay (LOS) is an important measure to assure patient safety and from an institutional financial perspective. Decrease in hospital LOS largely improves patient satisfaction, reduce hospital costs, nosocomial infections, and allows early return to normal daily living. Post operative recovery can be complicated by both patient factors and surgical factors, and similar to pain assessments, can be difficult to measure. However, the concept of reduced post operative pain correlates with improved post operative recovery and hospital length of stay (HLOS). THA through the DAA has been reported amongst several studies to have an overall reduced HLOS in comparison to other approaches. Hip precautions are rarely employed following a DAA THA. Patients are, therefore, able to mobilise and get back to normal daily living activities sooner. This is evidenced in the literature, where studies have demonstrated that subjects of the DAA were able to discontinue their walking aids, ascend stairs, and drive quicker, when compared to those undergoing a posterior approach THA. Although long-term differences between surgical approaches are relatively similar in the long run, exponents for the DAA utilise it mainly to improve short term patient

Table 6.1 Advantages of the direct anterior approach

Advantages of the DAA
Improved post-pperative pain
Earlier rehabilitation
Reduced hospital length of stay
Reduced risk of dislocation
No post-operative hip precautions required
Quicker return to daily living activities

recovery for those undergoing a THA (Zhao et al. 2017; Putananon et al. 2018; Martin et al. 2013; Alecci et al. 2011; Barrett et al. 2013).

6.3.3 Contraindications of the DAA

Absolute contraindications to any surgical approach include active surgical site infections, ischemia or fragile skin (secondary to steroid use or radiotherapy) (Zabaglo and Sharman 2022). Concerning the DAA, it is important to factor in specific patient considerations that have the potential to make this approach more challenging. The ideal patient for utilising the DAA is described as a lean non-muscular patient, with 'normal' native hip anatomy (Realyvasquez et al. 2022).

Increased BMI (> 30 kg/m^2) can make any surgical approach challenging. Although subcutaneous fat composition over the anterior thigh is minimal, patients with large abdominal pannus can make the exposure through the DAA difficult. Additionally, the surgical wound underlying the panniculus is vulnerable to wound complications. For that reason, it is imperative to take this into consideration and extra precautions must be employed when using this approach on obese patients (Sang et al. 2016; Jahng et al. 2016; Sali et al. 2019; Berend et al. 2016; Sidler-Maier and Waddell 2015).

The anatomic variability of the native hip may additionally play a role in hindering use of the DAA for THA. Acetabular protrusion or decreased femoral offsets for example, place the proximal femur deeper in the thigh, which may limit access to the femoral canal and consequently complicate appropriate implant placement. The DAA also limits access to the posterior acetabular wall. Any work that needs to be done to the posterior acetabulum column is therefore difficult and a different approach may be considered (Sang et al. 2016; Jahng et al. 2016; Sali et al. 2019; Berend et al. 2016; Sidler-Maier and Waddell 2015) (Table 6.2).

Table 6.2 Contraindications of the direct anterior approach

Absolute	Relative
Local skin Cellulitis/infection	BMI > 30
Abdominal stoma	Distorted/complex anatomy
	Revision surgery

6.4 Applied Surgical Anatomy

6.4.1 Landmarks

The Anterior Superior Iliac Spine (ASIS) is the primary anatomical landmark of the DAA. It is located at the uppermost anterior border projection of the iliac bone, formed by the confluence of the iliac crest and anterior border of the ilium. The ASIS serves as an attachment point for two structures: the sartorius, which originates from it, and the inguinal ligament, which attaches medially. The lateral cutaneous nerve of the thigh runs in close proximity to the ASIS, piercing the fascia lata to enter the thigh region. However, the exact location of the nerve can vary between individuals.

6.4.2 Superficial Exposure

The first tissue layer encountered through the DAA, following skin and subcutaneous fat dissection, is the Fascia Lata (FL). The FL is a broad superficial structure that envelops the anterior and posterior muscles of the thigh. It's importance in the DAA is projected through its relationship with two distinct muscles: the Sartorius (femoral nerve) and Tensor Fascia Lata (superior gluteal nerve), forming a true Internervous plane (Moskal et al. 2013).

The Sartorius muscle is the longest muscle in the body. It originates from the ASIS and runs obliquely on the anterior compartment of the thigh, covered by the fascia lata, to span both the hip and knee joints. Its insertion is on the superomedial surface of the tibia, at the pes anserinus. The Sartorius muscle functions synergistically to aid with hip flexion, lateral rotation of the femur, and medial rotation of the leg.

The Tensor Fascia Lata (TFL) muscle arises from the anterior portion of the outer lip of the iliac crest and inserts into the iliotibial tract. Although the exact function of the TFL is still not completely understood, recent evidence suggests it acts as a secondary stabilizer for both the hip and knee joints. Activation of the TFL leads to abduction, flexion, and internal rotation of the hip joint (Trammell et al. 2022).

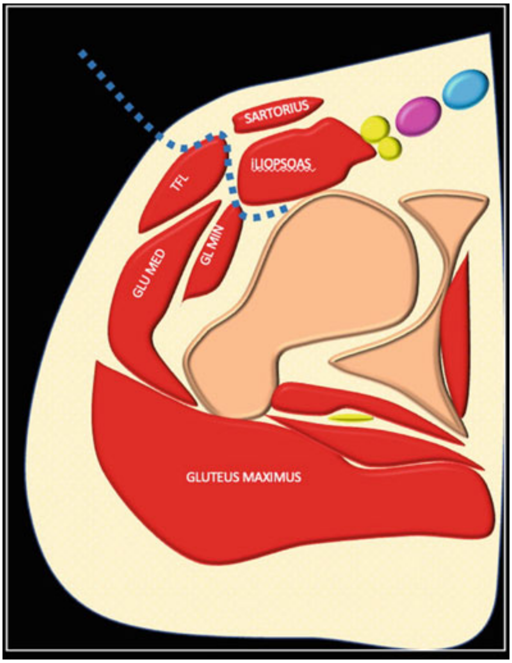
The ascending branch of the lateral femoral circumflex artery and the lateral femoral cutaneous nerve of the thigh (LFNT) lie between the sartorius muscle and TFL.

6.4.3 Deep Exposure

The initial deep layer of the DAA is formed by the rectus femoris (femoral nerve) and the gluteus medius (superior gluteal nerve) muscles. The interval between them correspondingly forms an Internervous plane. The inferomedial aspect of the approach is encroached by the iliopsoas muscle and iliocapsularis. The latter must be retracted medially to improve anterior exposure of the femoral neck.

The rectus femoris muscle has two sites of origin; a straight head that arises from the anterior inferior iliac spine and a reflected head, arising directly from the supraacetabular groove and anterior joint capsule. The rectus femoris converges with the Vastus muscles to form a thick tendon (Quadriceps tendon) that attaches to the patella. While the rectus flexes the hip joint, it primarily functions to extend the knee joint. The gluteus medius (GM) muscle is one of the three gluteal muscles, taking origin from the outer aspect of the ilium, between the anterior and posterior gluteal lines. It fans out to attach to the lateral aspect of the greater trochanter. It functions to abduct the hip and plays an important role in pelvic stabilisation. Although the intermuscular plane between the rectus and GM muscles can be readily identified, mobilizing the rectus femoris can be challenging due to its direct attachment to the anterior capsule.

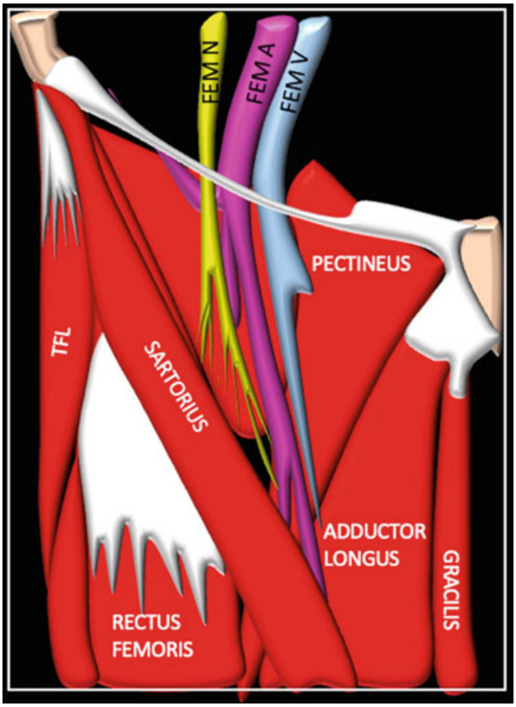
The iliopsoas tendon is formed by two muscles, the psoas major (anterior rami of spinal nerve L1–L3) and iliacus (femoral nerve), both of which span the pelvis and hip joints. Its fibres run down, crossing anterior to the hip joint to insert into the lesser trochanter, and partly to the joint capsule (iliocapsularis). The iliopsoas is the strongest flexor of the hip joint. Release of the iliocapsularis is a critical step in the DAA to further improve exposure to the hip joint. Bilateral contraction of the iliopsoas produces flexion of the trunk at the hip joint (Schematic A).



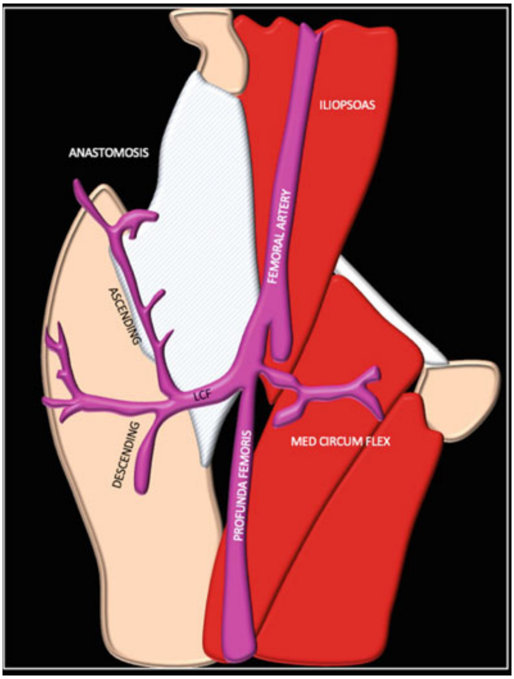
Schematics A: Axial view of the surgical Planes to access the Hip joint during the direct anterior approach

6.4.4 Vessels

The femoral vessels are a direct continuation of the external iliac vessels and receive their name after they passes the inguinal ligament, entering the femoral triangle of the thigh. The femoral vessels travel on the anteromedial aspect of the thigh, sitting deep to the fascia Lata. Both vessels primarily supply and drain the lower limb correspondingly. The femoral vessels should never be visualised during the DAA; however, both can be damaged by misplacement of the anterior acetabular retractors within the iliopectineal eminence. It is, therefore, imperative to avoid placement of any retractors over the acetabulum until full exposure and capsulotomy has been achieved. The tip of the retractors should be placed under direct vision, precisely on bone, with care to avoid any traversing soft tissues (Schematic B & C).



Schematics B: Coronal view of the surgical planes and major structures



Schematics C: Schematic showing the ascending branch of the lateral circumflex femoral artery encountered during the DAA. TFL—Tensor fascia lata, Gl Min—gluteus minimus, FEM A—femoral artery. FEM V—femoral vein, FEM N—femoral nerve, Med circum flex—medial circumflex artery, Ascending—ascending branch of lateral circumflex artery, Descending—descending branch of lateral circumflex artery

6.4.5 Nerves

Two nerves are at particular risk during the DAA: The femoral nerve and the lateral cutaneous nerve of the thigh (LCNT). The femoral nerve is the largest branch of the lumbar plexus, originating from nerve roots L2–L4. It travels inferiorly through the psoas muscle, posterior to the inguinal ligament to lie lateral to the femoral vessels in the femoral triangle. The femoral nerve has a motor supply to the anterior compartment muscles of the thigh as well as cutaneous branched to the anteromedial thigh and medial side of the leg. Similar to the femoral vessels, it is rarely encountered during the DAA. Damage to the femoral nerve most commonly presents as a compression neuropraxia secondary to forceful medial retraction of the anterior soft tissue structures.

The lateral cutaneous nerve of the thigh (LCNT) originates from the lumbar plexus, and runs close to the ASIS, piercing the fascia lata to enter the thigh region, with a variable anatomic distribution. The LCNT may run across or through the sartorius muscle and must be protected to avoid compression syndromes during the DAA.

6.4.6 Pointers

Landmarks: *ASIS*

Internervous planes:

Superficial dissection—Sartorius (Femoral Nerve) and TFL (Superior Gluteal Nerve)

Deep dissection—Rectus Femoris (Femoral Nerve) and Gluteus Medius (Superior Gluteal Nerve).

Dangers

Lateral Femoral Cutaneous Nerve of the Thigh

Femoral Nerve

Femoral Artery.

6.5 The DAA Surgical Technique

6.5.1 Preoperative Planning

- Patient selection
- Implant Choice
- Anaesthetic Choice
- Tranexamic Acid
- IV antibiotics.

Special Instrumentation (Fig. 6.1):

- Curved retractors
- Right angle retractors
- Femoral Elevators
- Double Offset Broach.

Fig. 6.1 Special instruments and retractors required for the direct anterior approach

6.5.2 Theatre Set Up and Patient Position

The set-up of the procedure can be variable and is dependent on surgeons' preference. The procedure can be done on a regular operating room table or a traction table. For the purposes of this chapter, we describe the approach used with the patient positioned on a regular OR table.

The patient is positioned supine, and two instrument trolleys are placed caudal to the patient. A second mayo table can be adjusted on the ipsilateral side of the table holding instruments for direct utilisation by the operating surgeon. The primary surgeon and a surgical assistant stand on the ipsilateral side of the patient, while a second assistant may be utilized on the contralateral side of the limb. The surgeons can switch positions depending on the stage of the procedure. A scrub nurse stands at the end of the table.

Both lower extremities should be prepped and draped appropriately with care taken to appropriately expose the surgical field and allow intraoperative manual limb length comparisons and stability testing. Standard prepping using alcoholic chlorhexidine is done from the umbilicus towards the distal third of both legs. An assistant holds both feet of the table, and a drape is placed underneath. A second drape covers the surgical field from just distal to the umbilicus, extending cranially (Fig. 6.2).

A perineal drape covers the perineal area. Both feet are draped and covered with stockinet extending up to the ASIS, and a bilateral extremity drape with two holes for both limbs is used to cover both lower limbs, extending up to and beyond the umbilicus. The surgical field is exposed, marked, and covered with adhesive Ioband.

Fig. 6.2 Surgical draping for the DAA

6.5.3 Surgical Approach

The skin incision starts approximately 2 cm distal and 2 cm lateral to the ASIS, directed caudally towards the fibular head. The incision is carried through skin and subcutaneous fat to the level of the fascia overlying the tensor fascia Lata (TFL). An anterior retractor should be placed superiorly at the ASIS, to aid in identifying the interval between TFL and sartorius.

The TFL fascia is incised over the TFL muscle about 2 cm lateral to the interval, ensuring adequate proximal and distal exposure through the whole incision is achieved (Fig. 6.3).

A self-retainer can be used to retract the fascia medially and lateral exposing the TFL muscle bulk. Blunt finger dissection is performed creating a plane over TFL with care taking care not to disrupt the underlying muscle fibres. The self-retainer can then be placed more deeply to retract the TFL laterally and the sartorius and deeper rectus femoris muscles medially. Care must be taken to avoid damage to the lateral femoral cutaneous nerve of the thigh, which overlies the fascia over the sartorius muscle. At this stage, the anterior ascending branch of the lateral femoral circumflex vessels is identified at the centre of the wound, which serves as a good landmark for the intertrochanteric line. The vessel is ligated along with its concomitant veins to prevent excessive bleeding.

Fig. 6.3 Skin & tensor fascia lata fascia exposure

6.5.4 Capsular Exposure

After the fascia lata and TFL muscle are retracted laterally, the next layer visible is the pre-capsular fat. To access the hip capsule, a Cobb retractor is used to identify the iliocapsularis muscle and through blunt dissection, create a plane beneath the reflected head of the rectus muscle medially and anterior hip capsule (Fig. 6.4).

The Cobb retractor is then replaced by a curved Hohmann retractor medial to the femoral neck. A second plane is created over the superolateral edge of the femoral neck between the abductors and hip capsule, using another Cobb retractor. This is replaced by a second anterior curved Hohmann retractor, and the self-retainer is removed. A third curved Hohmann retractor is positioned at the origin of the Vastus lateralis muscle from the greater trochanter, while a fourth 'very-curved' retractor is placed underneath the rectus and over the anterior acetabular rim. Caution must be observed in placing this retractor on bone as the tip lies close to the neurovascular bundle as it leaves the pelvis and into the femoral triangle. Using direct visualization, an anterior capsulectomy is performed, beginning superolaterally over the reflected head of the rectus and the anterior acetabular rim, extending medially over the lateral border of rectus and iliofemoral capsule, and ending laterally towards the anterior intertrochanteric ridge. The superolateral and inferomedial femoral neck retractors are repositioned deep to the capsule for better exposure.

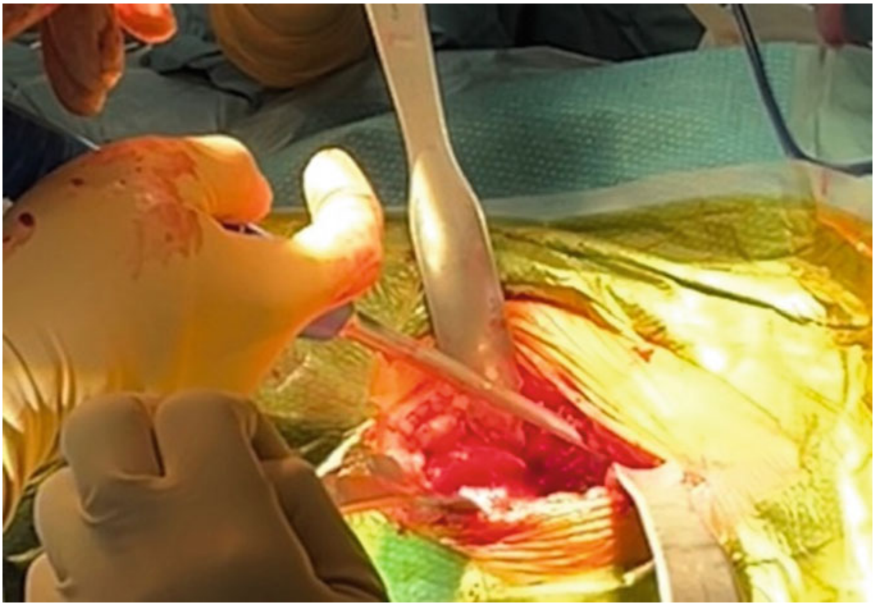


Fig. 6.4 The surgeon places a Cobb retractor to create a plane beneath the reflected head of rectus muscle medially and anterior hip capsule

6.5.5 Femoral Neck Cut and Head Extraction

A cork-screw is secured onto the superolateral femoral head using sequential tightening (Fig. 6.5).

The direction of the handle of the cork-screw indicates the direction of the planned femoral neck osteotomy. Using an oscillating saw, a pre-templated osteotomy is made on the femoral neck, starting from the medial edge and extending towards the lateral edge. Care should be taken to avoid damage to the TFL muscle. The four retractors are then removed. The femoral head is carefully extracted with gentle traction, leveraging over the calcar in the direction of the TFL muscle fibres to prevent any potential damage.

6.5.6 Ligamentous Release and Acetabular Exposure

To achieve optimal 360° exposure of the acetabulum and prepare the femur for implantation, further capsular releases are performed prior to acetabular exposure. The ipsilateral leg is repositioned into a lazy figure of 4 position. A large langen-beck retractor is positioned over the medial femoral neck, and an inferomedial capsulotomy is performed, extending to the level of the lesser trochanter. The leg is then

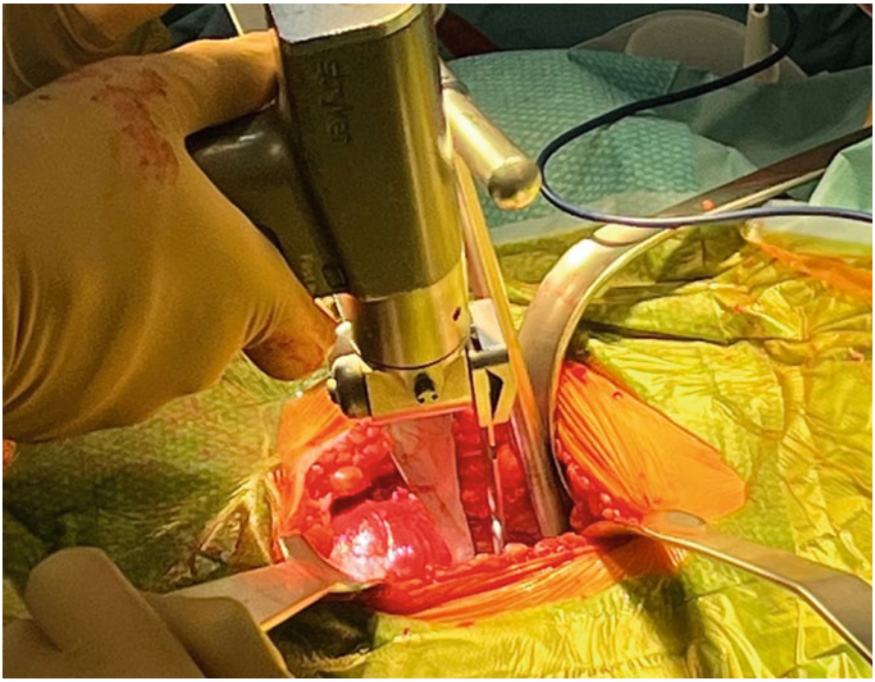


Fig. 6.5 Cork screw placement and planned femoral neck cut

returned to a neutral position. A second large langen-beck retractor is placed superolaterally, deep over the medial edge of the abductors to expose the cut femoral neck. A blunt bone hook retractor is inserted into the femoral neck cut to elevate the proximal femur anteriorly, while a superolateral capsulotomy is performed, starting anteriorly and ending posteriorly over the posterior cortex of the femoral neck cut. This manoeuvre frees the superior and inner surface of the greater trochanter, while preserving the piriformis and short external rotator muscles.

After adequate capsular release, a curved retractor is placed over the anteromedial border of the acetabular rim, while a second 'double prong' retractor is placed on the posterior wall of the acetabulum. An angled retractor is inserted deep to the transverse acetabular ligament to serve as a reference guide for acetabular reaming. The labrum is excised using a long-handled knife, and the medial acetabular wall is cleared of the ligamentum teres and floor osteophytes to ensure clear visualisation of the medial wall (Fig. 6.6).

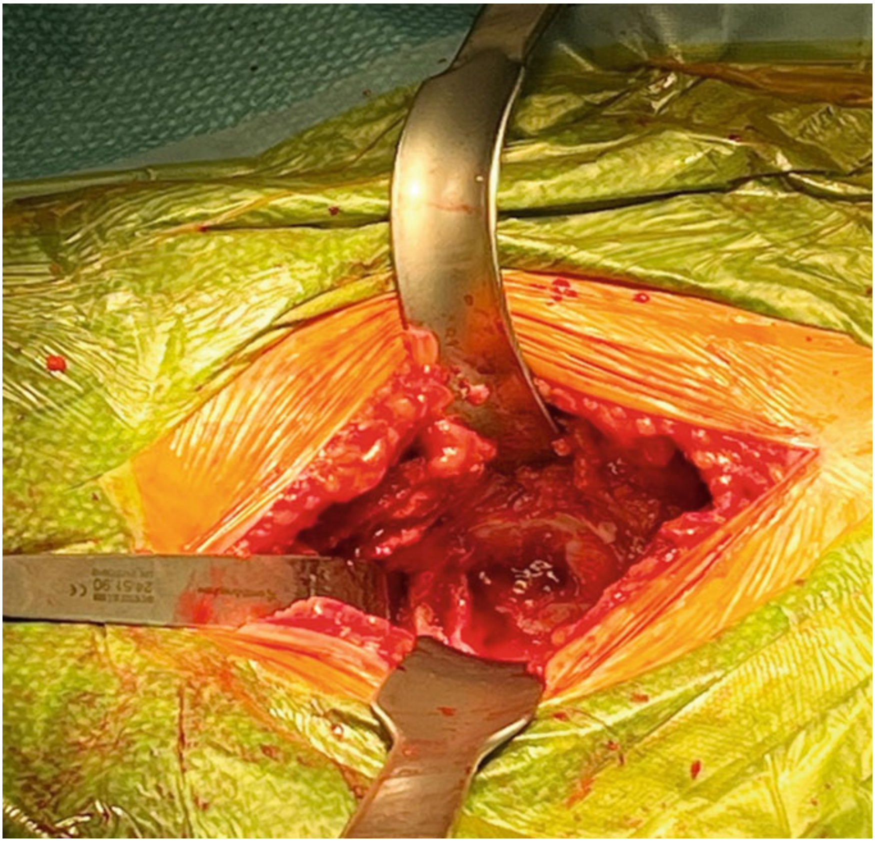


Fig. 6.6 Acetabular exposure with retractor placement

6.5.7 Acetabular Preparation and Implant Insertion

The appropriate size for the starting reamer should be determined based on preoperative templating and confirmed by referencing the size of the resected femoral head. Sequential reaming is performed using a straight or curved (offset) reamer handle, maintaining concentricity until subchondral bleeding is observed (Fig. 6.7).

The final position of the acetabular component depends on various factors that are beyond the scope of this chapter. Once the desired reaming size is achieved, a trial is performed. An uncemented acetabular shell component is implanted based on the pre-templated acetabular anteversion and inclination. An unlipped liner is then implanted and impacted into the shell.

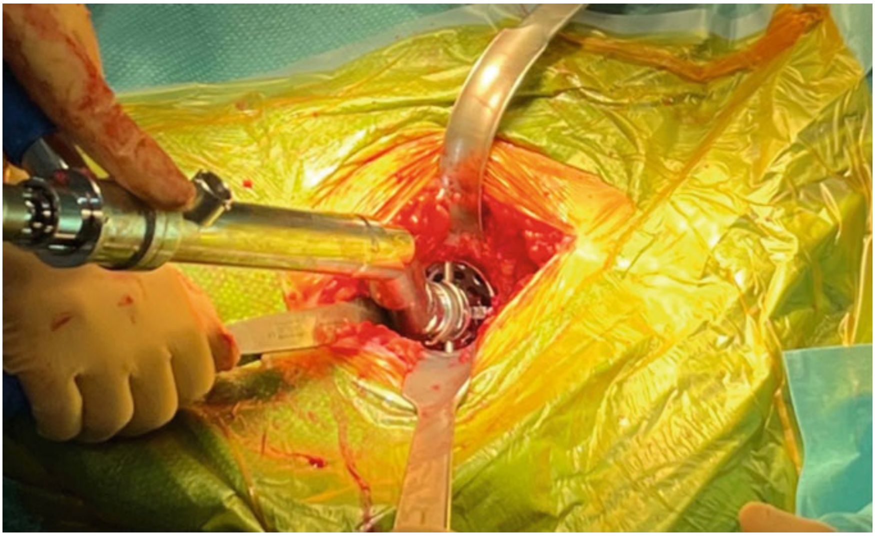


Fig. 6.7 Acetabular preparation and reaming

6.5.8 Femur Preparation and Implant Insertion

A large blunt hook is placed into the femoral neck canal and the femur is elevated anterolaterally. The caudal end of the operating table is flexed to allow for approximately 30° of hip extension. The leg is placed back in a lazy figure of 4 position. It is critical to ensure the greater trochanter is visualised. A double prong retractor is then placed on the posterior aspect of the GT, between the bone and gluteal muscles to maintain femoral elevation (Fig. 6.8).

A curved retractor is placed around the postero-medial femoral neck to improve exposure of the femoral neck cut. Using a box chisel, the proximal femur is opened, followed by an anterior curved rasped to further delineate the course of the internal canal. Sequential broaching must be performed using a double offset broach handle up to the desirable size. Attach the trial femoral neck and head prior to assessing stability. All retractors are removed. Reduction is performed solely by the operating surgeon; the leg is repositioned to neutral. The surgeon places two fingers on each side of the femoral neck and applies gentle inline traction with internal rotation. Once the hip joint is reduced, stability is assessing by hip flexion, extension, adduction, internal and external rotation. Once stability is confirmed, the hip joint is dislocated by gentle traction and external rotation. The retractors are placed in their primary position, and the leg repositioned back to a figure of 4. The trial implants are removed, and the desired stem size is checked and inserted (Fig. 6.9).

Stability is confirmed once again. Pulse lavage irrigation of the components is performed prior to closure.

Fig. 6.8 Femoral preparation and retractor placement

Fig. 6.9 Figure depicting the final position of THA implant

6.5.9 Wound Closure

The wound is closed in layers, starting by closure of the TFL fascia using vicryl sutures. Care must be taken to avoid damage to the lateral cutaneous nerve. Skin closure is performed using subcuticular monocryl sutures. A waterproof dressing is applied.

6.5.10 Key Aspects of the Surgical Technique

Capsular exposure: Utilize safe and reliable anterior retractors to nicely expose the anterior capsule.

Ligamentous release:

Step 1: Resect the anterior superior capsule, then extract the head following neck osteotomy.
Step 2: Release the inferior capsule until the base of the lesser trochanter is felt.
Step 3: Release the superior capsule starting from the anterior to posterior, ending at the posterior cortex of the neck. This allows for the inner surface and superior surface of the GT to be freed, while keeping the piriformis and obturator externus attached to the GT. It also exposes the fat pad between the GM and GT, providing easy exposure of the femur for preparation.

Component implantation

6.6 Complications

As noted earlier in this chapter, complications associated with the direct anterior approach (DAA) are more likely to occur during the early stages of the surgeon's learning curve. Common complications that have been reported in the literature include intraoperative fractures, dislocation risk, and nerve injury. Therefore, it is essential for surgeons to approach the DAA with caution and take the time needed to become proficient in the technique to minimize the risk of surgical complications. By doing so, surgeons can ensure better outcomes for their patients and enhance the overall success of the DAA as an approach for total hip arthroplasty (Trammell et al. 2022, Alexandrov and Ahlmann 2014).

6.6.1 Intraoperative Fracture Risk

Intraoperative femur fractures are a serious complication that can occur during any approach for total hip arthroplasty (THA) and can significantly prolong functional recovery and increase surgical time. While the direct anterior approach (DAA) offers many advantages, the risk of intraoperative fractures is a concern that should not be overlooked. Several risk factors have been identified, including the learning curve for less experienced surgeons, female sex, advanced age, and increased BMI. To minimize the risk of intraoperative fractures, careful patient selection is critical, along with a number of technical considerations, such as preoperative templating, appropriate acetabular exposure and capsular releases, visualisation of the greater trochanter and calcar, and careful mobilisation of the femur during femoral preparation. By following these strategies, surgeons can help to reduce the risk of intraoperative fractures and ensure better outcomes for patients undergoing THA with the DAA (Barton and Kim 2009; Petis et al. 2015; Cohen et al. 2017).

6.6.2 Dislocation Risk

Dislocation is a significant complication that can have detrimental effects on both patients and operating surgeons. As a result, the risk of dislocation is a crucial factor to consider when performing arthroplasty surgery, and it may affect the choice of a particular surgical approach. While the direct anterior approach (DAA) is a popular technique for hip joint replacement, there is ongoing debate regarding its ability to reduce the risk of dislocation. Many comparison studies have been conducted, and the majority of them show either a lower rate of dislocation or no significant differences in dislocation rates between the DAA and other approaches. It is important for surgeons to carefully evaluate the potential benefits and risks of each approach when deciding on the most appropriate technique for their patients (Aggarwal et al. 2019; Siguier et al. 2004; Huerfano et al. 2021; Maratt et al. 2016).

6.6.3 Neurovascular Injury

In this chapter, we have briefly discussed the potential risk of neurovascular injury associated with the direct anterior approach to the hip joint. During surgery, nerve complications can occur due to various factors, such as compression by instruments, direct trauma, or thermal injury. While the use of an Internervous plane during the DAA can help mitigate these risks, the LFCN nerve remains the primary nerve at risk. Although the true incidence of LFCN injury is uncertain and can range from 0.1% up to 80%, any damage to this purely sensory nerve can result in numbness or painful paraesthesia in the anterior thigh region. It is important to note that damage to the LFCN does not impact functional outcomes and symptoms often resolve without long-term effects. Therefore, setting patient expectations and employing careful tissue dissection can help to alleviate concerns regarding potential LFCN injury (Sariali et al. 2008; Farrell et al. 2005; Restrepo et al. 2010; Kennon et al. 2003; Goulding et al. 2010).

6.7 Conclusion

In conclusion, the direct anterior approach to the hip joint is a minimally invasive surgical technique that has gained popularity in recent years due to its potential benefits over other approaches. Nonetheless, it is associated with a significant learning curve, and it is important to note that not all patients may be candidates for the DAA. The decision to use this technique should be made on an individual basis by the patient and surgeon. Advancements in surgical techniques and technology continue to evolve, leading to improvements in patient outcomes and reduced complications. Further research and clinical studies are required to continue to evaluate the long-term outcomes of the DAA to the hip joint and its potential benefits over other approaches. In this chapter, we described a step-by-step guide of the DAA and highlighted learning pearls that may aid surgeons interested in adopting this approach to master the technique for THA.

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Chapter 7
Direct Anterior Approach for Total Hip Arthroplasty

Rajesh Malhotra and Deepak Gautam

Abstract Total Hip Arthroplasty (THA) has been established as one of the most successful surgical procedures for patients with end stage joint disease of hip or trauma not salvageable by osteosynthesis. Several approaches have been described for THA. The originally described Hueter's Approach is regaining its recognition as Direct Anterior Approach (DAA). The increasing number of literature a claiming several benefits of DAA has not only made DAA attractive for patients who demand this approach, but is also compelling the surgeons to switch over this approach. However, it is still less commonly being performed because of its steep learning curve, and theoretical requirement of a special table and instruments. This chapter elaborates a step by step approach for THA by Direct Anterior Approach in an ordinary table so that it becomes easier for all the surgeons round the globe to perform this surgery without any hesitation.

7.1 Introduction

Total Hip Arthroplasty (THA) has been established as one of the most successful surgical procedures for patients with end stage joint disease of hip or trauma not salvageable by osteosynthesis (Learmonth et al. 2007). Apart from the advances in metallurgy for newer implants and assisted techniques like navigation and robotics, a topic that has been trending recently as a subject of discussion among the arthroplasty surgeons is regarding the newer approaches for THA, especially the Direct

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Anterior Approach (DAA). With its introduction long back in 1881 and publication in an English literature in 1917 to its first application for THA in 1940, this approach remained apparently dormant for almost four decades. It was in the year 1980 when Light and Keggi, and Judet re-popularized it with further modifications (Light and Keggi 1980; Smith-Petersen 1917, 1949; Judet and Judet 1983). This approach utilizes the anterior internervous and intermuscular plane to provide a direct view of the acetabular socket. Most commonly performed in supine position, it gives an easy access for the fluoroscopic arms for its use intraoperatively to look for component positioning (James et al. 2018). Regarded as a demanding procedure in the past because of its requirement of a special table and distinct instrument sets, now it is being performed even on an ordinary table with an ordinary set of instruments. The main inducement factor for its rejuvenation is its evident clinical outcome, non-restriction of functional activities to the patients and rational approach to the surgeons that can be mastered by a process of learning. However, like any other newer approaches, it comes through a steep learning curve. With a number of cadaveric courses and formal training being conducted worldwide, surgeons are slowly adopting it as their preferred approach. Here, in the chapter we discuss the one-by-one steps of Direct Anterior Approach so that a beginner surgeon could adopt it with ease.

7.2 Selection of the Patient for Initial Cases

Every surgeon is cognizant of the fact that every patient is different from others with the same diagnosis in clinical presentation, radiographic findings and relevant anatomy, and these differences will likely have a direct impact on the surgical procedure. A difficult case that could be performed by a surgeon in a stipulated time with the conventional approach, may take a considerably longer time with DAA if attempted as initial cases of his/her career. Patient selection is of utmost importance to start with, which helps in confidence build up and gradual advancement leading up to using DAA for the challenging cases. The clinical diagnosis, patient habitus and the radiographs help in selecting the suitable cases in early stages of DAA career. The authors from their personal experience would suggest the following spectrum of cases from relatively easier to challenging ones that a DAA aspirant surgeon should follow:

Fracture Neck of femur (preferably transcervical) in a patient with low muscle mass
↓
Avascular Necrosis of femoral head with valgus neck with low to moderate muscle mass
↓
Avascular Necrosis of femoral head with varus neck with low to moderate muscle mass
↓
Inflammatory arthritis with mobile joint with moderate to high muscle mass
↓
Above patients with deformities and high muscle mass
↓
Secondary Arthritis with Protrusio Acetabuli / fibrous ankylosis
↓
Inflammatory Arthritis with bony ankylosis
↓
Dysplastic Hips
↓
Primary THA with Bone Defects
↓
Revision THA

This gradual sequence is based on the principle that, the soft tissues around the hip in fracture neck of femur are lax and patulous, hence, femoral mobilization is possible with limited need for releases (Rodriguez et al. 2017). While increasing the complexity of cases from a patient with valgus neck to dysplastic hips, the working space decreases from a maximum to minimum (Matsuura et al. 2010; Azim et al. 2012). In a valgus neck, the working space over the hip capsule is more and requires minimal releases while in varus neck the working space is less and may require extensive releases. This can be easily understood by drawing a triangle (MG triangle) on a pelvis x-ray joining the Anterior Inferior Iliac Spine (AIIS), mid-point of the vastus ridge and mid-point of the acetabular margin. The case with a wider base of triangle (Fig. 7.1) will have greater working space as compared to that with a narrow base (Fig. 7.2).

A surgeon would be comfortable initially in cases with maximum working space requiring minimal releases and gradually advancing to cases with minimum space and maximal necessary releases.

7.3 Templating Before Surgery

Although DAA provides immediate feedback on component position by the use of fluoroscopy, the correct sizing of the components is critical as there is a tendency to undersize femoral component especially in the initial few cases due to the fear of periprosthetic fractures if oversized. Hence, it is advisable to perform a precise templating to anticipate the size of implants (Fig. 7.3).

In addition to anticipation of the size and positioning of implants, templating also helps in determining the Hip Offsets and Leg Length Discrepa.ncy at the supra-trochanteric level so that it can be equalized during the surgery. Apart from

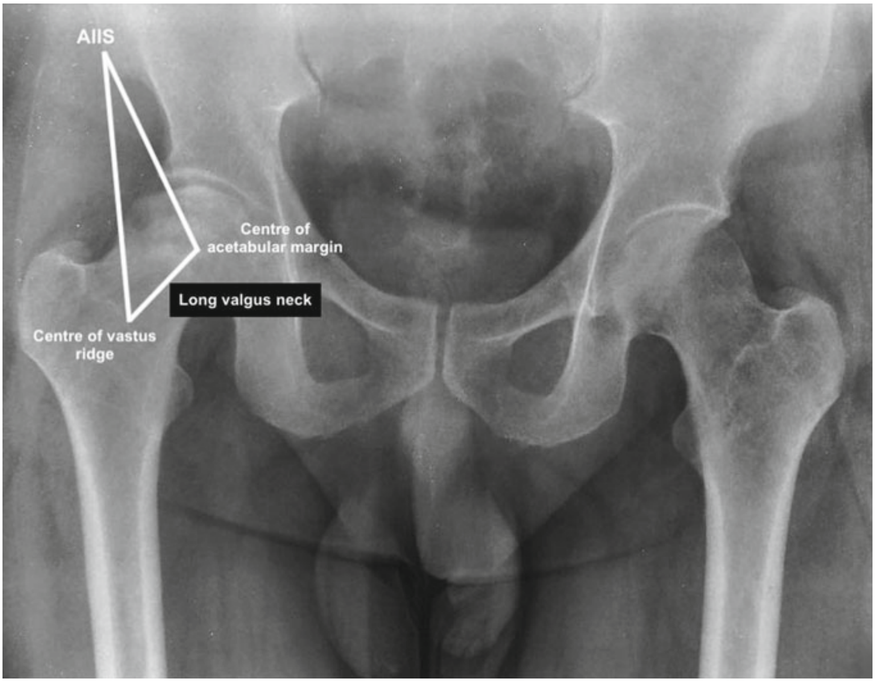

Fig. 7.1 X-ray of both hips with pelvis in a patient with right hip AVN planned for THA by DAA. Note the long valgus neck as compared to Fig. 7.2 (varus neck). The MG triangle subtended with the base as the line joining the mid-point of vastus ridge and the mid-point of acetabular margin with Anterior Inferior Iliac Spine (AIIS) showing the working space for DA approach

templating, ensure the availability of retractors and the special instruments required during the surgery (Fig. 7.4).

1. A right-angled retractor for retraction of the superior capsule
2. A curved retractor for retraction of the inferior capsule
3. A curved retractor for retraction at the Anterior Column
4. A curved retractor with long handle for retraction of the proximal femur at the posterior aspect of the acetabulum
5. A curved retractor to be applied on the posterior aspect of cut femoral neck to push the proximal femur away from acetabular margin
6. A pointed curved retractor for trochanteric elevation
7. A cup impactor with offset handle
8. A canal finder
9. Offset reamer handle
10. Offset broach handle

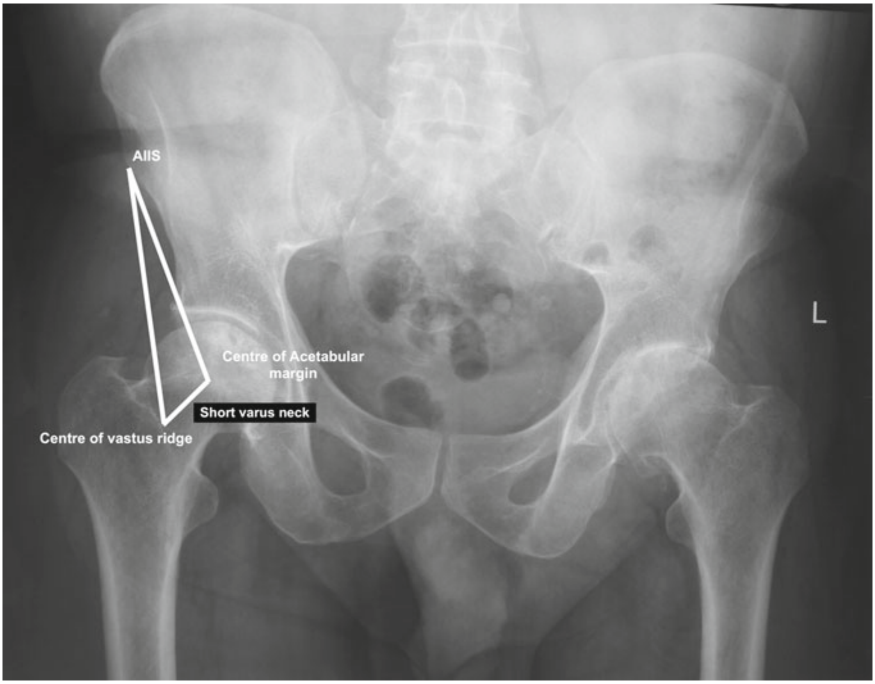

Fig. 7.2 X-ray of both hips with pelvis in a patient with right hip AVN planned for THA by DAA. Note the short varus neck as compared to Fig. 7.1 (valgus neck). The MG triangle subtended with the base as the line joining the mid-point of vastus ridge and the mid-point of acetabular margin with Anterior Inferior Iliac Spine (AIIS) showing the working space for DA approach

7.4 Surgical Steps

The surgical procedure in the operating room are carried out in the following sequence:

1. Positioning of the patient

A standing operating table or the special table can be used depending on the availability and surgeon's preference. For the initial cases during learning, one can use the special table. If the special table is used then care should be taken to include the extension attachments within the sterile field and an assistant is required in the room for moving the limb in different positions during surgery.

The authors prefer to use an ordinary table with the provision for breaking the table at the level of the pelvis (Fig. 5A).

This feature in the table helps in extension of the hip during the surgery for femoral elevation, if needed. The patient is positioned on the table in such a way that the imaging of the hip is not obstructed by any metallic part of the table during fluoroscopy (Fig. 5B).

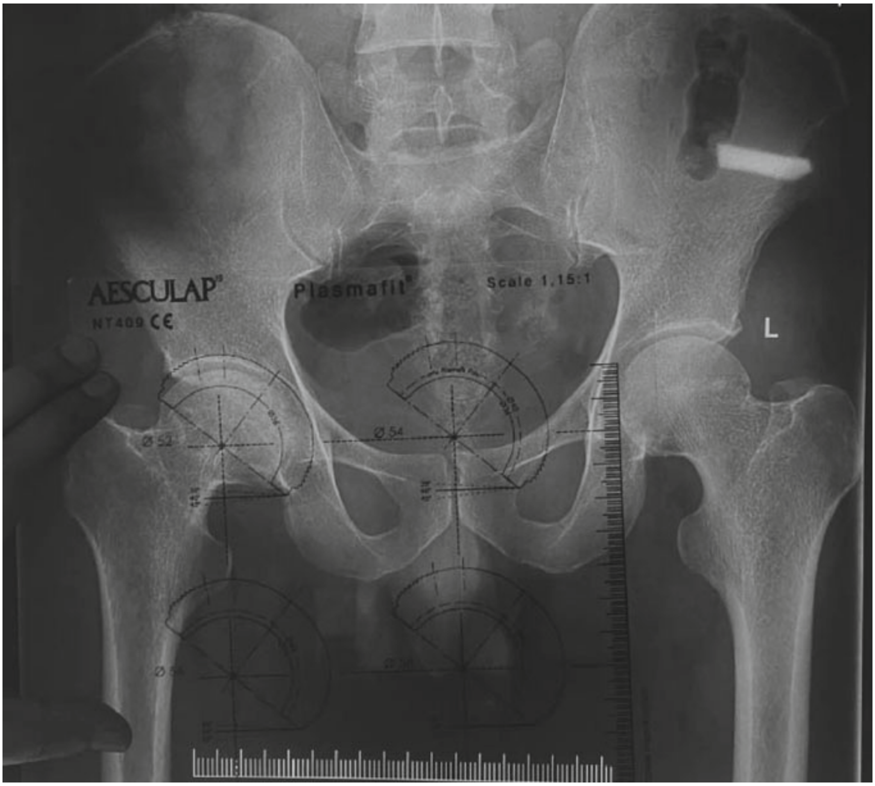

Fig. 7.3 X-ray of both hips with pelvis in a patient with right hip arthritis showing templating for the right acetabular component

Both the lower limbs are cleaned and draped separately. However, the operating hip is isolated by the use of a U-drape after tucking the genitals away safely with a sterile towel.

2. Preliminary markings

The most important surface landmarks for the DAA incision are the Anterior Superior Iliac Spine (ASIS) and the tip of Greater Trochanter (GT). The proximal extent of the incision is a point which is 2 cm below and lateral to the ASIS. The authors follow a simple method of marking the incision line by keeping the cautery wire along the anterolateral aspect of thigh joining the above-mentioned point to the fibular head (Figs. 7.6A and B).

An 8–10 cm long incision site is marked along the cautery wire (Figs. 7.7A and B).

Alternatively, a line is drawn joining the ASIS with the tip of GT and its mid-point is marked as the proximal extent of incision from where the 8–10 cm long incision

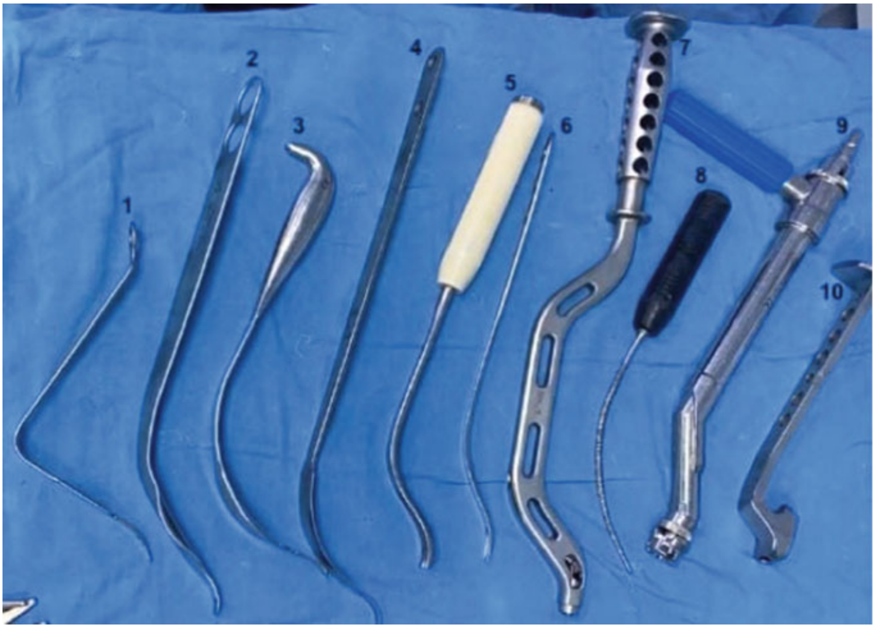

Fig. 7.4 Instruments used for THA by the Direct Anterior Approach

marking runs along the anterolateral aspect of the thigh towards the fibular head (Fig. 7.8).

Many a time, especially in lean patients, the TFL muscle can even be palpated clinically (Fig. 7.9).

This serves as a guide to keep the skin incision within the muscle boundary and avoids it going astray over the other nearby muscles.

3. Incision

The skin incision is made along the line marked as above (Fig. 7.10A).

To re-confirm the proximal extent of incision, the index finger is insinuated under the skin from the proximal end so that the tip of ASIS is palpable with the distal phalanx buried under the intact skin. The subcutaneous tissue is incised along the line of incision deep till the anterior fascia of Tensor fascia Lata (TFL) muscle and the tissue of either side retracted with the help of universal retractor (Fig. 7.10B).

The TFL muscle is identified by its pinkish hue. (Fig. 7.10C).

The other identifying feature to differentiate it from the Sartorius muscle is the direction of muscle fibres. The fibres of TFL run along the anterolateral direction while the fibres of Sartorius muscle are directed anteromedially.

4. Deep Dissection

A nick is made over the middle of anterior fascia of TFL (Fig. 7.11A).

Fig. 7.5 A: Photograph showing positioning of the patient on Operating table with a provision of break at the level of pelvis. B: Photograph showing positioning of the patient and centering the Image Intensifier (crossed red lines) for intraoperative image (inset) to look for any obstruction or any metallic parts coming on the way of image arms

The incision is then extended proximally and distally with Metzenbaum scissors (Fig. 7.11B).

It is to be noted that the incision shouldn't be more medial to prevent injury to the Lateral Femoral Cutaneous Nerve (LFCN). Also, it shouldn't be more lateral as it will make the retraction of muscle belly difficult and hence compromise the exposure. The medial flap of fascia is held with two Allis forceps and elevated off the muscle (Fig. 7.12A).

A blunt dissection is carried underneath the medial fascia with the help of Cobb's retractor to separate the muscle belly from the fascia (Fig. 7.12B).

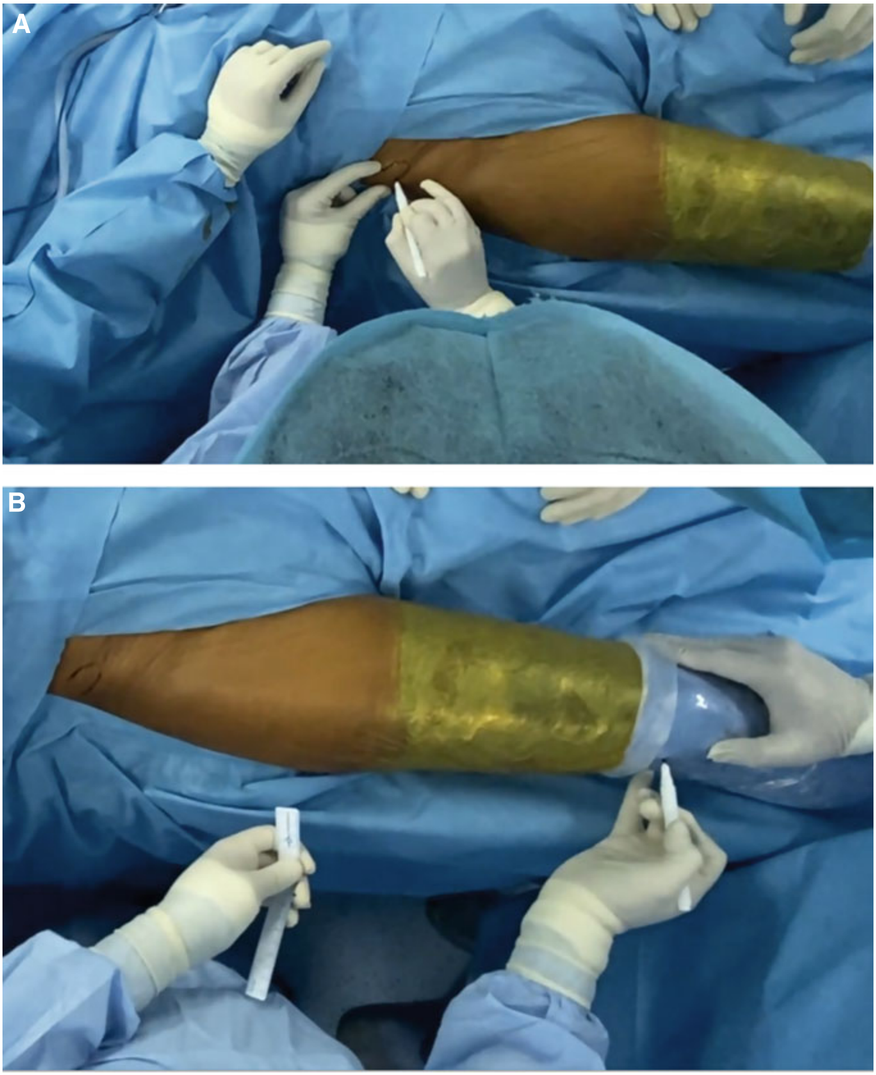

Fig. 7.6 A. Photograph showing marking of the Anterior Superior Iliac Spine (ASIS). A point is then marked which is an inch inferior and lateral to it. B. Photograph showing marking of a point at the fibular head

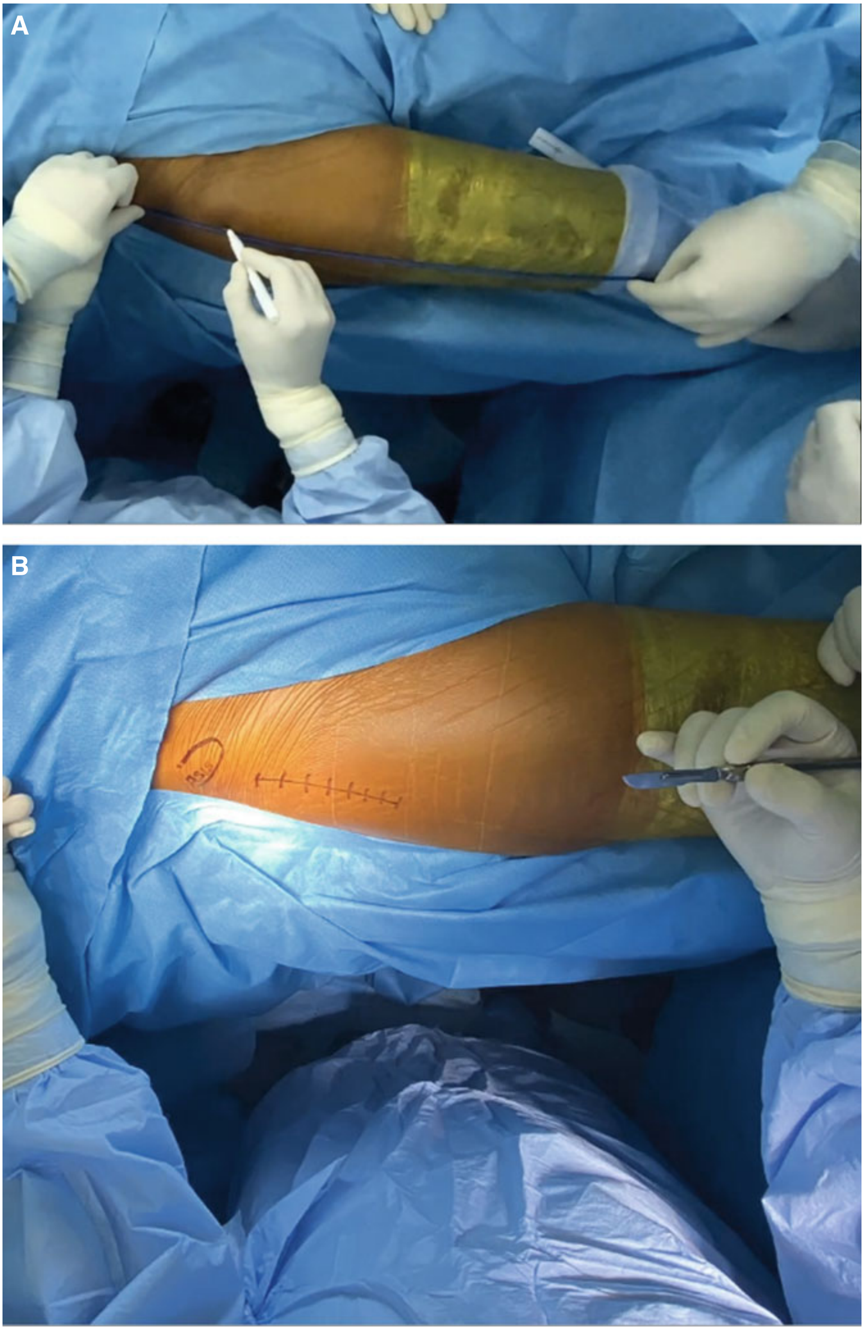

Fig. 7.7 A. Photograph showing an electrocautery lead being used to connect the points described in Fig. 7.6A and B. B. Photograph showing the site and length of incision for DAA

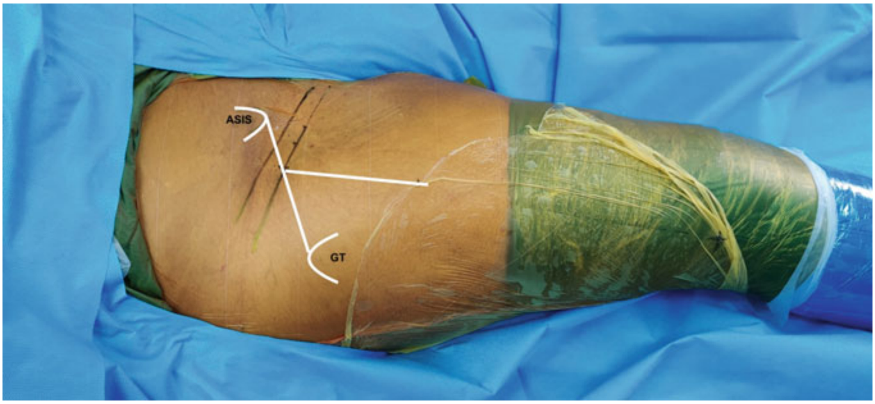

Fig. 7.8 Photograph showing alternative way for making the incision in DAA, the proximal end is the mid-point of the line joining ASIS and GT and running 8–10 cm towards the ipsilateral fibular head

Fig. 7.9 Photograph showing clinical palpation of the Tensor fascia Lata (TFL) muscle

The retractors are repositioned at this level by retracting the TFL laterally and the reflected head of the rectus femoris and iliocapsularis muscles medially thereby exposing the posterior fascia of TFL muscle.

5. Exposure of the joint capsule

A delicate dissection is performed to delineate the branches of lateral circumflex femoral artery (Fig. 7.13A).

This dissection is very important because an inability to find these vessels suggests that you are not in the right path. Finding these vessels is an important to way confirm

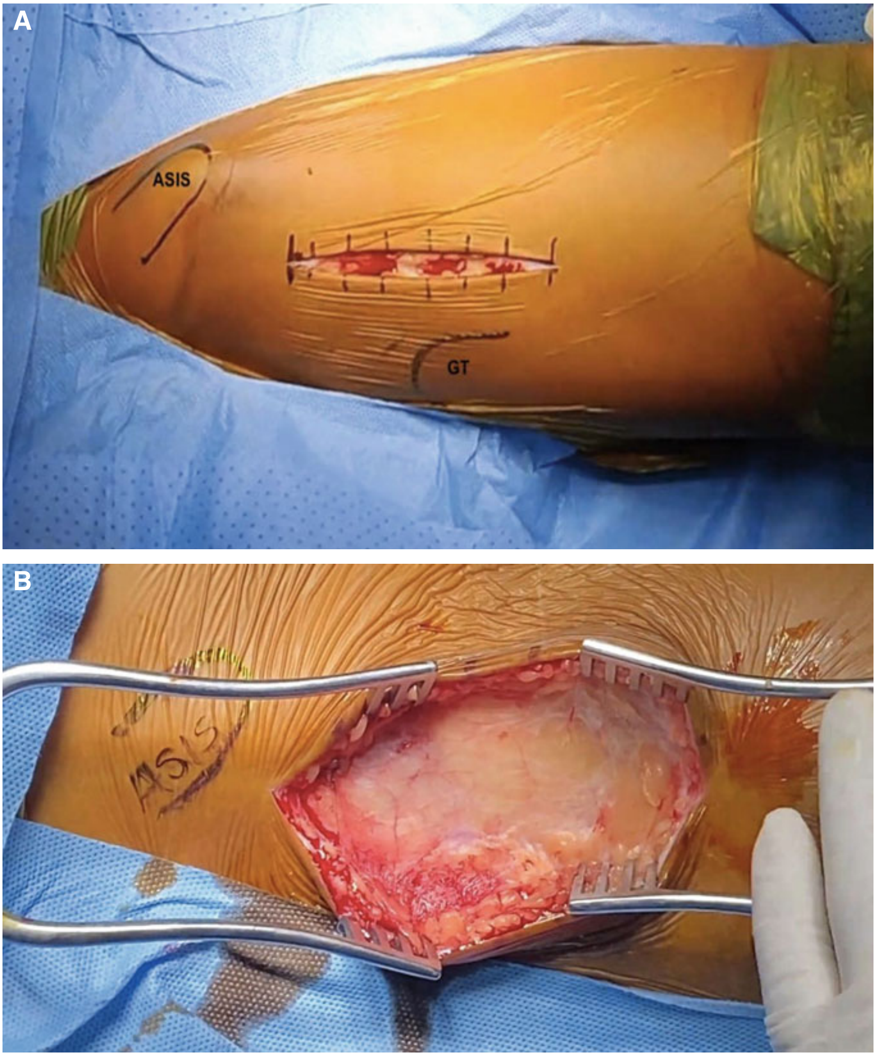

Fig. 7.10 A. Intraoperative picture showing the skin incision following subcutaneous tissue dissection. B. Intraoperative picture following subcutaneous tissue dissection. C. Intraoperative picture showing deep dissection exposing the anterior fascia of TFL muscle

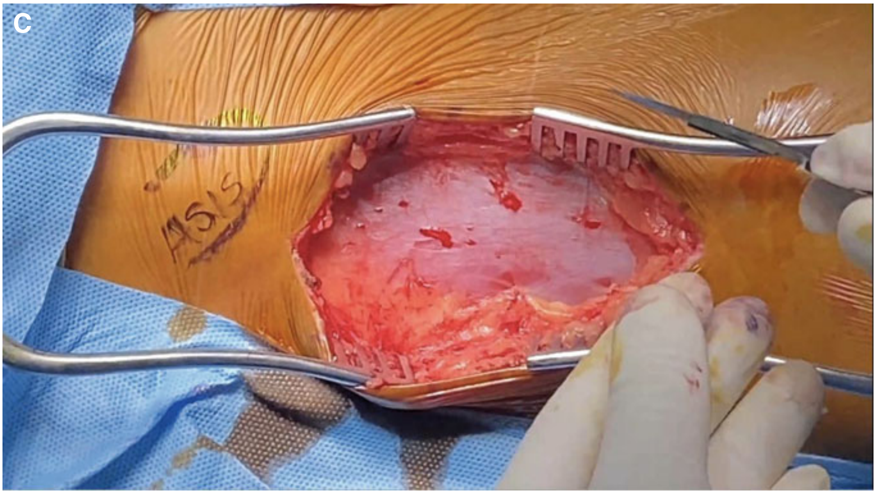

Fig. 7.10 (continued)

that you are in right plane and not too medial. These vessels may be either cauterized or ligated without leaving any branches with potential to bleed (Fig. 7.13B).

The posterior fascia is then incised and often the precapsular fat just pops out thereby confirming that you are over the anterior capsule of the hip joint (Fig. 7.14).

The index finger is run over the fat to reach the capsule over the superior and inferior neck and position the curved retractors over them (Fig. 7.15).

The hip is then slightly flexed to relax the rectus and iliocapsularis. The reflected head of rectus femoris and the iliocapsularis muscle are gently teased away from the capsule thereby exposing the white glistening anterior capsule (Fig. 7.16).

A curved retractor is then insinuated over the anterior capsule over the anterior column of the acetabulum (Fig. 7.17).

Here, the retractor should be directed towards the contralateral kidney to prevent inadvertent injury to the femoral vessels. With the retractors in place, the precapsular fat is excised for good visualisation of the joint capsule (Fig. 7.18).

6. Capsulotomy

Anterior capsulotomy is performed in an inverted T-shaped fashion (Fig. 7.19) which may be completed to a H-shape as shown in Fig. 7.20A–C.

The superior flap of the capsule is secured with a Ethibond suture and reflected superiorly towards gluteus minimus muscle lying immediately above the capsule (Fig. 7.21).

The curved retractors are then repositioned to similar positions inside the joint capsule around the neck and anterior acetabulum (Fig. 7.22).

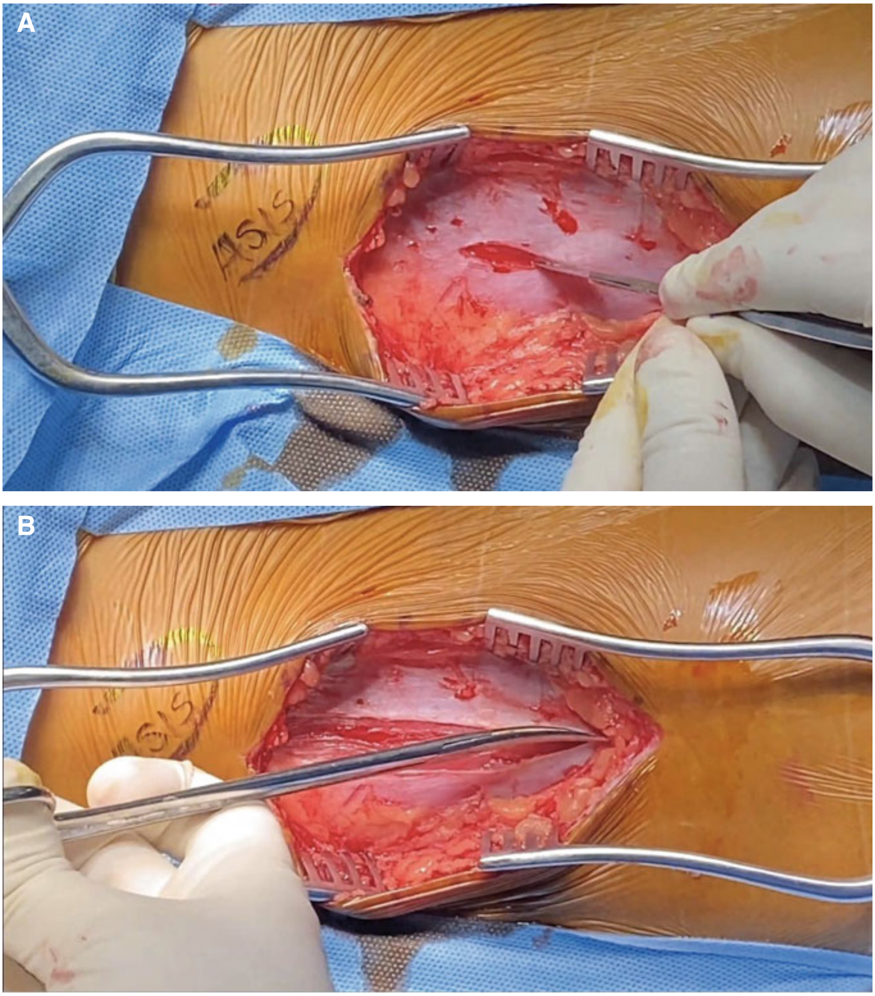

Fig. 7.11 A. Intraoperative picture showing nick at the anterior fascia of TFL. B. Intraoperative picture showing extension of the nick proximally and distally along the line of incision

The femoral neck should be well visualised at this point.

7. Femoral neck osteotomy

An insitu double osteotomy at the femoral neck is marked (Fig. 7.23) to remove a ‘napkin ring’ of the bone that facilitates the removal of femoral head. While performing the osteotomy, the sub-capital osteotomy is performed first followed by the distal one (Fig. 7.24A–C).

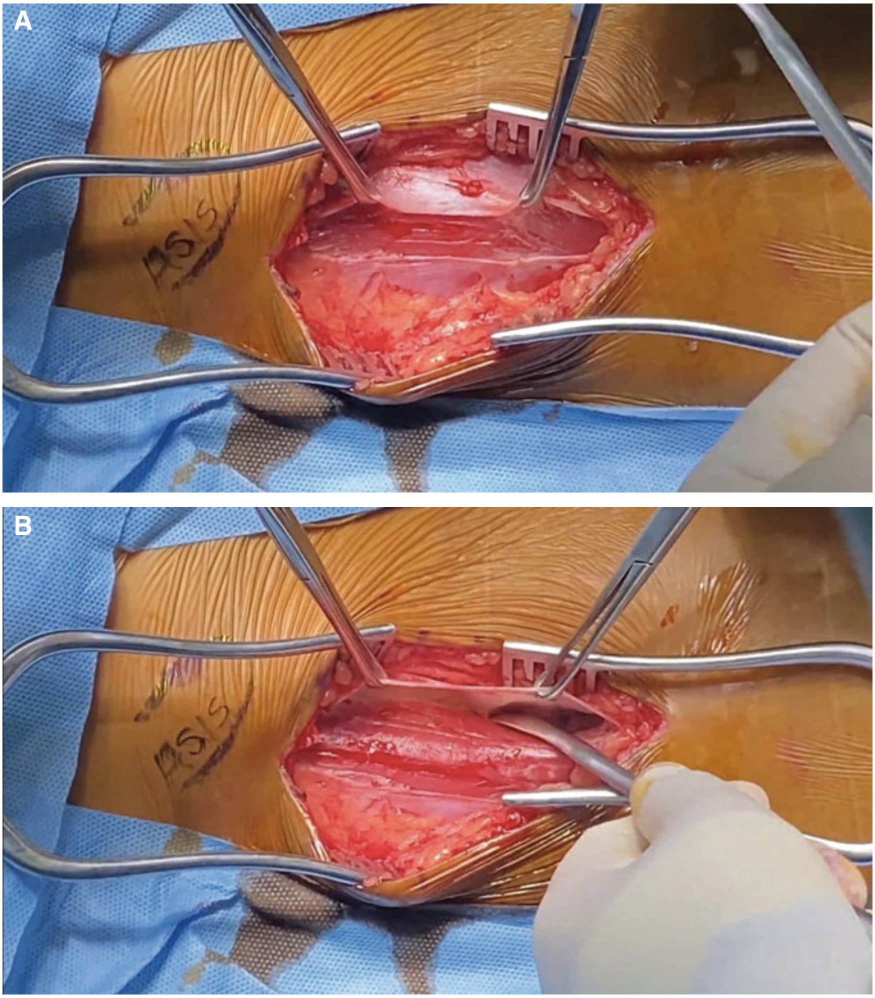

Fig. 7.12 A. Intraoperative picture showing holding of the medial flap of anterior fascia of TFL with the help of Alli's forceps. B. Intraoperative picture showing blunt dissection underneath the medial fascia using the Cobb's elevator

The distal osteotomy should be at the level of the femoral neck intended to be left depending on the femoral stem to be used and the vertical offset to be restored.

8. Removal of femoral head

The femoral head is removed with the help of a cork screw drilled into the femoral head (Figs. 7.25A–C).

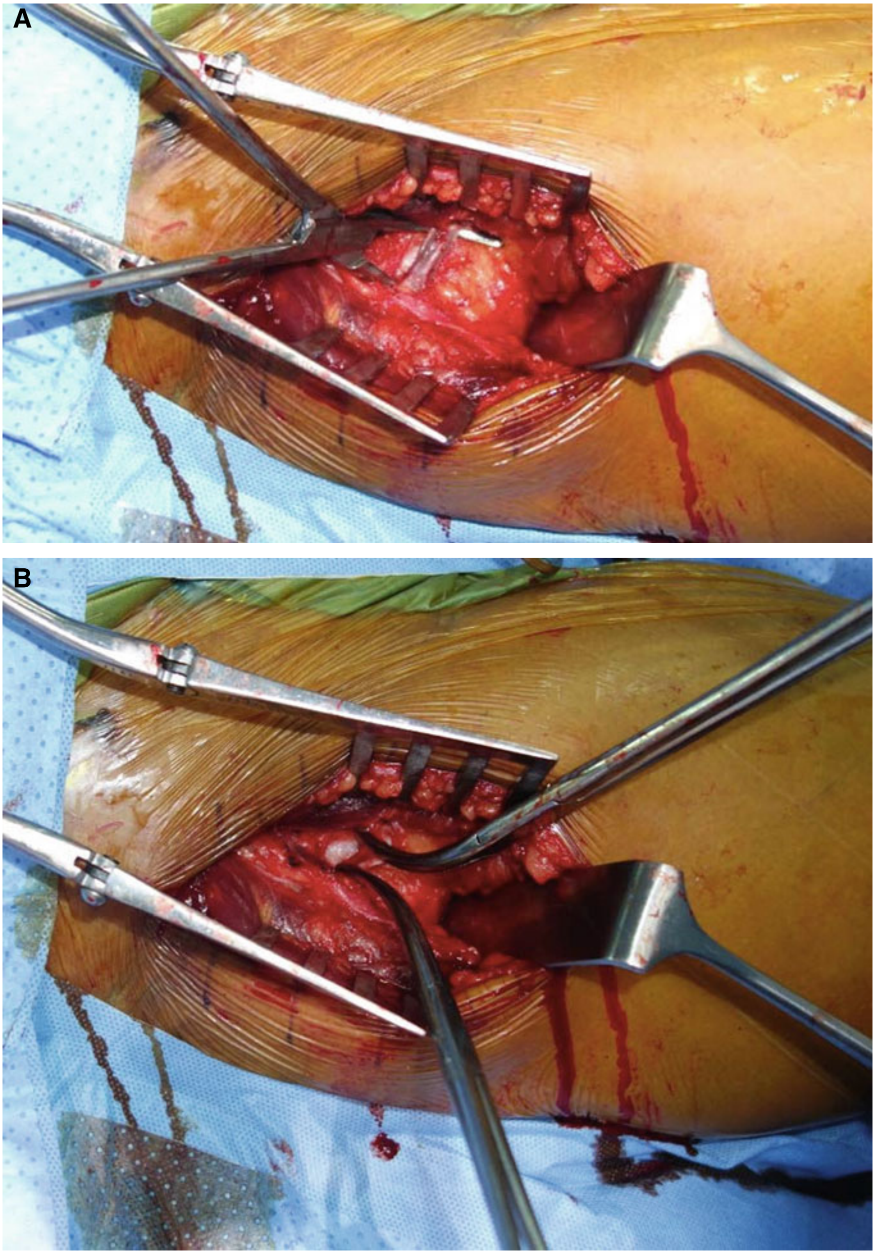

Fig. 7.13 A. Intraoperative picture showing dissection and identification of the branches of lateral circumflex femoral artery. B. Intraoperative picture showing coagulation of the branches of lateral circumflex femoral artery

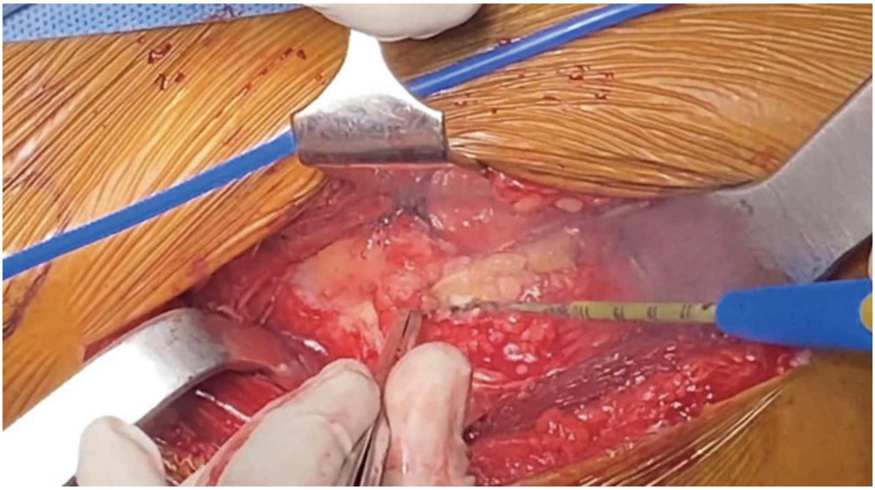

Fig. 7.14 Intraoperative picture showing removal of the fat overlying the anterior capsule of the hip joint

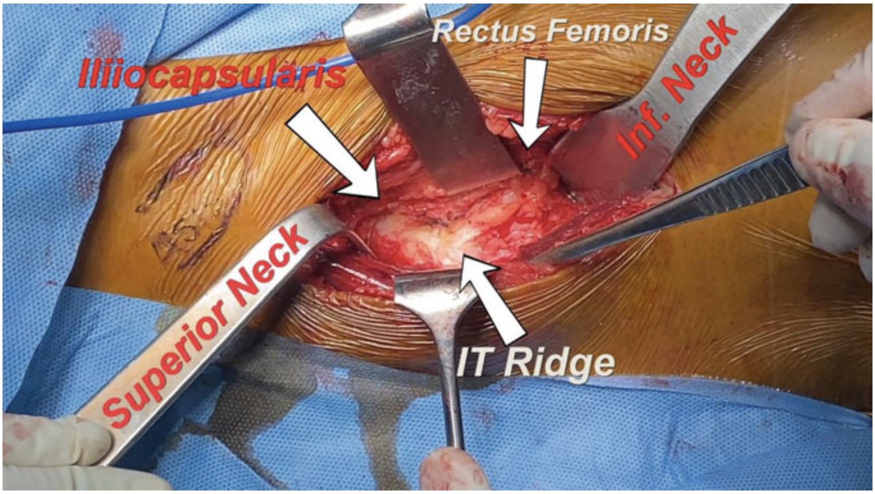

Fig. 7.15 Intraoperative picture showing the placement of the retractors above the joint capsule

It is to be noted that the screw needs to be put at the region of good bone in the femoral head to prevent cut out. Before pulling out the femoral head, the corkscrew handle with the screw holding the femoral head is moved 360^0 to break adhesions in the joint, if any. The head needs to be removed while moving it within the joint rather than directly pulling to prevent pull out of corkscrew in case the bone quality is poor.

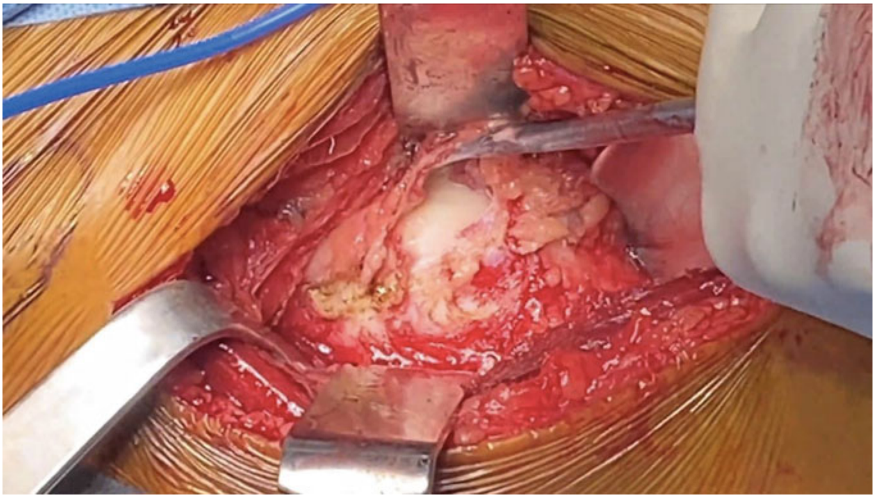

Fig. 7.16 Intraoperative picture showing teasing off the fibres of rectus and iliocapsularis muscle with the help of cobb's retractor. Note the white glistening capsule underneath the cobb's elevator

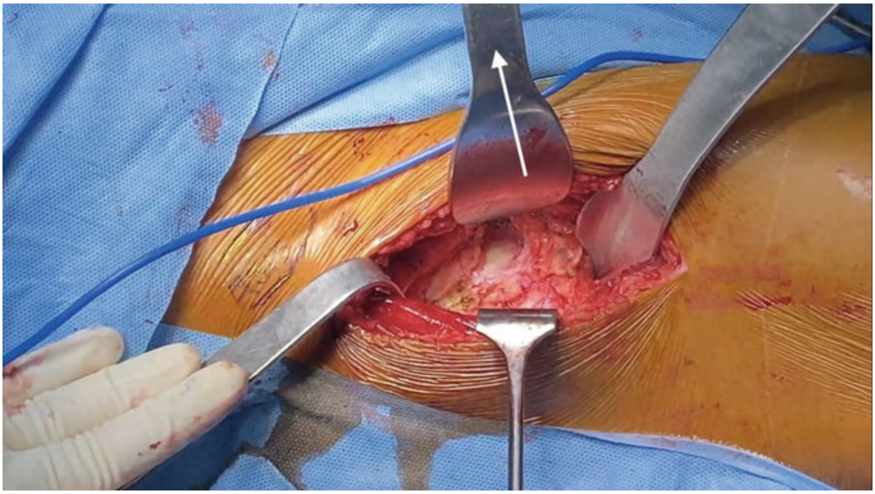

Fig. 7.17 Intraoperative picture showing insertion of the anterior curved retractor the handle of which is directed towards the contralateral kidney (white arrow)

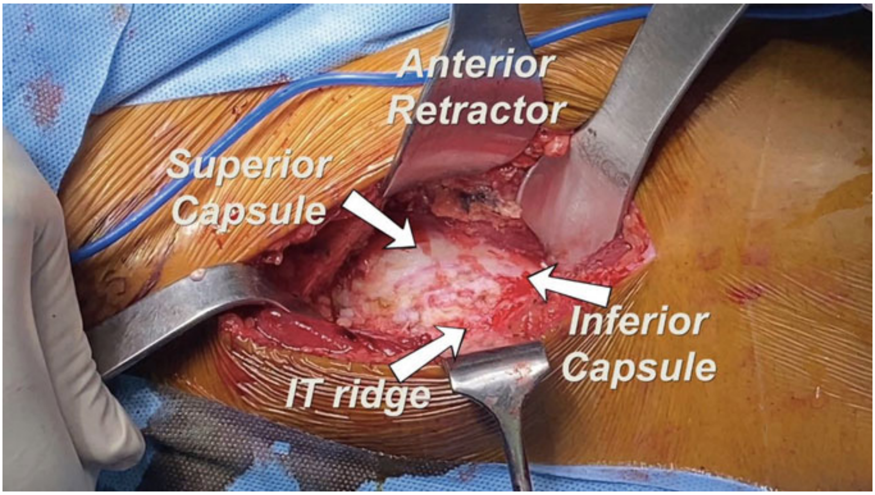

Fig. 7.18 Intraoperative picture showing the final placement of the retractors above the joint capsule

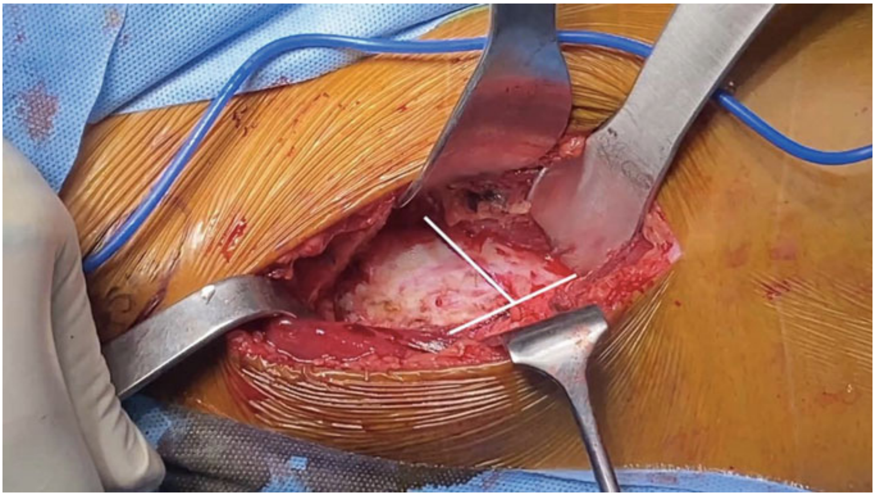

Fig. 7.19 Intraoperative picture showing marking for the inverted "T" shaped incision over the anterior capsule

Rotation of sharp bony cut surface of the neck away from TFL while extracting the femoral head will prevent inadvertent laceration of the TFL.

9. Acetabular exposure and preparation

Once the femoral head is removed, it gives a view of the acetabular cavity. However, remember that, while removing the femoral head, almost in all cases the curved retractors especially the superior and inferior ones get displaced and ultimately land in the hands of your assistant(s). For proper acetabular visualization, these retractors need to be repositioned. But before that, for an adequate visualisation of the acetabular cavity, the femur needs to be mobilized laterally. The following capsular releases are performed at this stage:

1. The plane between the superior capsule and the labrum at the acetabular rim which will be around 11 o'clock position for left hip and 1 o'clock position for the right hip, is identified and the cautery tip is run vertically upwards to release the capsular attachment adjacent to it in an inside-out direction (Fig. 7.26).

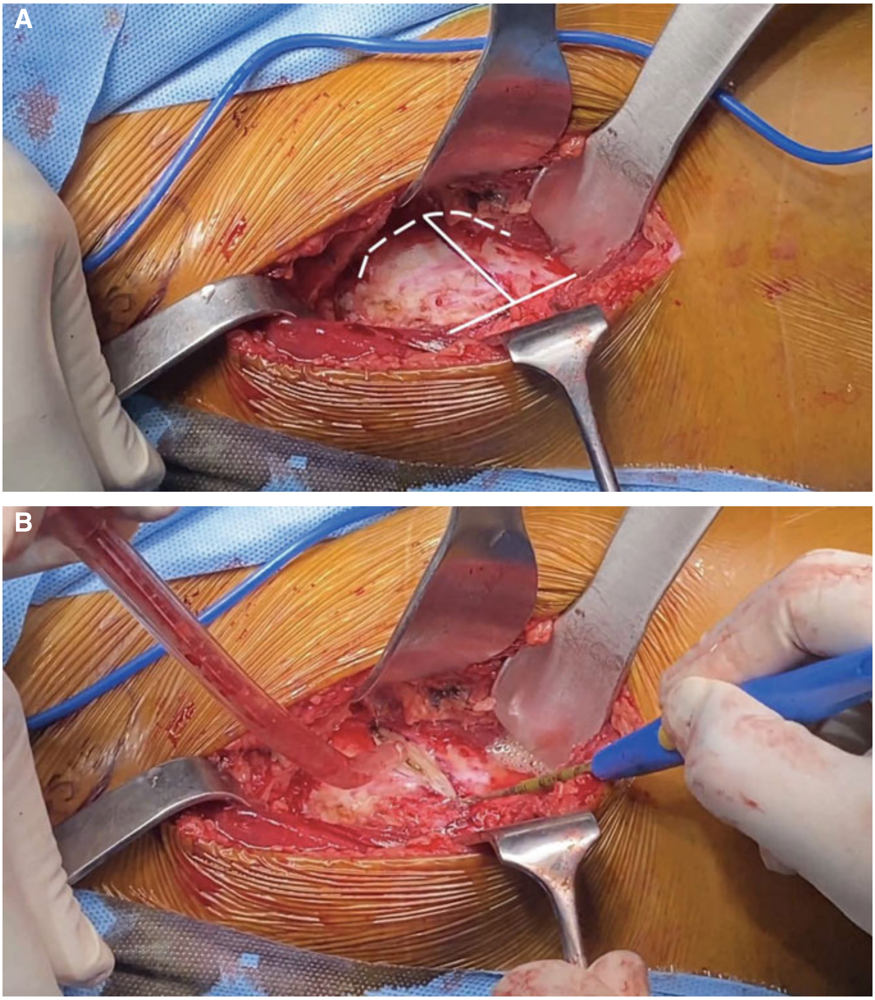

Fig. 7.20 A. Intraoperative picture showing marking for completion of the inverted "T" shaped incision to a "H" shaped. B. Intraoperative picture showing incising the anterior capsule with electrocautery. C: Intraoperative picture showing elevation of the superior flap of the capsule

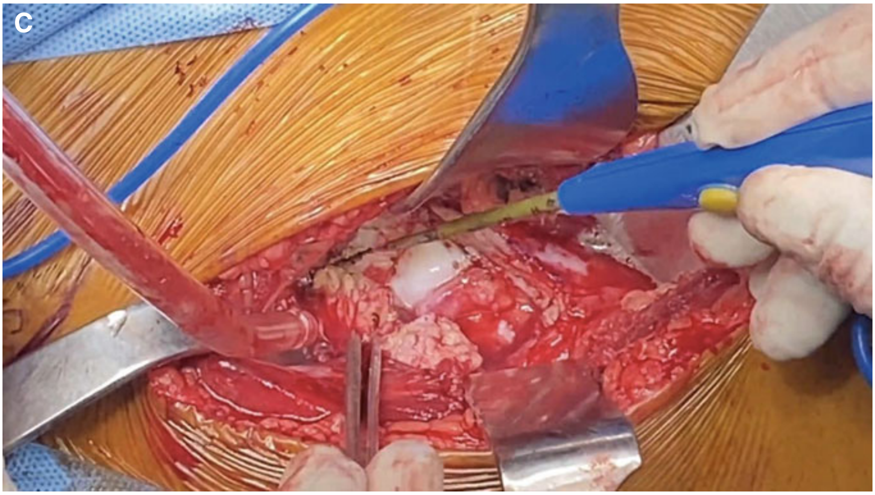

Fig. 7.20 (continued)

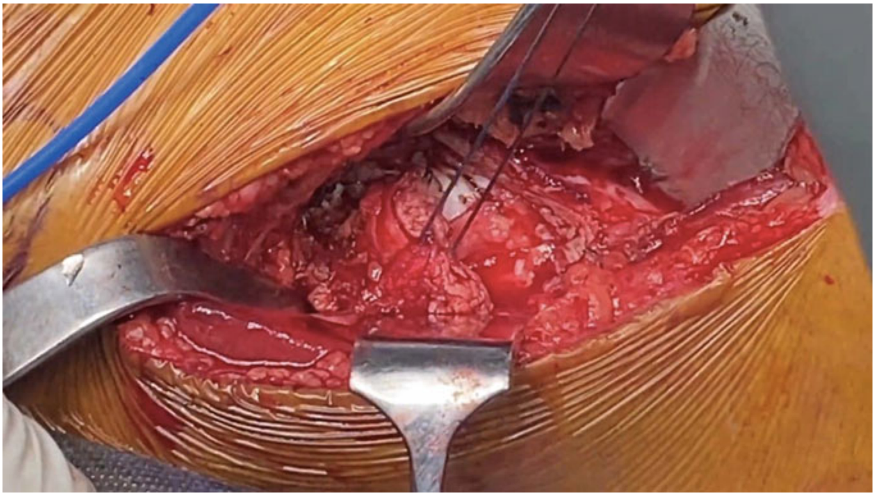

Fig. 7.21 Intraoperative picture showing securing the superior capsular flap with the ethibond suture and reflecting it upwards

2. This will not only help in enhancing the visualization of acetabular cavity but also help keep the proximal femur away from the acetabulum.
3. The capsule is released off the medial aspect of the femoral neck proximal to the lesser trochanter at the base of neck (Fig. 7.27).
4. Simultaneously the femur is externally rotated and the lesser trochanter is palpated (Fig. 7.28).

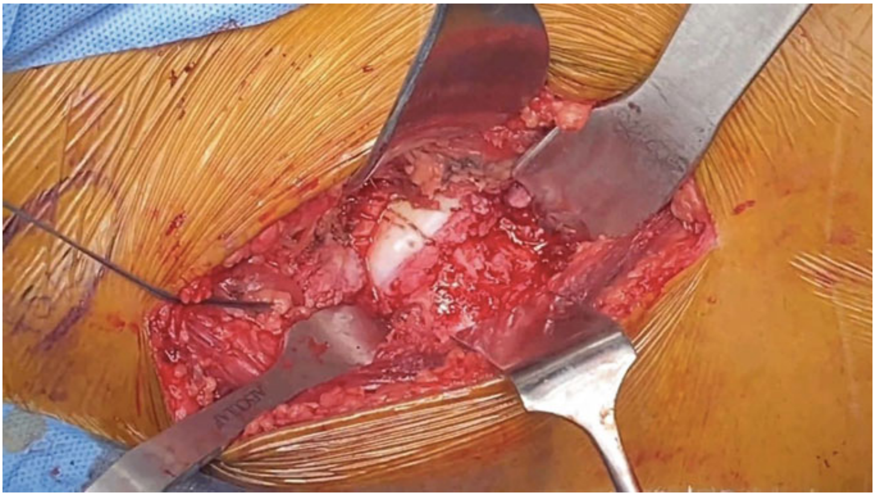

Fig. 7.22 Intraoperative picture showing readjustment of the retractors beneath the capsule

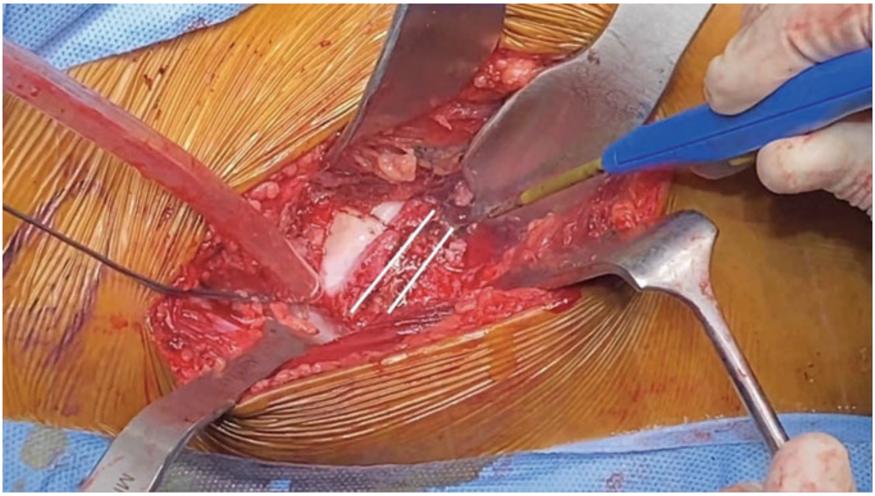

Fig. 7.23 Intraoperative picture showing marking for the double osteotomy over the anterior neck

5. Simultaneous external rotation of the leg while performing the medial capsular release enhances visualisation and keeps the capsular tissue under tension facilitating the release.
6. The capsular release around the calcar is performed directly by bending the cautery tip and running it on the calcar insertion.

The sequence of releases here can be remembered with the acronym a-b-c signifying acetabular rim—base of neck—calcar.

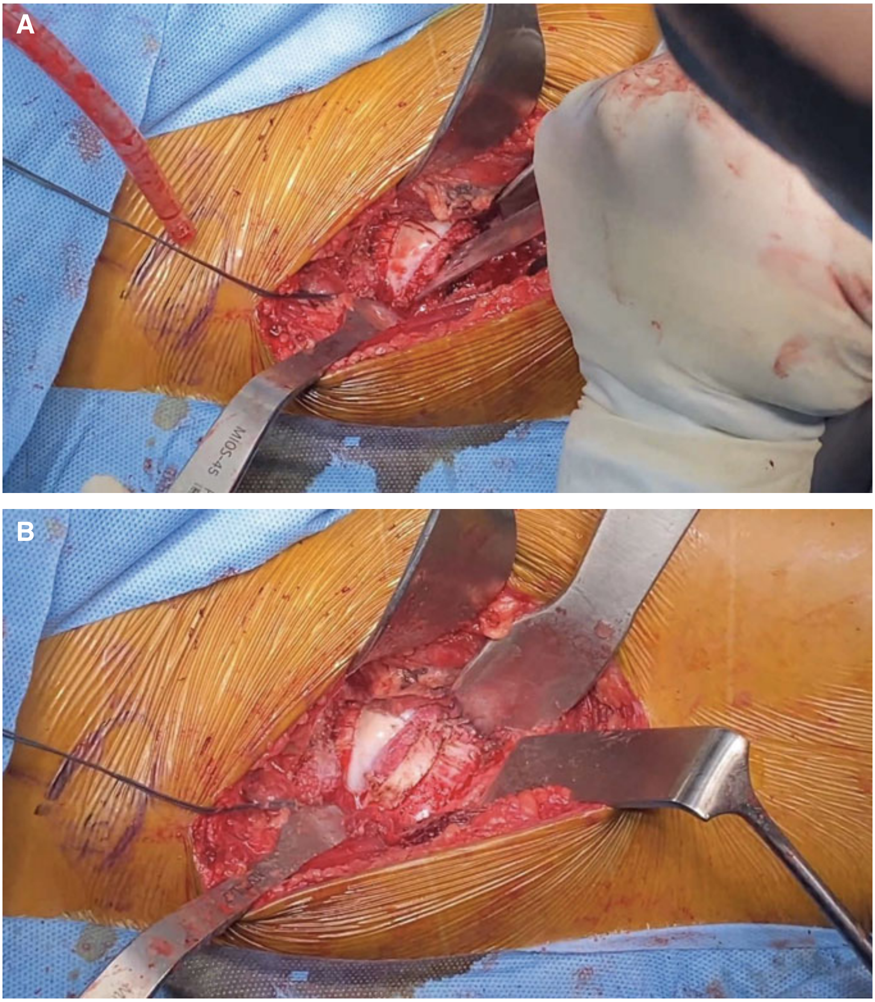

Fig. 7.24 A. Intraoperative picture showing osteotomy at the sub-capital level. B. Intraoperative picture following osteotomy at the distal level. C. Intraoperative picture showing removal of the napkin ring of bone

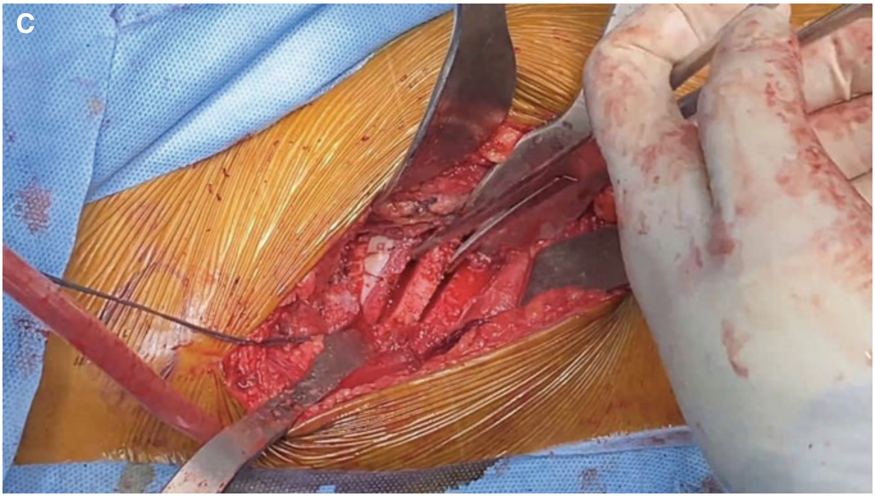

Fig. 7.24 (continued)

With the anterior retractor at the anterior column of the acetabulum, the other retractors are re-adjusted now. The inferior retractor is positioned such that the tip lies against the transverse acetabular ligament (TAL) to retract the inferior capsule and the iliopsoas tendon away from the acetabular rim. The pubofemoral ligament may be split using an electrocautery whenever required to allow insertion of the retractor and improve the exposure. A curved retractor with long handle is positioned against the posterior aspect of acetabulum to retract the proximal femur away for acetabular preparation. An additional retractor may be placed underneath the tied superolateral capsule that is protecting the gluteus minimus muscle to further improve the acetabular exposure (Fig. 7.29).

The labrum and the soft tissues at the margin of the acetabular rim which interfere with the acetabular preparation are removed. The acetabulum is reamed with the help of offset reamer handle successively to a satisfactory size. One can use a trial cup to see the size and fitting over the reamed acetabulum. The authors use the last reamer in situ to look for the acetabular component size and view it in the image intensifier to look for the orientation of cup (Fig. 7.30A and B).

The acetabular component mounted over the offset handle is implanted into the reamed acetabulum (Fig. 7.31).

- Care should be taken while impacting the acetabular component. If the handle is closer to the thigh the cup may be more horizontal, if its more away from the thigh the cup may be impacted in vertical position. Similarly, if the handle is down towards the floor, the acetabular anteversion may be less and if it is towards the ceiling, the anteversion may be more (Fig. 7.32A and B).

The acetabular component may be impacted under the image guidance (Fig. 7.32).

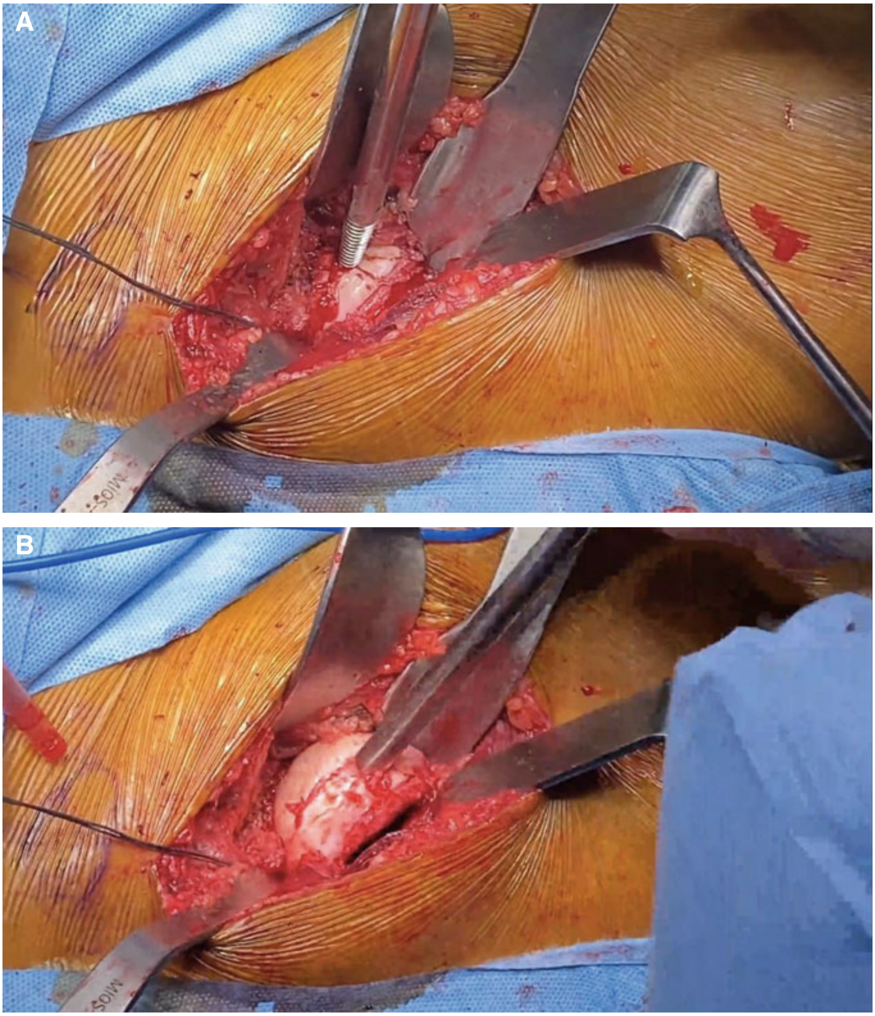

Fig. 7.25 A. Intraoperative picture showing insertion of the cork screw into the femoral head. B. Intraoperative picture moving the head inside the joint to break the adhesions, if any. C. Intraoperative picture showing removal of the femoral head

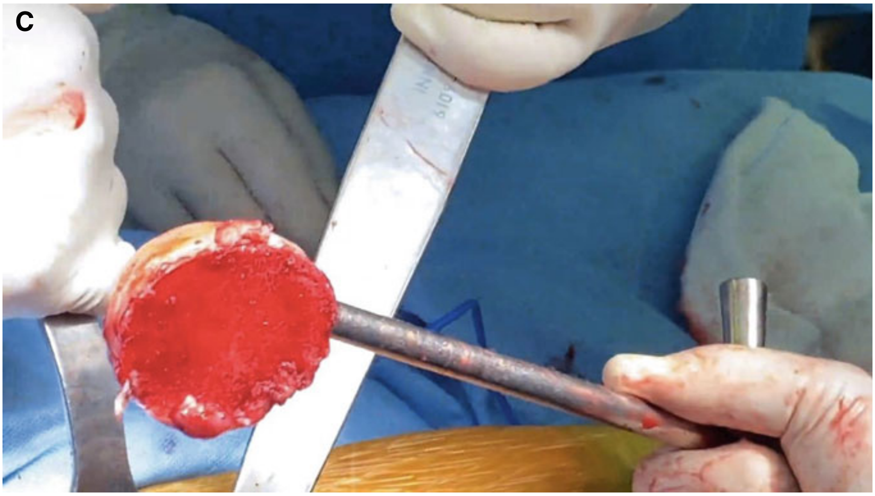

Fig. 7.25 (continued)

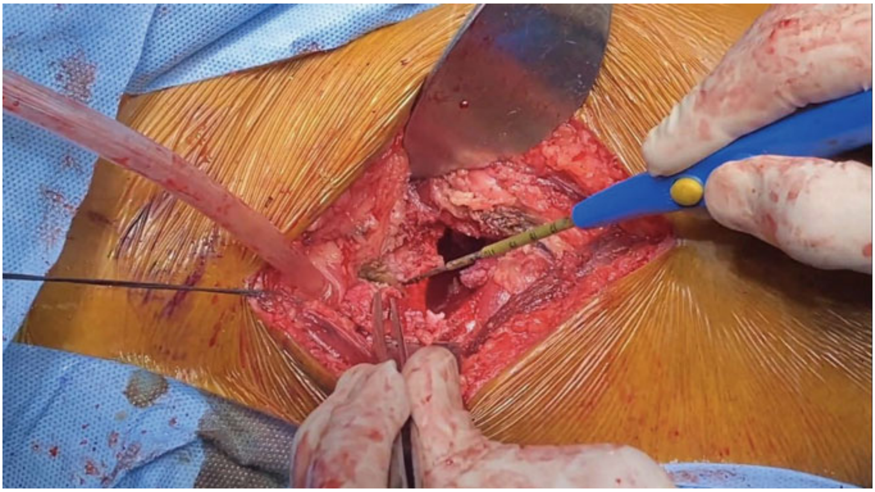

Fig. 7.26 Intraoperative picture showing release at the acetabular side between the labrum and the lateral capsule. Note the 11 o'clock position for the left hip

Alternatively, the Transverse Acetabular Ligament (TAL) also helps as a landmark for cup orientation as it does for the posterior approach. Once the cup is impacted, it can be supplemented with screws under image guidance (Fig. 7.33A–C) followed by the insertion of the acetabular liner (Fig. 7.34A–C).

After implantation of the acetabular components, the superior capsule tied with the Ethibond can be excised. The capsule is pushed medially and centrally into the

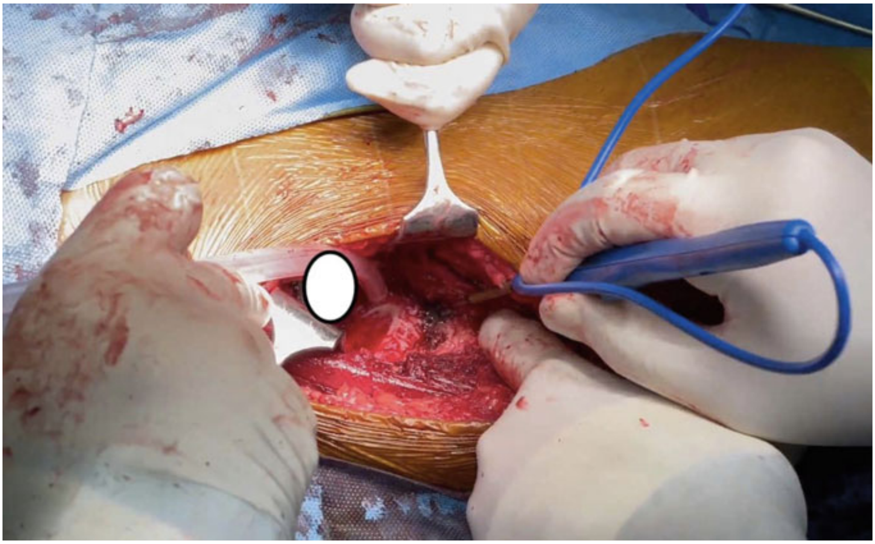

Fig. 7.27 Intraoperative picture showing release of the capsule from the medial aspect of the femoral neck with simultaneous external rotation of the femur, till the lesser trochanter. The white shade covering the acetabulum

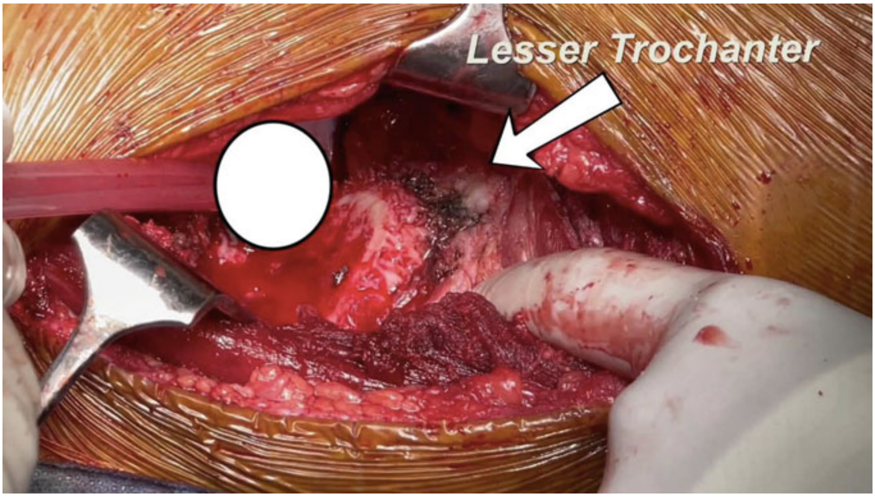

Fig. 7.28 Intraoperative picture showing the lesser trochanter (white arrow) following the medial release at the femur. The white shade covering the acetabulum

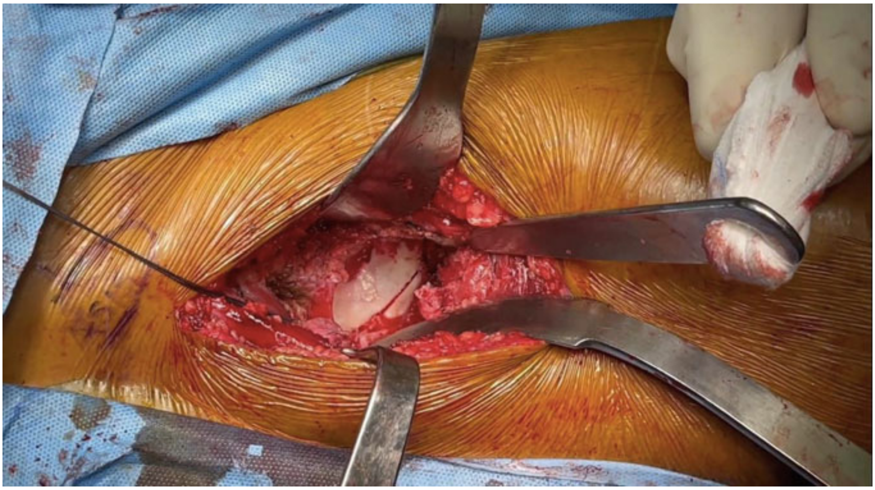

Fig. 7.29 Intraoperative picture showing placement of the retractors exposing the acetabular cavity

socket by holding with a Kocher's forceps to develop a plane between it and the gluteus minimus muscle (Fig. 7.35A–C).

10. Femoral mobilization

Preparation of femur is considered as the most challenging part in DAA to Hip. The proximal femur needs to be delivered up through the surgical wound before broaching. At this stage, most of the soft tissue releases from the medial aspect of the femur and the acetabular rim must have been already performed during acetabular exposure. These releases help in retracting the proximal femur away from the acetabular margin. There are three main steps to deliver the femur upward for preparation viz, external rotation, adduction and elevation. The first two movements can be achieved by the releases performed till this stage. However, for elevation, the proximal femur should be freed of the soft tissue attachments at the posterolateral aspect of the cut face of the femoral neck just cephalad to the insertion of short external rotators. The releases here are carried out in the following steps:

1. With the limb in external rotation, a bone hook is inserted into the cut surface of the femoral neck which is pulled upwards (Fig. 7.36).
2. This maneuver helps in proper visualisation and puts the posterolateral soft tissue under tension thereby facilitating release. As this maneuver can potentially cause inadvertent injury to the femur, the limb may be extended by breaking the table at the junction and lowering down the foot end of the table or bringing the foot down if the special table is used. With the bone hook handle pulling the proximal femur up, the electrocautery is run along the lateral neck close to the bone releasing off the soft tissue from the inner aspect of the greater trochanter till the trochanteric fossa, from 10 O'clock to 12 O'clock on the left side and 12 to 2 O'clock on the right side (Fig. 7.37).

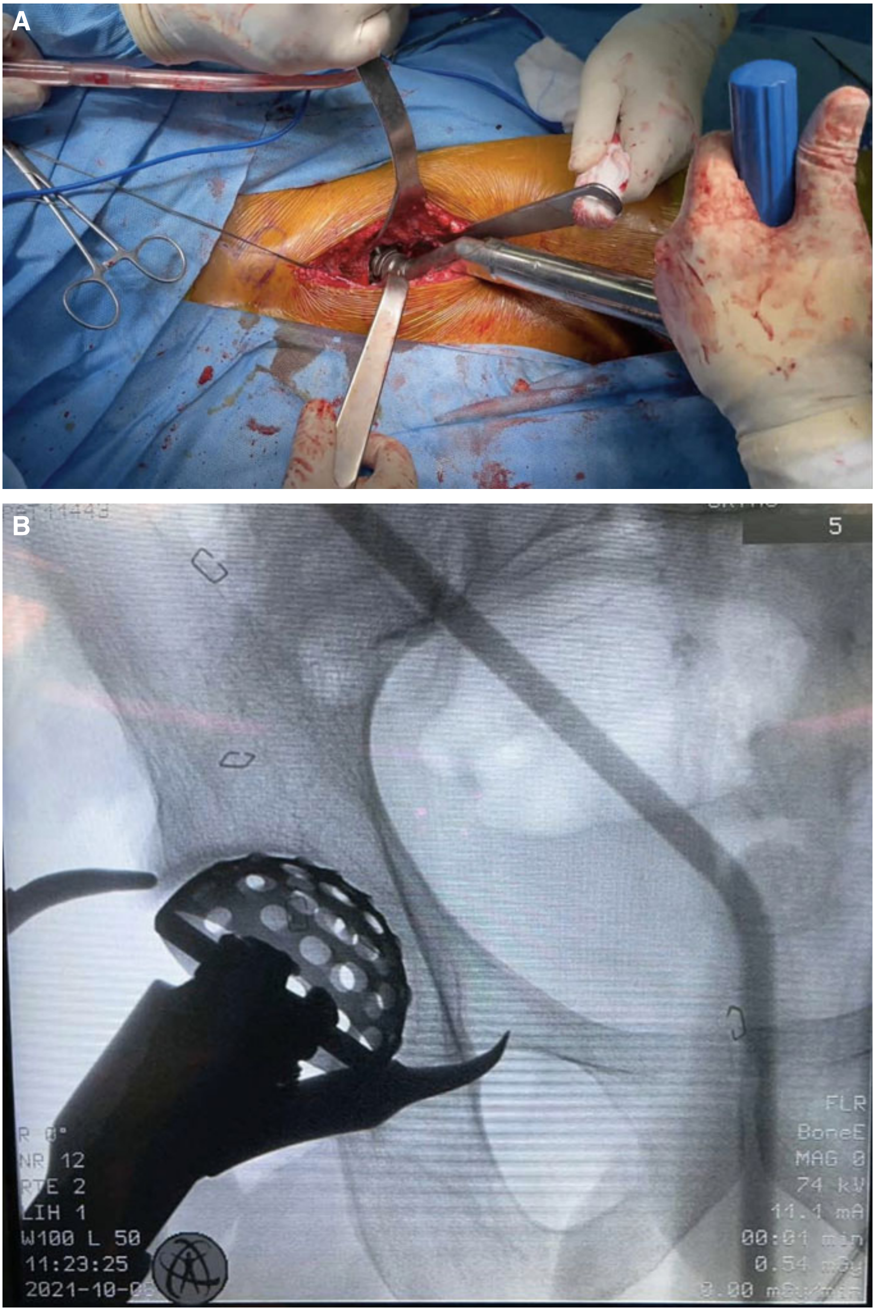

Fig. 7.30 A. Intraoperative picture showing reaming of the acetabular cavity with an offset reamer handle. B. Intraoperative picture showing intraoperative image showing orientation of the reamer

Fig. 7.31 Photographer showing mounting the acetabular component onto the offset cup impactor

While performing this release, one can appreciate the proximal femur being pulled upward slowly with the bone hook.

3. The remnants of the lateral neck can be removed with the rongeur. The conjoint tendon and piriformis tendons are visualized on the medial aspect of the GT. If the proximal femur is still not mobilized sufficiently, the conjoint tendon can be sharply incised with the cautery at its insertion on the medial greater trochanter. After this release, the femur should be pulled easily upward as the piriformis gets flipped posteriorly. Rarely, if the femur is still not mobilized, the piriformis tendon can be incised. Releasing these tendons improves the mobility of the femur with little morbidity as these rotators do not retract but heal in their anatomic position (Ziran and Matta 2016). Often the obturator externus tendon is visible on the medial aspect of GT at this stage. This tendon must be preserved as it has a direct medial pull on the proximal femur and provides the maximum resistance to hip dislocation. During all these releases, keeping electrocautery close to the bone is essential to avoid injury to the posterior retinacular vessels. Bleeding, if any should be coagulated properly to avoid post operative hematoma.

After all the releases are completed, a curved retractor for trochanteric elevation is placed posterior to the GT on the externally rotated femur (Fig. 7.38).

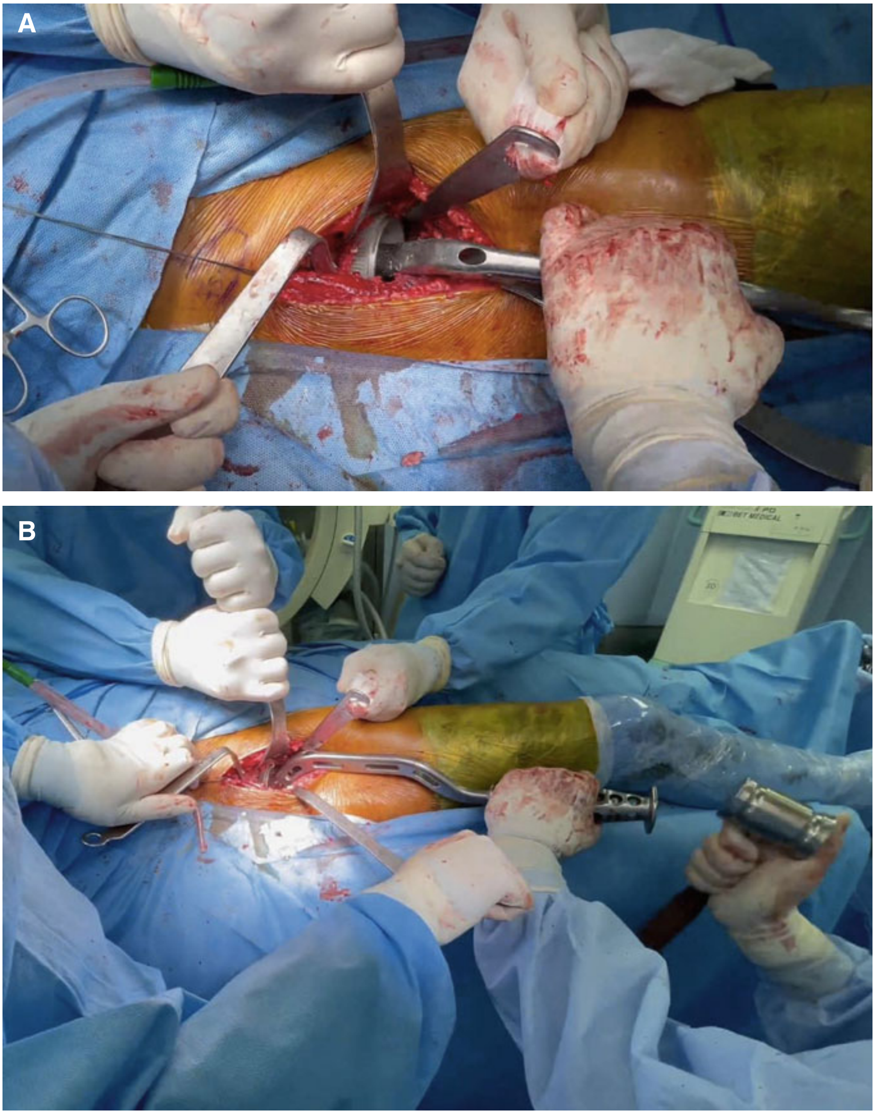

Fig. 7.32 A. Intraoperative picture showing impaction of the acetabular component into the reamed acetabulum. B. Intraoperative picture = Note the position of the handle of the cup impactor. C. Intraoperative picture = Intraoperative image following impaction of the acetabular component

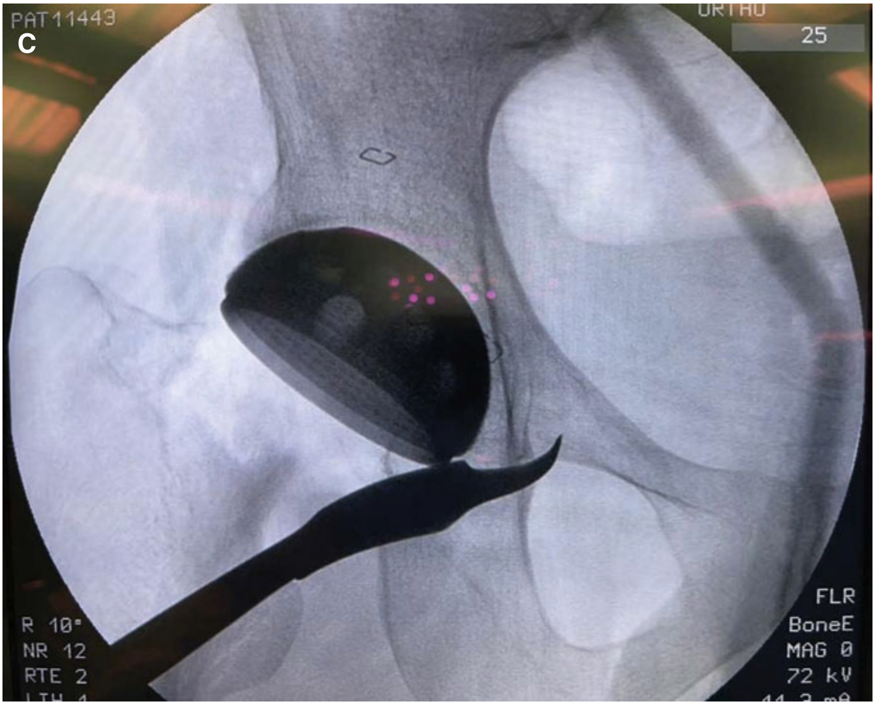

Fig. 7.32 (continued)

The hip is then extended and adducted for femoral preparation. This can be achieved by moving the limb under the opposite limb thereby keeping it in ‘Figure-of-4’ position (Fig. 7.39).

Intraoperative photograph showing positioning of the operating limb under the contralateral limb.

Another curved retractor is placed against the posterior surface of the femoral neck to move it away from the acetabulum. This makes the proximal femur ready for further preparation (Fig. 7.40).

11. Femoral preparation

The femoral broaching depends on the type of femoral stem being used. The authors’ preferred stem is a short uncemented stem for which the entry point for femoral preparation will be the centre of the cut surface of femoral neck (Fig. 7.41).

For a standard conventional stem, a canal finder is rasped into the femoral canal starting adjacent to the posterior femoral cortex and directed towards the floor for valgus positioning without penetrating the cortex (Fig. 7.42).

The rasp can be moved in and out a couple of times to ensure that it is within the intramedullary canal. After confirming the entry in the canal, successive broaching is performed till the templated size (Fig. 7.43A and B).

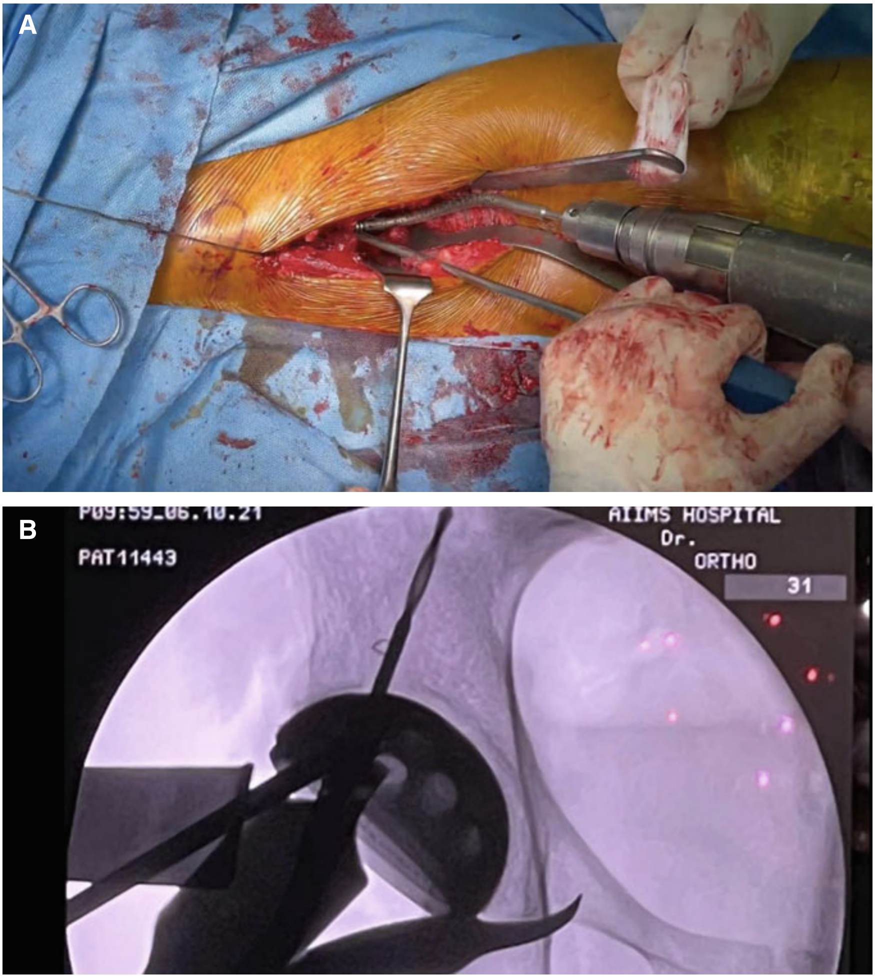

Fig. 7.33 A. Intraoperative picture showing drilling for the acetabular screws. B. intraoperative image showing the position of the drill bit. C. Intraoperative picture following screw insertion

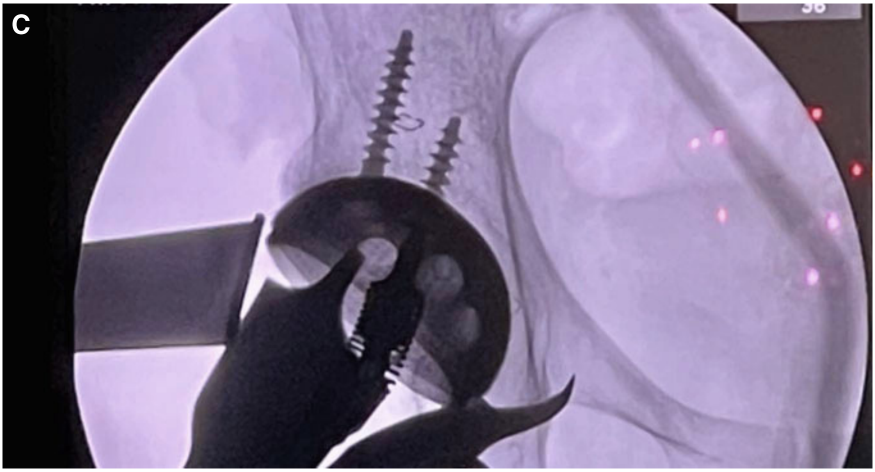

Fig. 7.33 (continued)

Once the appropriate broach fit is achieved, the broach is left in situ followed by insertion of trial neck and head (Fig. 7.44).

The hip is then reduced (Fig. 7.45A and B).

Both the limbs are brought back into neutral position. The hip is seen under Image for the stem position. At the same time, both the limbs are assessed for Limb Length by palpating both the patellae as well as the medial malleoli (Fig. 7.46A and B).

Adjustment for the limb length, if any required, is done by selecting the femoral head of appropriate offset. The hip may be moved in different directions to check for the stability. Once the stability is ensured, the hip is then dislocated with the use of a bone hook around the trial neck by pulling it outward and upward while the limb is simultaneously taken into extension (Fig. 7.47).

The limb is repositioned into previous 'Figure-of-4' position and the proximal femur elevated using the trochanteric elevator. The trial implants are removed and the definite stem is then impacted with successive light blows till it seats at the calcar (Fig. 7.48A and B).

The definitive head is then placed on the trunnion and gently impacted (Fig. 7.48C).

Before the final reduction, the acetabular cup is checked and irrigated for any soft tissue interposition. The hip is then reduced by pushing the head with the help of head impactor (Fig. 7.48D and E).

A final fluoroscopic image is taken to ensure the position of the implants and check for any inadvertent complication including periprosthetic fractures (Fig. 7.49).

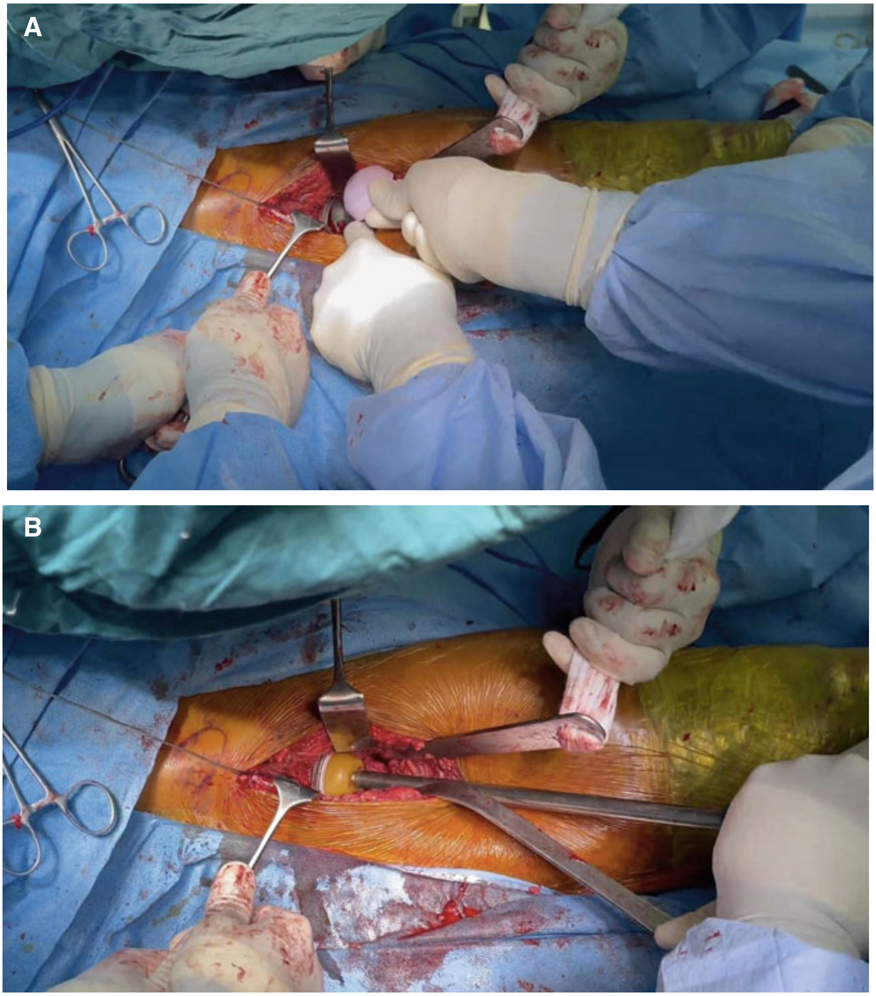

Fig. 7.34 A. Intraoperative picture showing insertion of acetabular liner. B. Intraoperative picture showing impaction of the acetabular liner. C. Intraoperative picture following final impaction

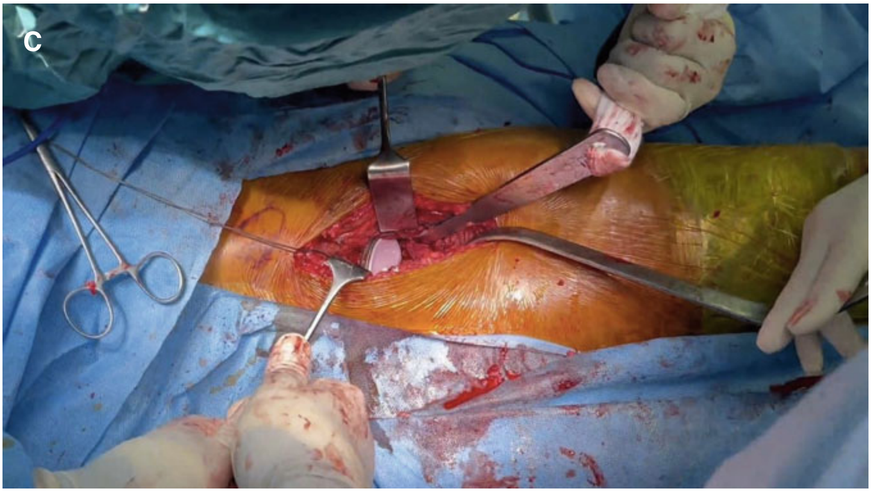

Fig. 7.34 (continued)

The authors routinely do not shift the patient out of operating room without seeing the final fluoroscopic image and advocate the same to all aspiring Direct Anterior surgeons.

12. Closure

The closure is performed in two layers only i.e., the anterior fascia of TFL muscle and the subcutaneous tissue with the skin. The fascia and subcutaneous tissue are closed with 2-0 vicryl (Fig. 7.50A and B) followed by staples for the skin over which a sterile dressing is applied.

7.5 Pearls and Pitfalls

1. The proximal femoral mobilization is the key to successful surgical outcome of DAA to hip. However, the femoral mobilization is achieved to some extent in conjunction with acetabular exposure as well.
2. The acetabulum should be well exposed and the reaming should not be started unless the 360-degree view of acetabulum is available to the surgeon.
3. The retractors placed should allow an easy entrance of acetabular reamer. If there is any struggle, the surgeon should revisit at the tight structures that may need further releases including the pubofemoral ligament. If the inferior capsule comes in the way of acetabular preparation, it can be excised.
4. Injury to the TFL should be prevented by not retracting this muscle with excessive force. The muscle should be well protected while using the oscillating saw particularly if the neck cut has to be re-visited.

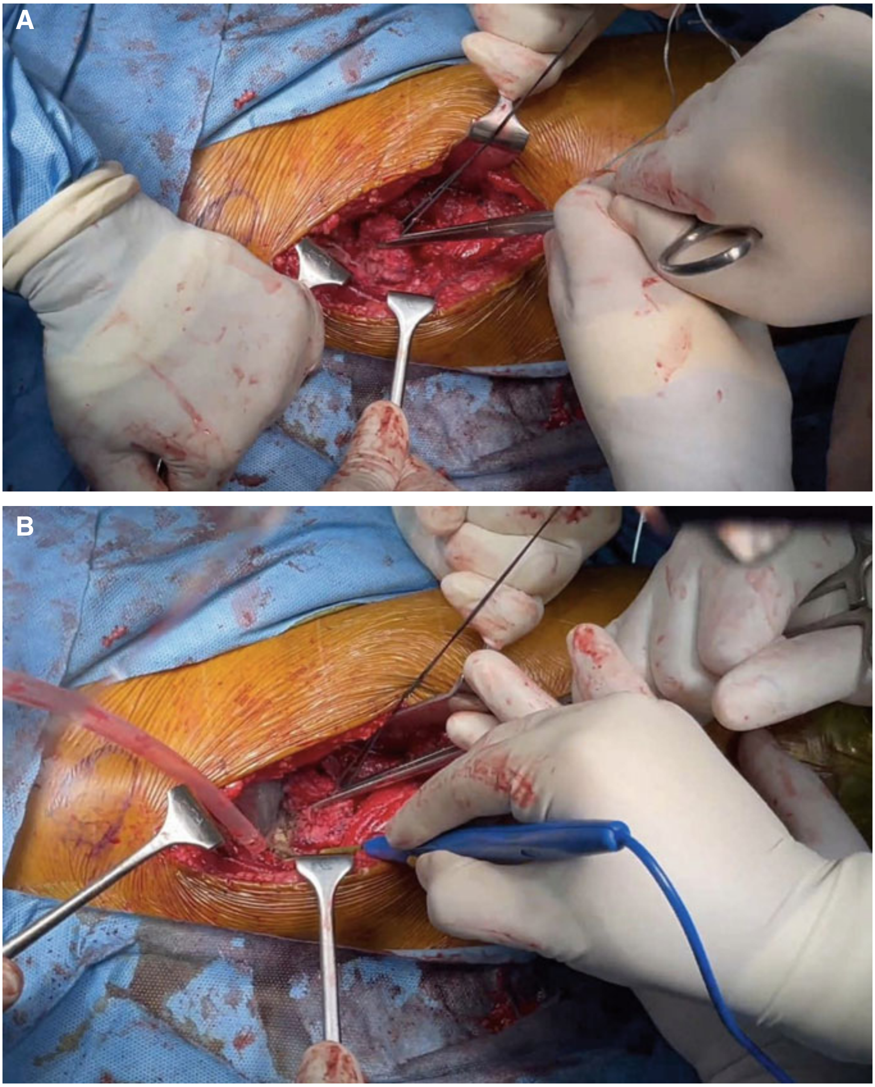

Fig. 7.35 A. Intraoperative picture showing holding and retracting the superior capsule towards the acetabular cavity. B. Intraoperative picture creating a plane between the capsule and the gluteus minimus muscle. C. Intraoperative picture following excision of the superior capsule

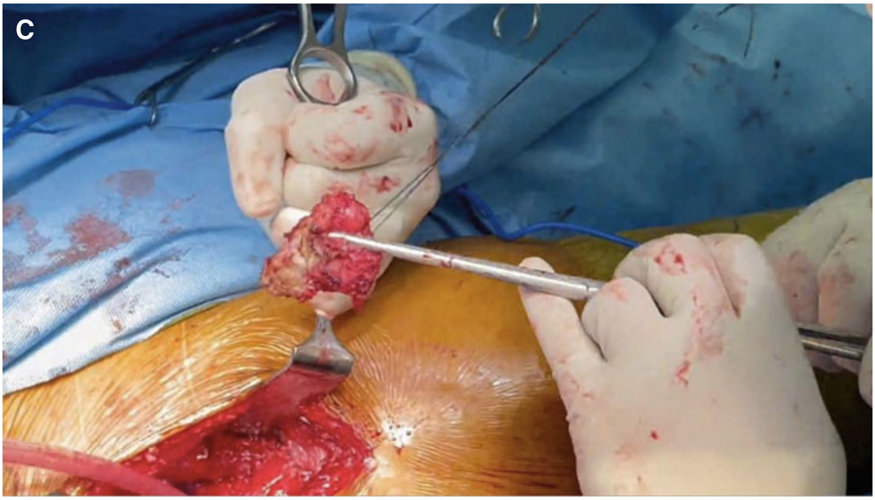

Fig. 7.35 (continued)

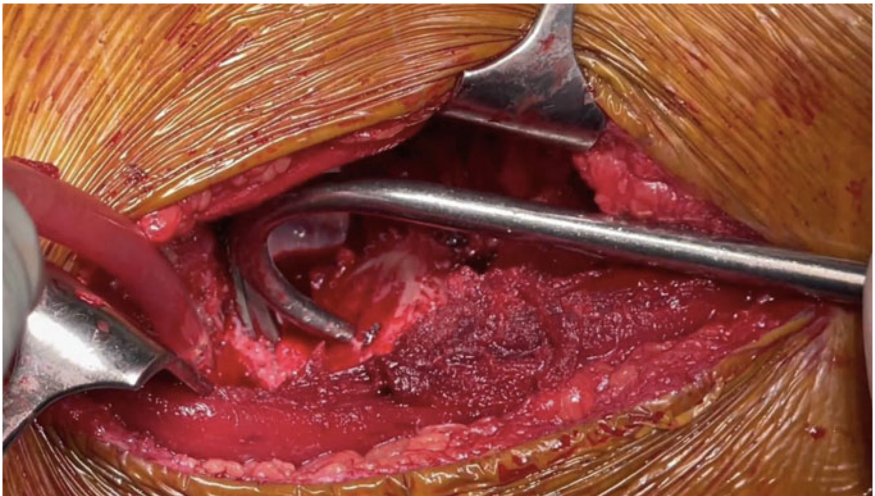

Fig. 7.36 Intraoperative picture showing insertion of the bone hook into the cut surface of the femoral neck

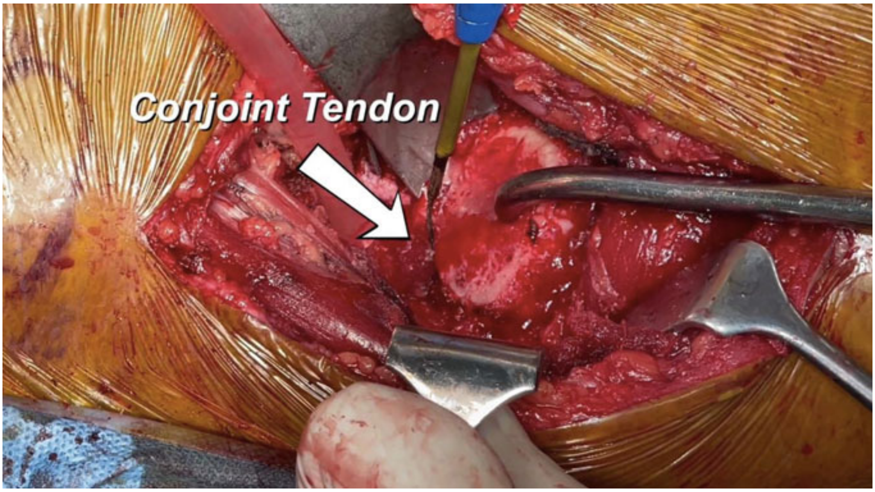

Fig. 7.37 Intraoperative picture showing pulling of the bone hook with simultaneous release of the superolateral capsule from the inner surface of the GT

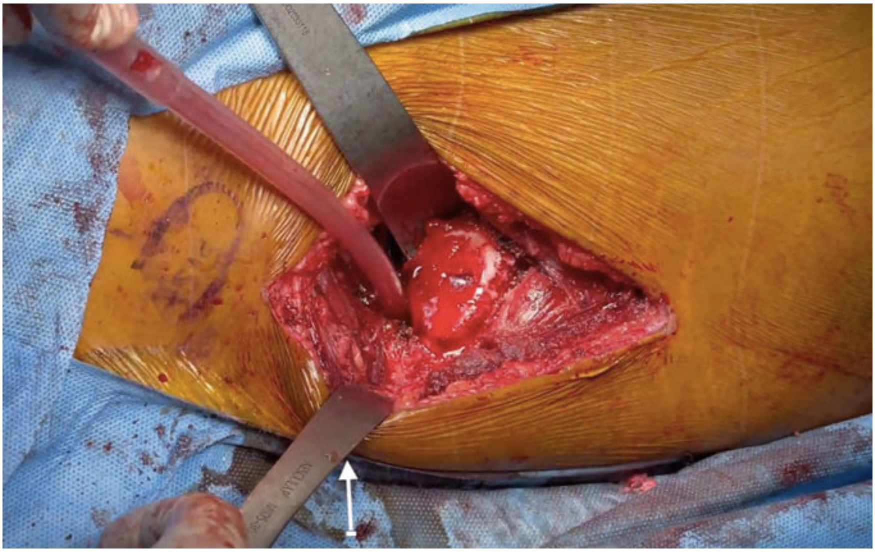

Fig. 7.38 Intraoperative picture showing elevation of the proximal femur with the help of trochanteric elevator (white arrow)

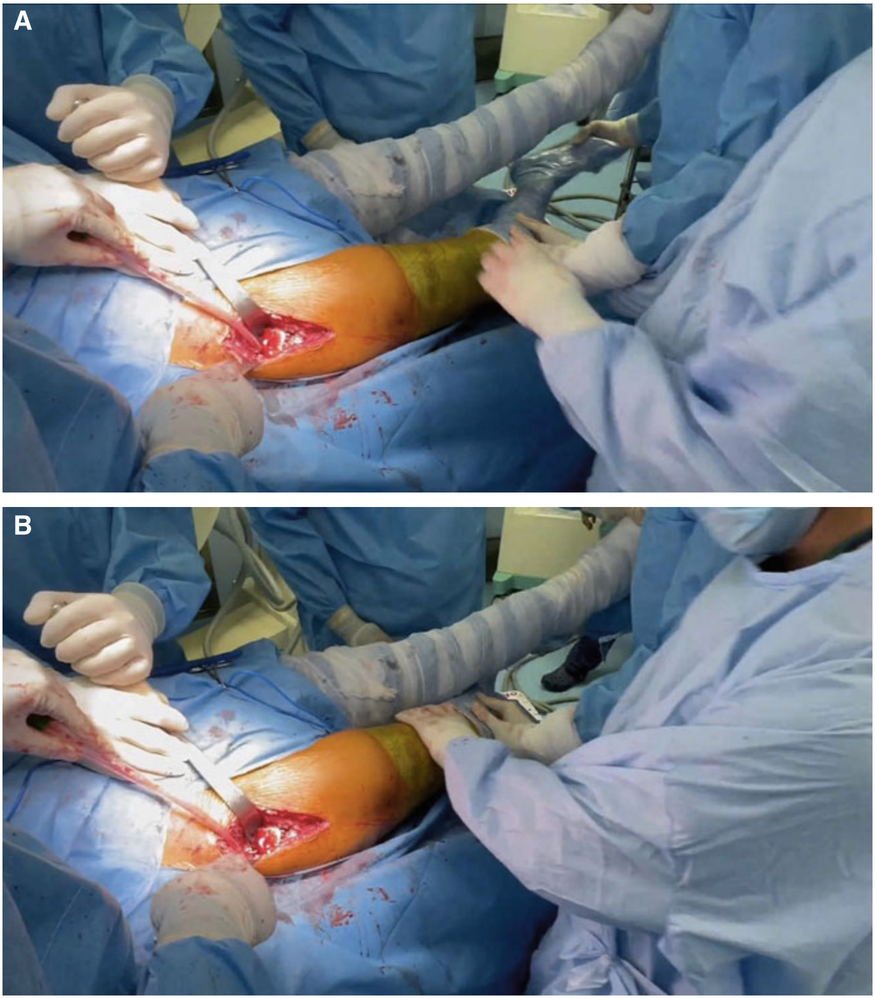

Fig. 7.39 A. Intraoperative photograph showing positioning of the operating limb under the contralateral limb. B. Intraoperative photograph showing positioning of the operating limb into a figure of '4' position

5. In initial cases of learning curve, the proximal femoral mobilization can be achieved by sharply releasing the obturator internus and piriformis tendon without injuring the obturator externus.

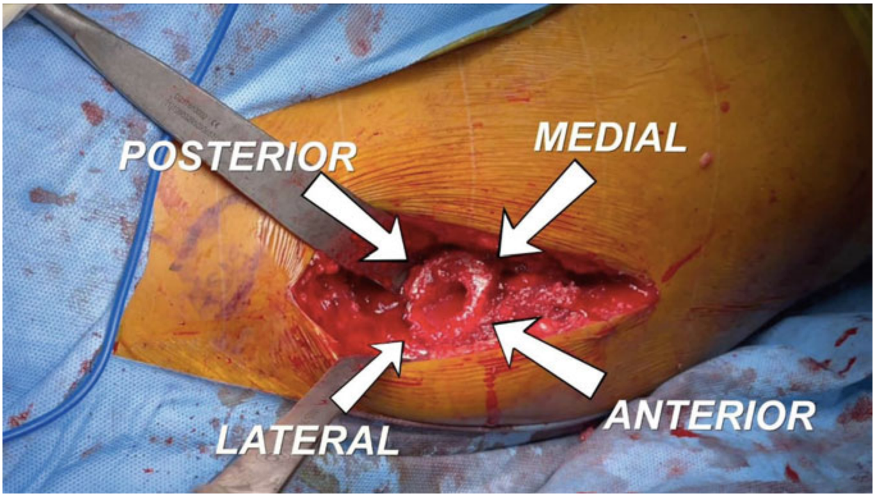

Fig. 7.40 Intraoperative picture showing placement of the retractors for femoral preparation

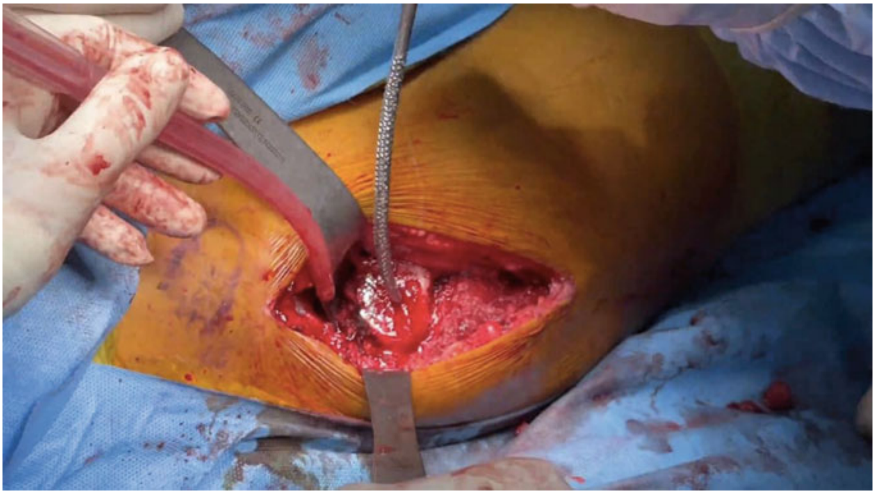

Fig. 7.41 Intraoperative picture showing insertion of the canal finder at the centre of the cut surface of the femoral neck for preparation of short stem

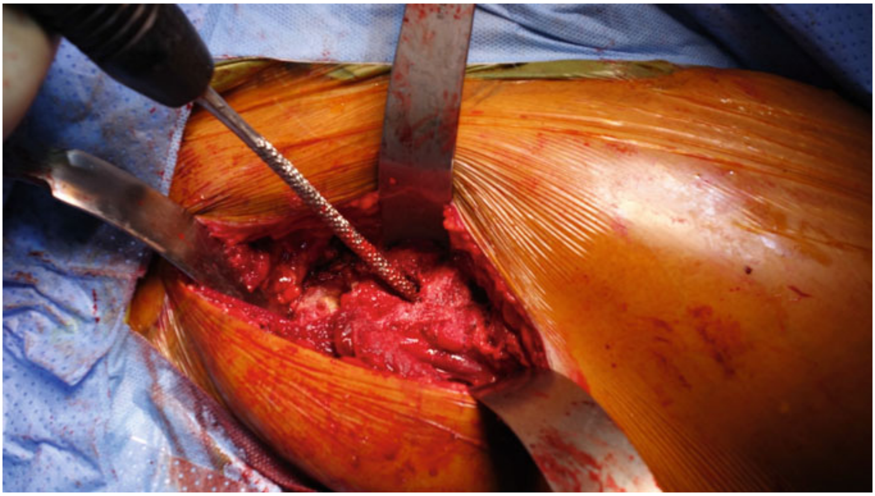

Fig. 7.42 Intraoperative picture showing insertion of the canal finer at the posterolateral corner of the cut surface of the femoral neck for preparation of conventional stem

Fig. 7.43 A. Intraoperative picture showing broaching for the femoral stem preparation. B. Intraoperative picture showing seating of the final broach

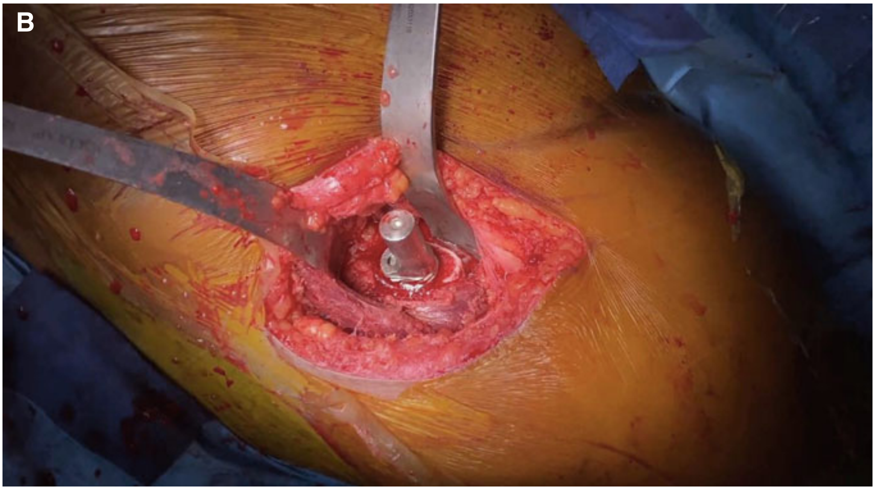

Fig. 7.43 (continued)

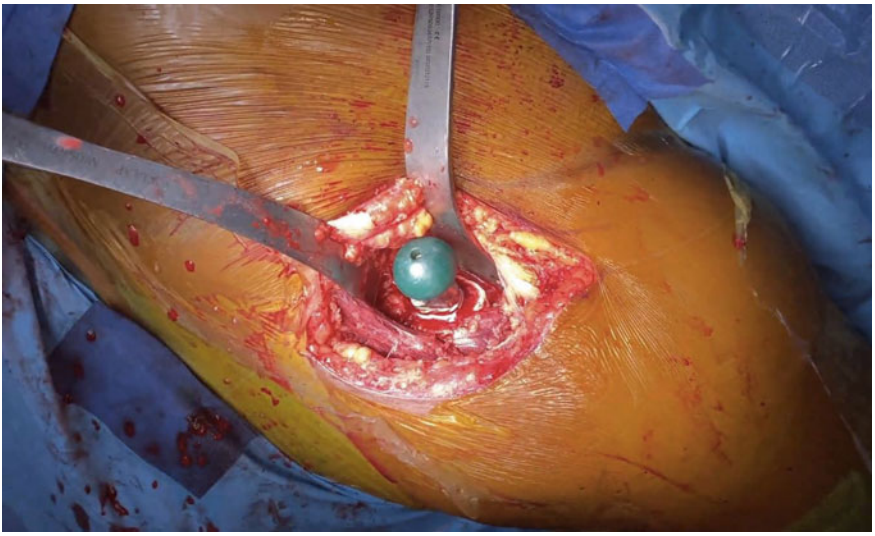

Fig. 7.44 Intraoperative picture showing insertion of femoral neck and head

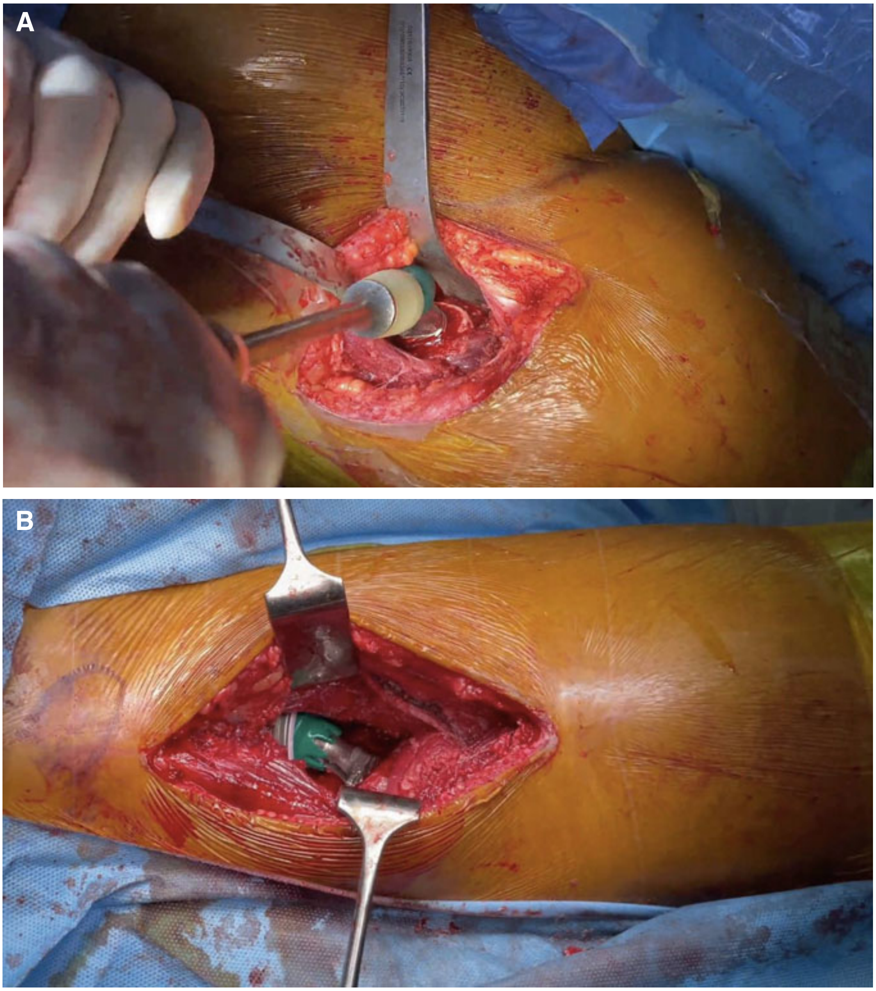

Fig. 7.45 A. Intraoperative picture showing trial head being pushed with head impactor. B. Intraoperative picture showing reduction of the trial femoral component

7.6 Results and Literature Review

A multicenter prospective randomized controlled trial comparing DAA versus posterior approach in Total Hip Arthroplasty by Kevin et al. reported that DAA is a safer and effective option with better functional outcome in patients in the early postoperative period (Moerenhout et al. 2020). In a metaanalysis by Yoo et al., gait speed and hip flexion were higher in patients following DAA as compared to Anterolateral approach for THA (Yoo et al. 2019). Wang et al., in a retrospective clinical study reported that the muscle damage in DAA is less as compared to posterolateral

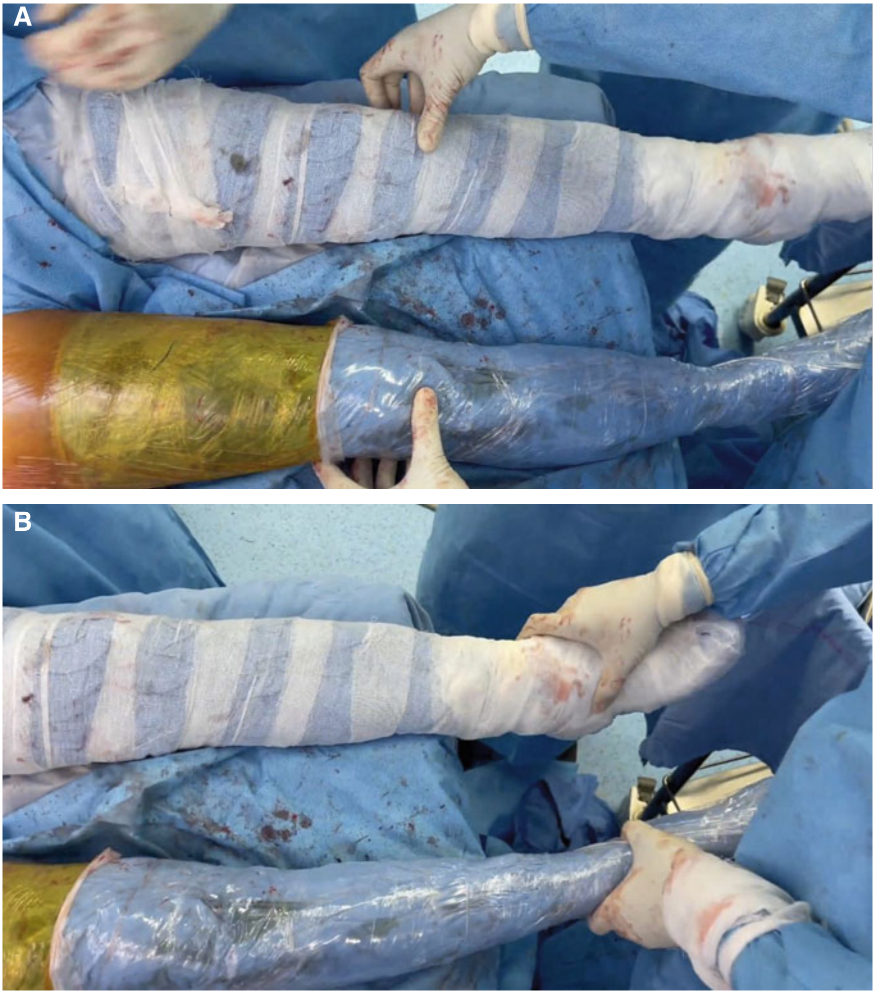

Fig. 7.46 A. Intraoperative photograph showing assessment of the limb length by palpating the patella of both sides in neutral position. B. Intraoperative photograph showing assessment of the limb length by palpating the malleoli of both sides in neutral position

approach which has a direct correlation with hip function after surgery (Wang et al. 2022). A systematic review and metaanalysis of DAA versus posterior approach concluded that DAA is not only associated with less blood loss and less pain scores

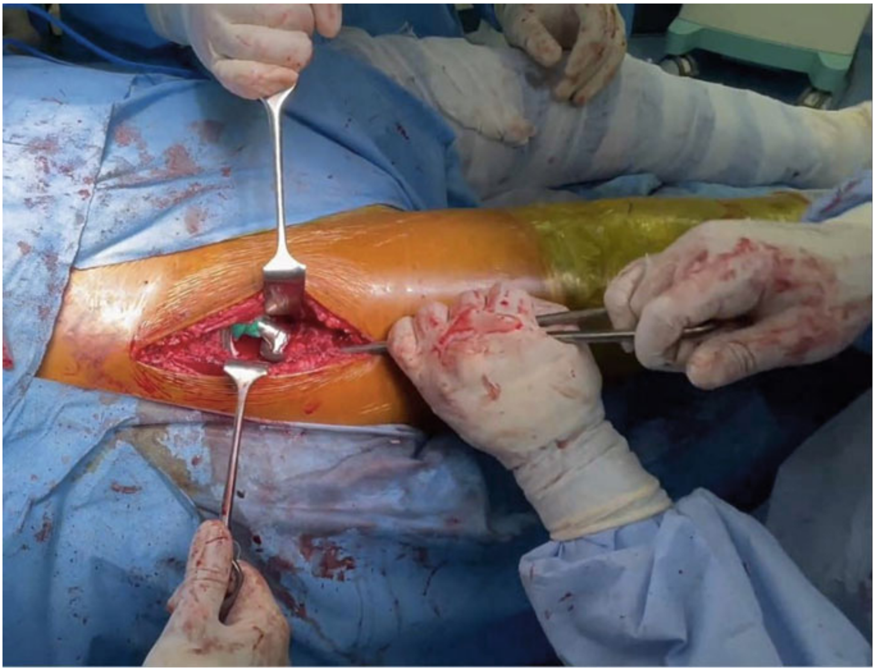

Fig. 7.47 Intraoperative picture showing insertion of the bone hook around the trail femoral neck for dislocation

but also cosmetically acceptable shorter incision length and early functional recovery (Wang et al. 2018).

In authors' experience, total hip arthroplasty done by DAA as described above has shown improved outcomes when compared to our legacy posterior approach. Being a muscle sparing approach, the most important advantage has been reduced pain. This has been proven by less requirement of opioids for pain management. The patients could be mobilized early and the length of hospital stay has been almost halved which has overall reduced the cost as well (Rajesh et al. 2022). Our experience with DAA has reinforced the findings reported in the literature that it is a rational approach for THA and can be performed even without a special table. This may overcome the

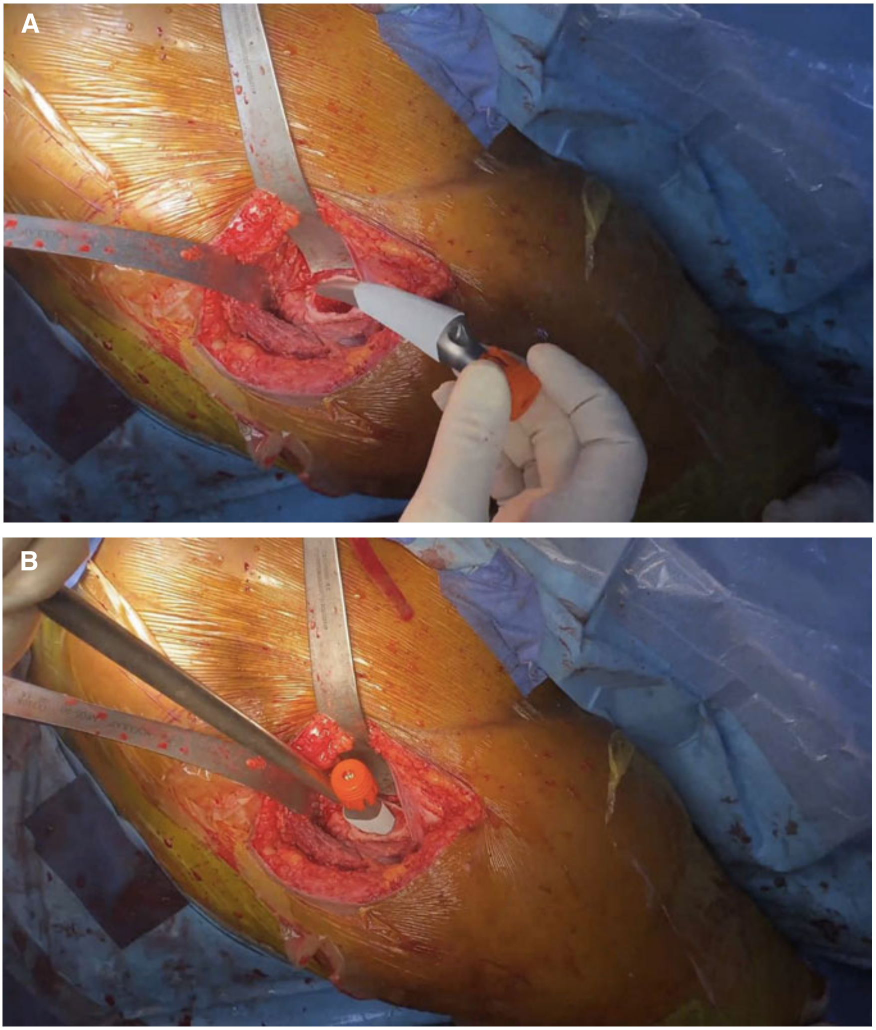

Fig. 7.48 A. Intraoperative picture showing insertion of the definitive femoral stem into the prepared femoral canal. B. Intraoperative picture showing impaction of the stem. C. Intraoperative picture showing insertion of the definitive femoral head. D. Intraoperative picture showing reducing the femoral head into the acetabulum. E. Intraoperative picture showing final image after reduction

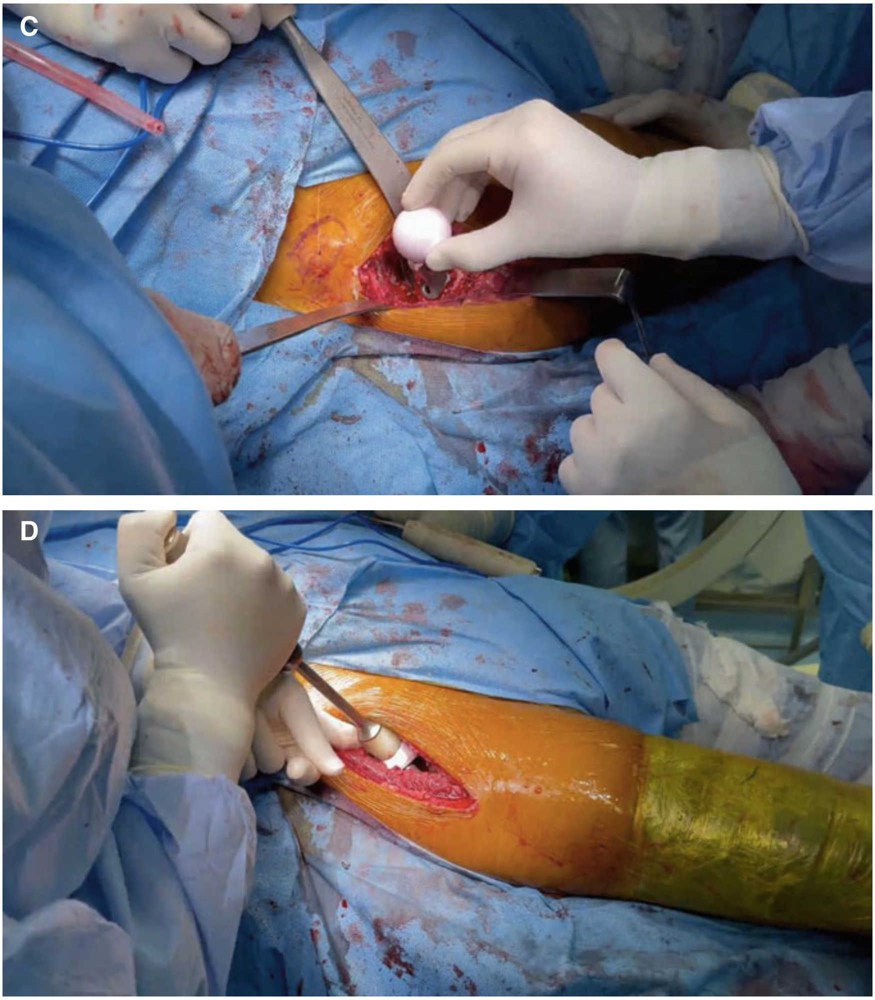

Fig. 7.48 (continued)

hesitancy among the aspiring orthopedic surgeons who have not practiced it due to the obsolete dogma of the requirement of a special table.

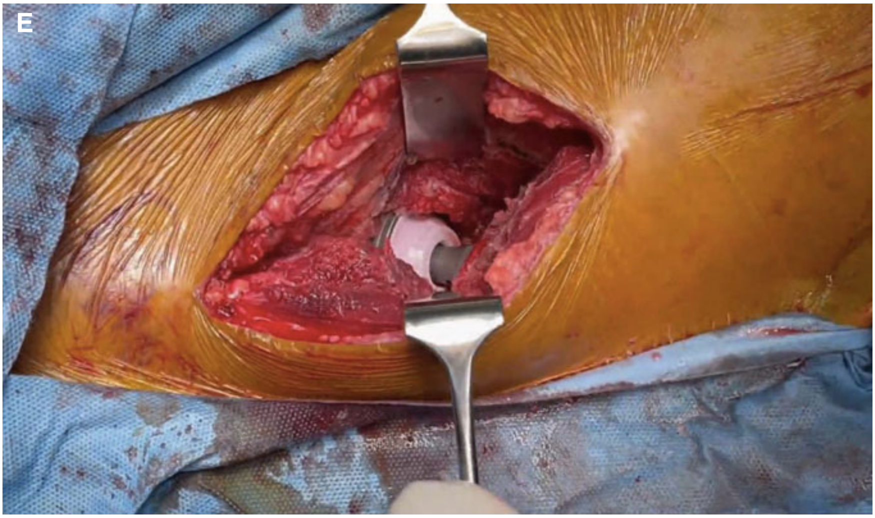

Fig. 7.48 (continued)

7.7 Summary

Direct Anterior Approach to Hip is among many other surgical approaches for performing THA. Despite a complex history of development, it has been proven that, with meticulously following the surgical key steps it can be performed with ease. The all-important technique involves the capsular releases around the acetabulum and proximal femur. Neither the reaming nor the femoral preparation should be done without adequate exposure of acetabular socket and sufficient elevation of proximal femur respectively. Femoral mobilization is considered the key step for successful outcome of DAA for THA. One should not hesitate to release the conjoint tendon and if required the piriformis as well if the femur is not sufficiently mobilized for femoral preparation. However, it is important to preserve the obturator externus to prevent postoperative instability.

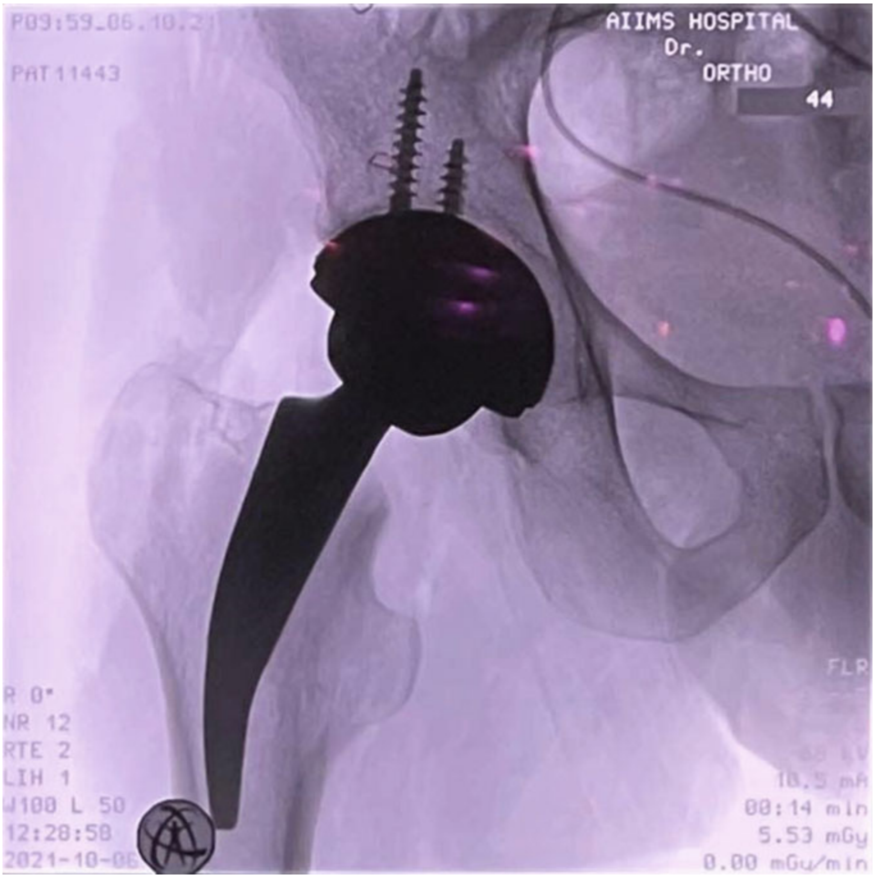

Fig. 7.49 Intraoperative image following final reduction with definitive implants

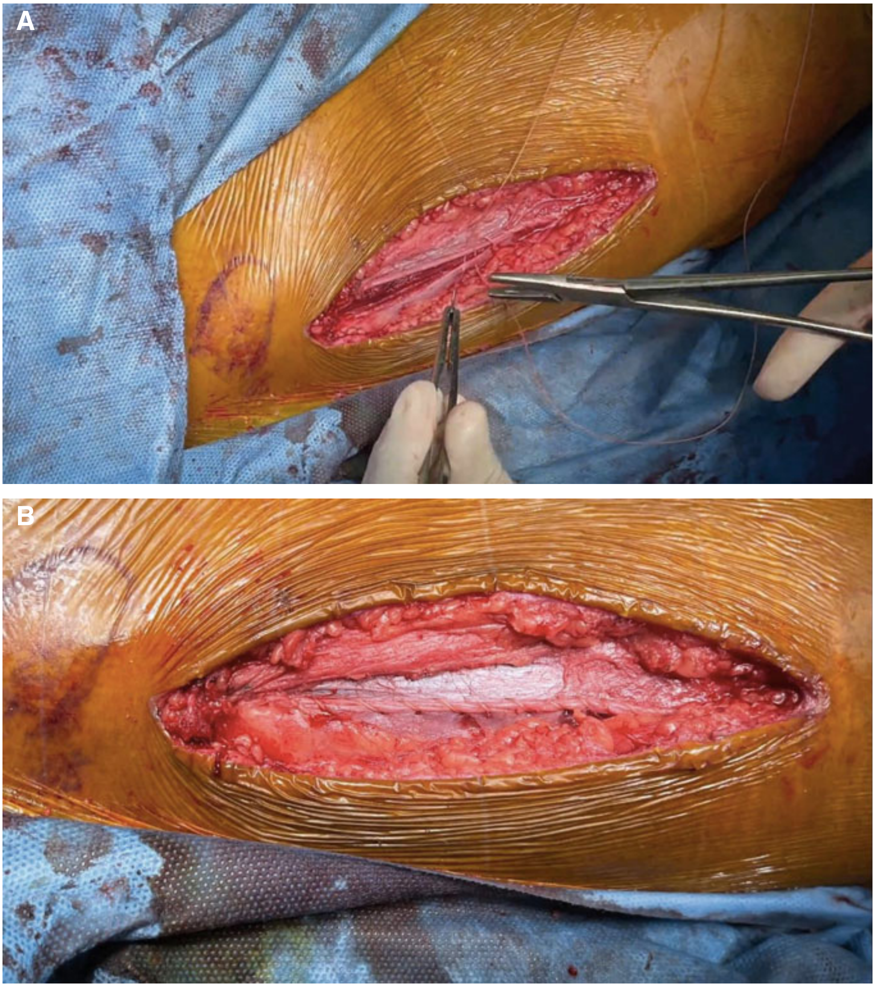

Fig. 7.50 A. Intraoperative picture showing closing the anterior fascia of the TFL muscle using the vicryl 2-0 suture. B. Intraoperative picture following final closure of the fascia

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