THE SURGICAL APPROACH TO TOTAL HIP ARTHROPLASTY: COMPLICATIONS AND UTILITY OF A MODIFIED DIRECT LATERAL APPROACH

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INTRODUCTION

A surgical approach for total hip arthroplasty (THA) must meet several requirements. It should provide wide exposure to the acetabulum and proximal femur to satisfactorily prepare the bony beds for implantation. The approach should be useful for the wide array of deformities seen in arthritis of the hip, and be extensile to improve exposure in difficult cases. Minimal trauma should be inflicted on surrounding muscles, tendons and ligaments. The sciatic nerve and femoral neurovascular bundle should be protected and preserved. Hip replacement should be performed in an efficient manner to lessen the risk of infection and thromboembolism, and hasten postoperative recovery. Finally, the approach cannot be associated with complications or untoward side effects.

Many basic surgical approaches and modifications have been described for total hip arthroplasty. Each approach has certain advantages and disadvantages, and no one approach completely satisfies all requirements. The choice of surgical approach is based on many considerations, including but not limited to: the size and muscularity of the patient, the number of assistants and type of retractors available, previous surgery and incisional scars, the need for increased postoperative inequality, etc. The most important factor is the experience and bias of the surgeon, and clearly a thorough knowledge of both surface and deep anatomy is required for any approach.

The anterolateral approach was first described by Watson-Jones in 1935 in his treatise on the treatment of femoral neck fractures. Mueller popularized this approach for total hip arthroplasty for the purpose of avoiding trochanteric osteotomy.[40] The approach is most commonly performed in the supine position with the affected buttock elevated. A straight, curved or V-shaped incision is made over the trochanter and the fascia lata is incised. The interval between the tensor fascia lata and gluteus medius is developed; thus there is no true internervous plane. It is usually necessary to release the anterior fibers of the gluteus medius tendon to avoid excessive retraction on this muscle. After the reflected head of the rectus femoris is divided, an anterior capsulectomy and femoral neck osteotomy are performed. A posterior capsulectomy with release of the short external rotators is usually necessary for exposure and mobility of the proximal femur.[40]

The dangers of the anterolateral approach include injury to the femoral nerve, artery or vein by excessive or prolonged anterior retraction. The superior gluteal nerve may be divided if dissection is carried too far proximally. This should rarely be necessary in routine THA, and the denervation of the tensor fascia lata has uncertain significance. The advantages of this approach include its utility in most primary THA's with excellent visualization of the acetabulum and femur and low postoperative rate of instability. Disadvantages include its lack of extensibility, the need to dissect on both sides of the hip joint, and the often excessive release or retraction of the abductor muscles necessary for exposure.

Described initially by Ollier in 1881, the lateral transtrochanteric approach was popularized by Sir John Charnley for THA to provide wide exposure and allow advancement of the abductor muscles during reattachment.[18] Great controversy exists regarding the necessity for an osteotomy and its advantages. Most primary THA's can be performed without osteotomy, but this approach is still popular for revision surgery and for reconstruction of the dysplastic hip. The patient may be placed supine with the buttock elevated or in the lateral decubitus position. A straight or slightly curved incision is centered over the trochanter, and the fascia lata is incised. The osteotomy is performed after identification and freeing the borders of the gluteus medius, and elevation of the origin of the vastus lateralis. The osteotomized fragment is reflected proximally and a complete capsulectomy is performed. Again, no true intervenous plane is employed. The trochanter may be advanced during closure to improve abductor muscle function and soft tissue tension. The major advantages of this approach include the wide exposure achieved, the preservation of the abductor musculotendinous fibers and the ability to advance the abductors. The disadvantages include an increased operating time and

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blood loss, postoperative bursitis from trochanteric wires, and the possibility of trochanteric non-union. Non-union without migration is usually asymptomatic. However, migration occurs in between 2 and 15% of cases, and will lead to loss of abductor function, a limp, and potential instability of the hip. Therefore, reattachment of the trochanter is a critical step in this approach.

The posterolateral approach was first described by Langenback in 1874, for the purpose of draining pyarthroses of the hip.[40] The approach was later modified by Kocher and others, then popularized in North America by Gibson. Moore advocated the use of a more inferiorly placed incision into the buttock to insert femoral endoprostheses, and the approach was thus named "Southern Exposure".[40] The procedure must be performed in the lateral decubitus position. Most commonly, the incision courses along the posterolateral border of the femur and greater trochanter, then curves posteriorly towards the posterior superior iliac spine. The fascia lata is incised and the fibers of the gluteus maximus are split. The short external rotators are released prior to a posterior capsulectomy and posterior dislocation of the femoral head. There is no true internervous plane in this approach, but the gluteus maximus is not significantly denervated and the dissection is behind the superior gluteal nerve-innervated abductor muscles. The principle danger of this approach is injury to the sciatic nerve which must be protected during dissection of the posterior hip capsule. The advantages of this approach include its reproducible anatomy and exposure, and the avoidance of the abductor musculature. The major disadvantages include the need to perform the procedure in the lateral decubitus position, limited extensibility, and difficulty in knowing the exact position of the pelvis during reconstruction. The posterolateral approach has been associated with the highest incidence of postoperative instability after THA.[50]

The anterior approach of Smith-Peterson reached its greatest utility for the performance of cup arthroplasty. The approach utilizes the superficial interval between the sartorius and the tensor fascia lata muscles and the deep interval between the rectus femoris and gluteus medius muscles. Thus, it is truly an internervous approach, between the femoral and superior gluteal nerves. The approach is most commonly used today for pelvic osteotomies, hip fusions and biopsies. Many variations of this approach have been described to increase exposure and improve its versatility, including transection of the tensor fascia lata or gluteus medius, osteotomies or extensive stripping off the pelvis. Despite these attempts, this approach provides inadequate exposure and has very little usefulness in performing THA.

The medial approach was first described by Ludloff in 1908. It employs the interval between the adductor longus and gracilis muscles. It is used primarily for the treatment of congenital dysplasia of the hip and to approach the iliopsoas tendon and lesser trochanter. It has no role in THA.

The direct lateral or transgluteal approach was apparently first described by Kocher in 1903.[28] McFarland and Osborne "suggested an improvement on Kocher's method" in 1954, noting the direct functional continuity of the tendinous periosteum of the gluteus medius and vastus lateralis.[34] They recommended swinging forward these muscle bellies after their release, like a "bucket handle". When it was not easy to peel the tendons from bone, they recommended taking a few flakes of trochanteric bone adhering to the tendons. Hardinge popularized the direct lateral approach in the modern era. In his description in 1982, he recommended incising this combined tendon directly over the trochanter, and carrying the dissection posteriorly into the gluteus medius fibers. The combined tendon was then sutured into bone and onto itself during closure.[15] This has become the standard direct lateral approach discussed in most textbooks and articles. McLauchlan described the Stracathro approach, whereby anterior and posterior slices of trochanter are elevated with the gluteus medius. He reported excellent results in over 2000 THA's performed through this approach.[35] Anterior modification, employing just an anterior trochanteric osteotomy, was described by Dall in 1986. He stated that this partial osteotomy leaves intact the posterior gluteus medius and its thick tendon.[8] Finally, Frndak et al recently reported excellent clinical results using an abductor muscle "split", which also leaves the posterior gluteus medius intact, but does not require an osteotomy.[12] Extensile versions of this approach have also been described for the purpose of revision surgery.[13,19]

Thus, there have been many modifications of the direct lateral approach since its original description. These l ateral approaches have been studied in several ways recently, including the relevant anatomy,[25] abductor function,[1,16,36,39,47] and heterotopic ossification.[23,48] There is certainly no consensus regarding the utility or complications of any or all of these approaches. Direct lateral approaches have been blamed for a high prevalence of limp, heterotopic ossification and hemorrhage.[3,33,43,48] Others have reported normal abductor function, and generally satisfactory results when compared to other approaches.[12,23,36] To our knowledge, a comprehensive review of any direct lateral approach used in a large series of patients does not exist in the literature.

Discouraged with an unacceptably high rate of THA dislocation using the posterolateral approach, the senior authors turned to a direct lateral approach for THA in 1985. After a short period on the learning curve, incorporating slight modifications, the approach described in this

paper has been used exclusively for all primary THA and most revision THA at our institution since 1987. This report reflects our experience with a modified direct lateral approach in primary THA in a large consecutive series of patients with a minimum two year follow-up.

For the purposes of this report, 770 consecutive primary total hip arthroplasties were reviewed. The complications considered potentially attributable to the approach included postoperative instability, limp, heterotopic ossification (HO) and nerve palsy. Direct measures of the utility of the approach included its applicability to a wide array of problems seen in primary THA without the need for further exposure, as well as the average duration of surgery. Utility, without untoward effects, was assessed using clinical results as taken from the Harris hip rating and AAOS-Hip Society rating forms. Component placement was recorded as an indirect measure of the adequacy of exposure.

The pertinent results will be outlined here, and described in detail later. Of the 770 hips, there have been three known dislocations, for an overall prevalence of instability of 0.4%. Excluding those who died or were lost to follow-up, there were two dislocations of 712 THA's that were followed for greater than two years, for a prevalence of instability of 0.3%. A moderate or severe limp from any cause was present in 10% of patients at two year follow-up, and in 4% of a subgroup of patients with only unilateral osteoarthritis of the hip (Charnley A). Heterotopic ossification developed in 34% of hips. It was functionally limiting in only seven patients. A total of four partial sciatic nerve palsies occurred in this series.

It was never necessary to convert to a trochanteric osteotomy or perform a concomitant posterior capsulectomy to gain exposure. The duration of surgery, including patient transfers and prepping and draping, has averaged one hour and thirty-eight minutes for primary THA using this approach. Acetabular and femoral component placement was considered excellent in over 90% of patients.

As this review will show, this modified direct lateral approach has greatly diminished the potentially devastating complication of postoperative instability in our experience. It has been associated with an acceptable level and severity of limp and heterotopic ossification. Excellent exposure can be achieved, allowing accurate placement of components in an efficient manner.

Operative Technique

The technique described here varies significantly from many previously described lateral approaches to the hip. Therefore, the approach will be described in some detail. The approach is very similar to the Translateral Abductor Muscle "Split" described by Frndak et al.[12]

Preoperative templating is carried out to estimate limb length inequality and approximate acetabular and femoral component sizes. The patient is transferred to the lateral decubitus position, nonaffected hip down on an inflatable bean bag. Supplemental taping is used to secure the patient. The hip and leg are prepped and draped free, and a sterile pouch is made on the assistant's side, anterior to the patient. A straight lateral skin incision is made midway between the anterior and posterior dimensions of the greater trochanter, equidistant cephalad and caudad to the tip of the trochanter (Fig. 1). The fascia lata is incised between the muscle bellies of the tensor fascia lata and the gluteus maximus (Fig. 2). The trochanteric bursa is incised and the anterior and posterior borders of the gluteus medius and the vastus lateralis are identified. Blunt retractors are used to separate the muscle fibers of the gluteus medius at its anterior-middle one-third junction, up to three cm cephalad to its insertion (Fig. 3). Care is taken to protect the inferior branch of the superior gluteal nerve as it courses between the gluteus medius and minimus muscles. Electrocautery is used to split and detach the combined tendon and periosteum of the gluteus medius and vastus lateralis. This division is carried anterior to the trochanter to leave behind a posterior tendinous cuff for later suturing. Distally, the incision curves posteriorly at the vastus ridge and taken in line with the fibers

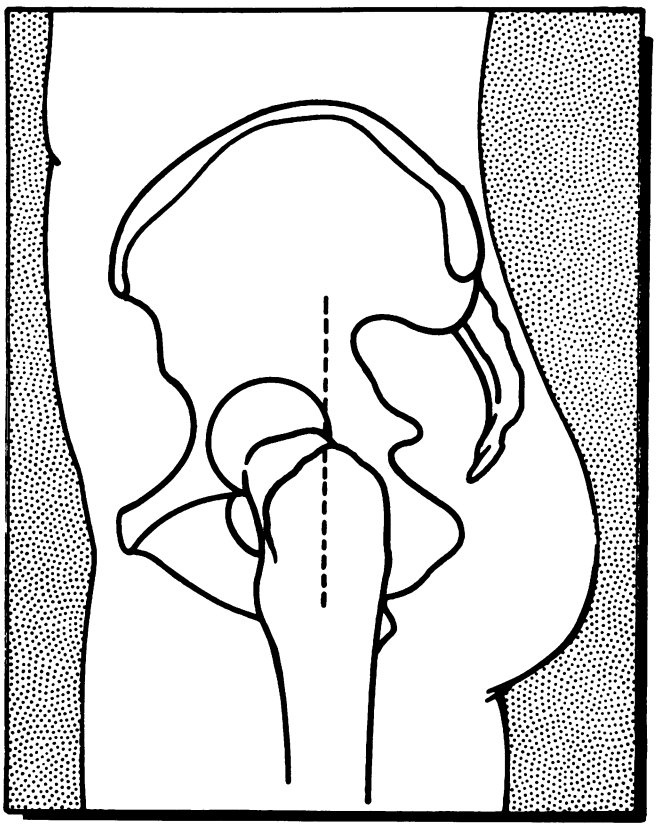

Figure 1
Illustration of the skin incision, centered over the trochanter.

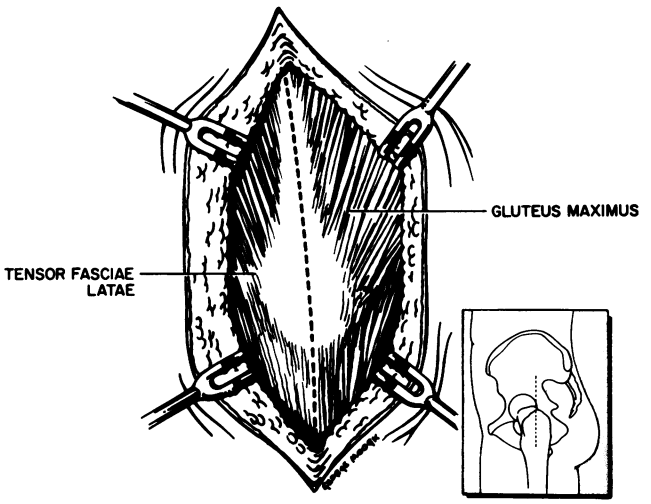

Figure 2
The incision in the fascia lata, between the insertion of the tensor fascia lata and gluteus maximus muscles.

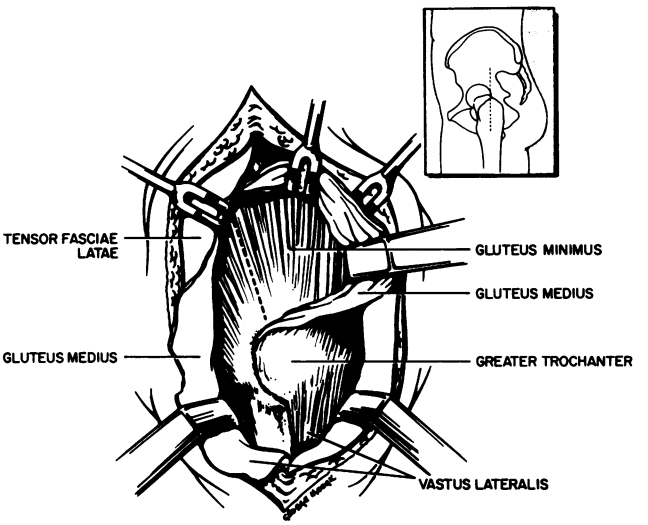

Figure 4
Division of the gluteus minimus is done in line with its fibers, under direct vision and limited to three cm from its insertion.

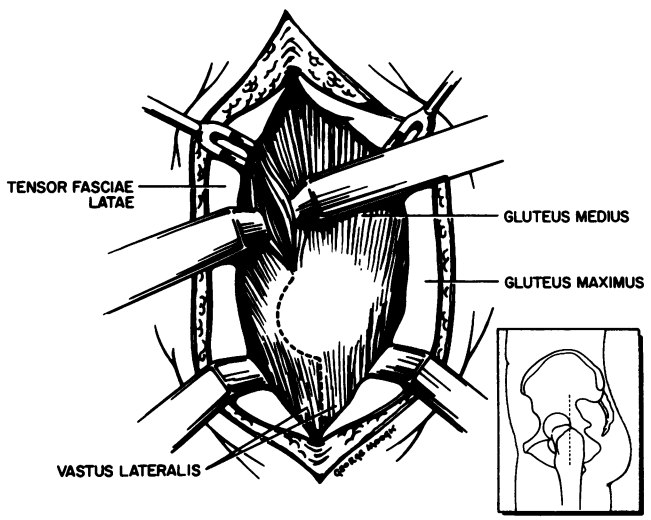

Figure 3
Blunt retractors are used to spread the fibers of the gluteus medius at its anterior-middle one-third junction. The combined tendon/ periosteum is divided anterior to the trochanter, and the fascia of the vastus lateralis posterior to or at the midline.

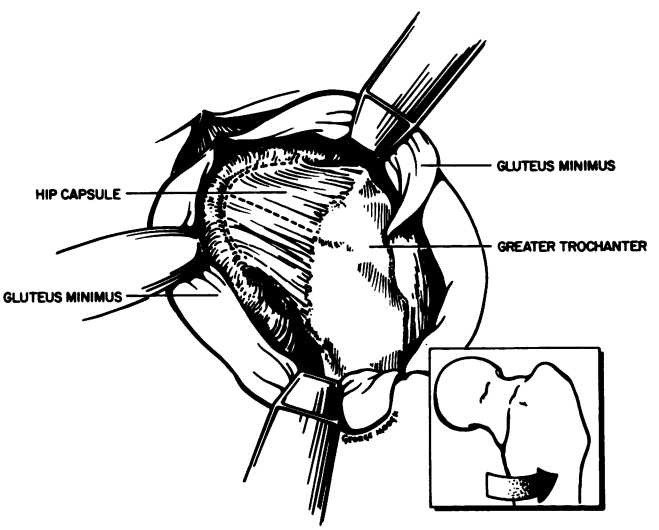

Figure 5
Exposure of the anterior capsule for capsulectomy.

of the vastus lateralis. Two points of bleeding may be encountered. First is the ascending branch of the medial circumflex artery behind the trochanter. Second is the transverse branch of the lateral circumflex artery in the vastus lateralis. Both arteries are easily cauterized. Under direct vision, the gluteus minimus is divided in line with its tendinous fibers (Fig. 4). A plane between the gluteus minimus and anterior capsule is easily found proximally. Blunt dissection with scissors is carried out to the acetabular rim, identifying and cutting the reflected head of the rectus femoris, as the leg is externally rotated. The origin of the vastus lateralis is elevated from the intertrochanteric line, and medially to the lesser trochanter as necessary. A blunt-tipped retractor can be carefully placed over the anterior acetabular rim or alternatively, a sharp-tipped retractor is placed into the anterior-superior ilium. With adequate exposure of the anterior capsule, an anterior capsulectomy is performed (Fig. 5). A smooth Steinmann pin is placed in the ilium and a mark made on the greater trochanter for leg length determination. Dislocation of the femoral head is achieved by external rotation, flexion and adduction, while pulling the head from the acetabulum using a bone hook. The leg is brought over into the sterile

Figure 6
Positioning of the leg for femoral neck osteotomy and canal preparation.

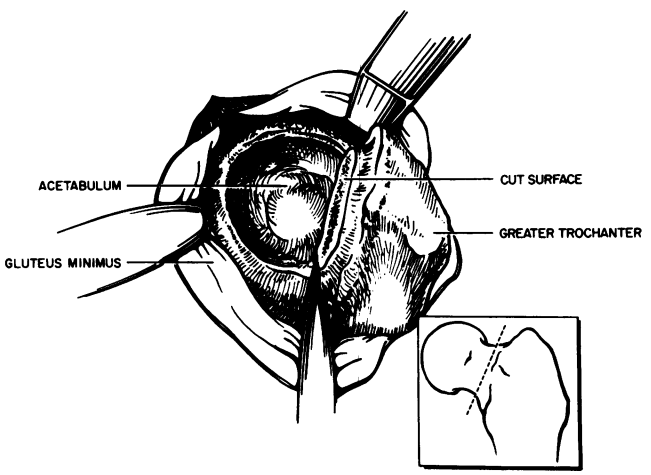

Figure 7
Acetabular exposure requires an anterior-superior retractor, an inferior retractor that holds the femur posterior, and a posterior soft tissue retractor.

pouch to perform a femoral neck osteotomy (Fig. 6). One may then elect to prepare the femur or place the leg back on the operating table and move to the acetabulum. For acetabular preparation, a Hohman retractor is placed in the acetabular notch beneath the transverse acetabular ligament (Fig. 7). Posterior retraction is generally adequate by externally rotating the leg and use of a soft tissue retractor. Rarely is a posterior rim retractor required.

If limb length and femoral offset are restored after placement of components, there is generally no tendency to subluxation with a full range of motion. The positions of maximal external rotation in extension and internal rotation in 90 degrees of flexion are particularly important to assess.

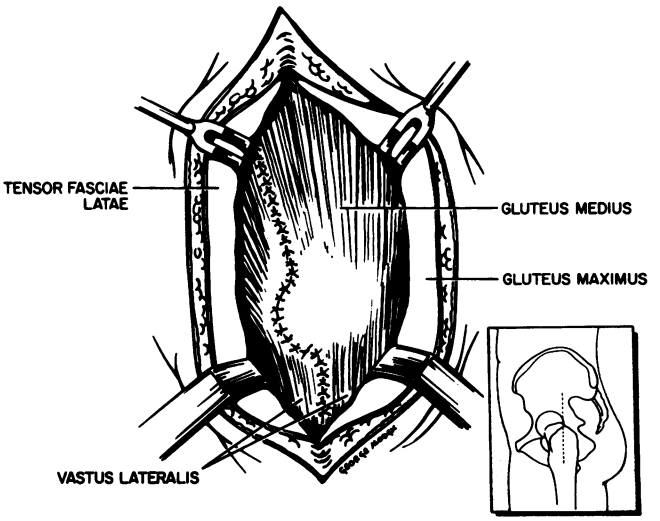

Figure 8
Closure is carried out in layers, with reapproximation of the combined tendon and periosteum of the gluteus medius and vastus lateralis.

Careful attention to the detail of closure of the muscular layers is paramount to the success of this approach. A heavy absorbable suture is used to reapproximate the divided gluteus minimus. Interrupted, heavy absorbable suture is used to draw up and reapproximate the anterior flap of gluteus medius and vastus lateralis to the posterior tendinous cuff. We feel this tight soft tissue closure is critical in preventing postoperative abductor weakness. This suture line is then carried proximally into the muscle fibres of the gluteus medius and distally, closing the fascia of the vastus lateralis (Fig. 8). The fascia lata, subcutaneous tissues and skin are closed in the usual fashion.

Postoperative Rehabilitation

A pillow is placed between the patient's legs until they are awake in the recovery room. Braces and/or splints are not used. Ambulation is begun the next day. For the first six weeks, patients are instructed on crutch-walking, progressing to full weight-bearing as tolerated. They are cautioned to avoid excessive flexion of the hip and to avoid crossing their legs. Abduction exercises are allowed with gravity removed. From six weeks forward, they are advanced from crutches to a contralateral crutch or a cane, full weight-bearing. Abduction exercises are performed against gravity and with resistance up to four kg. in addition to hip flexion and straight leg raising exercises. Patients are generally released from physiotherapy and the use of a cane at three months and are allowed to progress to full activity at that time.

MATERIALS AND METHODS

Seven hundred and seventy primary total hip arthroplasties were performed at the University of Western Ontario

DEMOGRAPHICS				
	Hips	Patients	F/U Average	
	770	697	3.6 yrs (2-6.5)	
Died	46	45	≥2 yrs	712
LTF	12	12	≥3 yrs	514
Clin/X-ray	697	615	≥4 yrs	369
Clinical	712	640	≥5 yrs	183
Gender	394 F	318 M	≥6 yrs	43
Dx (%)	OA 83	RA 6		
	ON 4	CDH 3		

Table 1

Hospital, between October 1987 and January 1992. The period of study reflects a time after the learning curve of using this approach, but allows a minimum two year follow-up. However, our experience with this approach before and after these dates has been similar. All surgeries were performed under the supervision of two senior surgeons (CHR,RBB) using the described modified direct lateral approach. Forty-five patients with 46 hips died prior to two year follow-up, and 12 patients with 12 hips were lost to follow-up and could not be contacted. Therefore, 712 THA's in 640 patients had a 2 to 6.5 year review with an average follow-up of 3.6 years. These hips form the basis for the clinical portion of this review. Twenty-five patients could be contacted by phone only. Therefore 687 hips had both clinical and radiographic review. Hips were placed in 394 females and 318 males. The average age of patients at last follow-up was 64.3 years with a range of 19 to 87 years. The diagnosis leading to hip replacement was osteoarthritis in 83%, rheumatoid arthritis in 6.3%, osteonecrosis in 4.2% and CDH in 2.8%. Contemporary implants were used in all patients; 65% of hips were hybrids. (Table 1)

Postoperatively, patients were followed at six weeks, three months, six months, one year and yearly thereafter. Clinical information had been recorded using the Harris Hip rating[17] with transition to the AAOS/Hip Society rating form after the recommendation of Johnston et al.[26] Because of this transition and lack of uniformity between various scores,[4] reporting will focus on individual parameters such as pain and limp. The criteria for the presence and severity of limp was based on the recommendations of the AAOS/Hip Society.[26] Patients were not divided into Charnley functional classes.[6] However, a subset of 230 patients known to have only unilateral osteoarthritis of the hip were evaluated separately.

All intraoperative, postoperative and follow-up complications were recorded prospectively in a computer data bank. In addition, the hospital charts and serial x-rays were available for review on all patients. The 25 patients who had failed recent appointments were contacted by telephone and queried specifically regarding hip dislocation, pain or other problems with the hip replacement.

Radiographs were reviewed by two of us (BM/NN) without knowledge of the clinical results. Acetabular inclination was measured from the interteardrop line. No attempt was made to measure component version. Femoral component alignment was referenced from the axial alignment of the proximal femur and was considered to be neutral if it fell within three degrees of being colinear. Heterotopic ossification was graded according to the classification of Brooker et al.,[2] and divided into A and B functional subtypes as per the modification of Maloney et al.[31]

No specific measures for HO prophylaxis were used in this series. Radiation therapy is not readily available at our institution, and anti-inflammatory medications were considered contraindicated during the Coumadin prophylaxis used in the majority of these patients.

A computer data bank is used in our operating room to record information regarding specific procedures. Operative time is defined as the duration the surgeon is involved in patient care, including patient transfers, positioning, prepping, draping and closure. This information has been recorded for all surgeries for the past 3 1/2 years, for the purpose of quality assurance.

Statistical analysis was carried out with an analysis of variance and Chi-squared tests to determine the relations between demographic variables, HO and clinical outcomes.

RESULTS

Complications

Of the entire group of 770 THA's, there have been three dislocations for a prevalence of instability of 0.4%. All three dislocations were posterior in direction and occurred without major trauma. One dislocation, in a patient with high riding CDH, became recurrent and required a revision to a longer neck femoral component and reattachment of the anterior flap of the gluteus medius, with a satisfactory outcome. The second patient dislocated stooping over in a flexed position while vomiting. The femoral neck had a long skirt thought to be partly responsible for the dislocation (Fig. 9). He had a satisfactory outcome with one closed reduction. A third patient dislocated his hip two months postoperatively and had a successful closed reduction and satisfactory outcome prior to his death, one year following total hip arthroplasty. Therefore, of the 712 hips with a minimum two year follow-up, there have been two known dislocations (prevalence = 0.3%). No other reports of THA instability

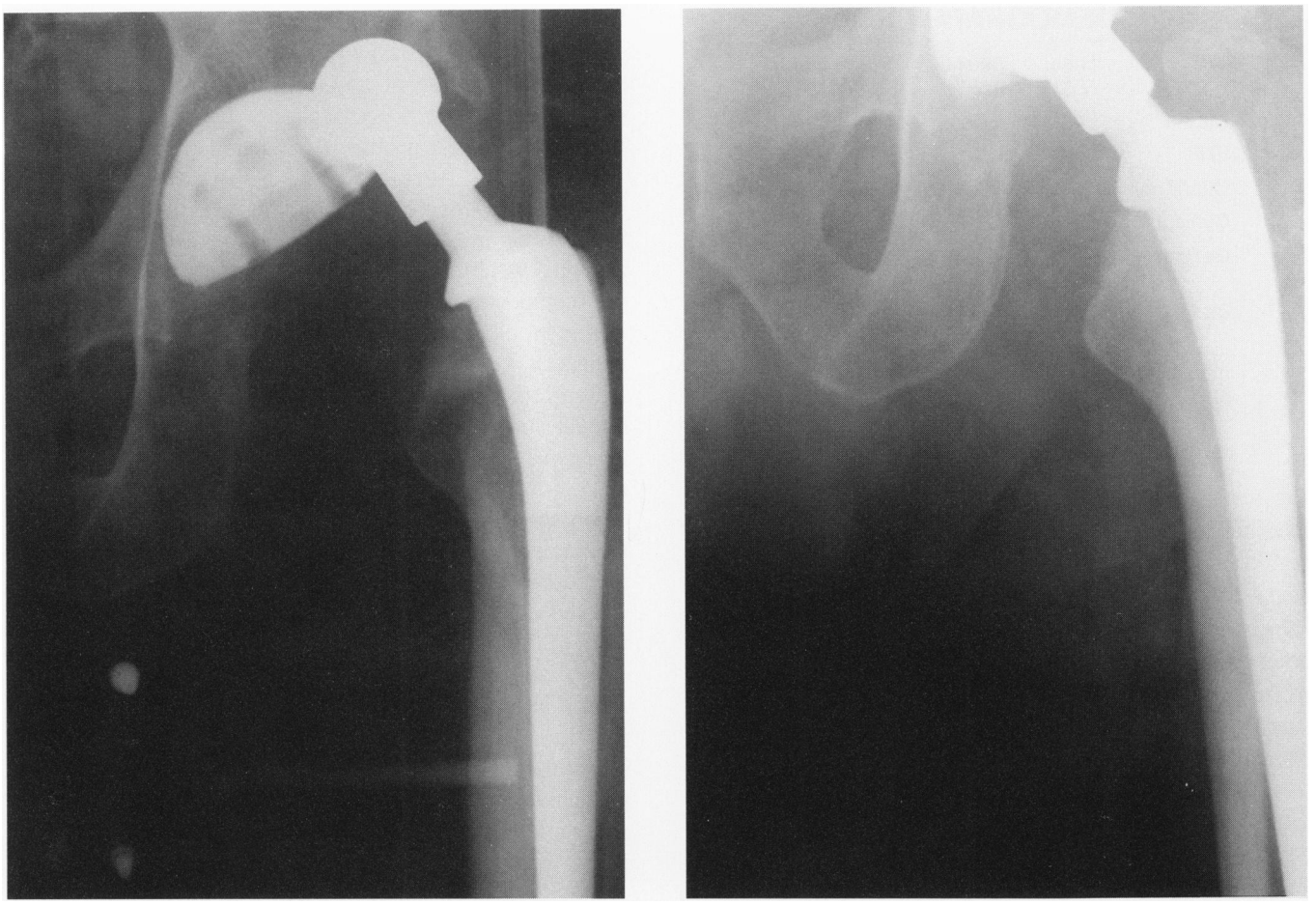

Figure 9
Dislocation occurred 2 years post-op while stooping over and 9b) relocation of THA.

in the form of subluxation or dislocation have been reported or recorded for any of these patients, over the length of follow-up studied.

Parenthetically, 178 revision THA's were performed during the same time period using a similar modified direct lateral approach. Of these hips, there have been only two known dislocations for a prevalence of 1.1%.

Limp was recorded as absent, slight, moderate or severe as graded by the AAOS/Hip Society recommendation. The prevalence of a moderate or severe limp in the entire patient series decreased from 12% to 10% from the one to two year follow-up but then increased to 21% at five year or greater follow-up. Similarly, the need for more than part-time cane use decreased from 9% to 7% from years one to two and then increased to 13% at five year or greater follow-up (Table 2).

In the subset of 230 Charnley type A patients who are the subject of a separate study,[29] limp was evaluated after a Six-Minute Walk. A moderate or severe limp was present in 4% at two year follow-up, gradually increasing to 11% at five year or greater follow-up. Again, the need for more than part-time cane use increased from 1% at two years to 8% at greater than five year follow-up (Table 3).

LIMP/WALKING AIDS (OVERALL)

Yr Follow-up	Mod/Severe Limp (%)	≥ Cane Use (%)
1	12	9
2	10	7
3	14	8
4	17	13
5	21	13
6	21	12

Table 2
The prevalence of moderate or severe limp and the need for more than part-time cane use at each length follow-up, for all patients with minimum 2-year follow-up.

LIMP/WALKING AIDS (CHARNLEY A)

Yr Follow-up	Mod/Severe Limp (%)	≥ Cane Use (%)
1	3	3
2	4	1
3	6	2
4	10	2
5	12	8
6	6	0

Table 3
The prevalence of limp, and need for more than part-time cane use for the 230 patients with unilateral hip osteoarthritis, evaluated after a timed six minute walk.

HARRIS HIP RATING (OVERALL)

Yr Follow-up	No Pts.	Average	% G + E
1	395	93	90
2	370	94	92
3	223	94	93
4	149	93	87
5	89	91	82
6	23	94	100

Table 5
Harris Hip rating, average and percentage good and excellent results at each length of follow-up, for the entire patient series.

HETEROTOPIC OSSIFICATION

Brooker	0	66%
	I	26
	II	5
	III A	1.8
	B	0.8
	IV A	0
	B	1 pt

Table 4
Heterotopic ossification, according to Brooker et al (2) and modified by Maloney et al (31) for the 687 hips with minimum 2-year radiographic review.

Heterotopic ossification was present to some degree in 34% of hips. It was Brooker Grade I in 25.7%, grade II in 5.3% and grade III in 2.6%. Only one patient in the series had apparent ankylosis (Grade IV). Of the 19 patients (2.8%) who had grade III or IV HO, seven were functionally limited (type B) in ascending stairs, sitting or donning shoes and socks (Table 4).

In the series, there were four partial sciatic nerve palsies, as discussed later. There were no femoral nerve or vascular injuries.

Utility

This approach was utilized for every primary THA performed during the period of study. In the entire series, it was never necessary to convert to a trochanteric osteotomy to improve exposure nor was it necessary to perform a concomitant posterior capsulectomy.

The average duration of surgery for primary THA over the past 3.5 years has been 1 hours and 38 minutes, including patient positioning, prepping and draping, and transfers.

As stated, both the Harris Hip rating and the AAOS/Hip Society rating were used to assess clinical results in these patients over the length of follow-up reported here. Approximately one-half of patients had serial numerical Harris scores at each length of follow-up, as seen in Table 5. The remaining patients were not given a cumulative "score", but the individual parameters of pain, limp, etc., as taken from the AAOS/Hip Society form are reported here. The Harris score averaged 94 at two year follow-up, decreasing to 91 at five years. Ninety-two percent of patients had good and excellent results at two years, compared to 82% at five years (Table 5).

Each of the 230 patients with unilateral hip osteoarthritis had serial Harris Scores. At two years, the average score was 96, with 97% good and excellent results. The average score decreased to 93, with 86% good and excellent results at five years (Table 6).

For the entire series, no or slight pain was present in 93% of hips at two years, with an average pain score of 42 out of 44. The average score decreased to 40, with 88% of patients having no or slight pain at five years (Table 7).

The average acetabular angle in this series was 40.3 degrees with a standard deviation of 6.4 degrees (range 20-65 degrees). Therefore, socket inclination was between 34 and 47 degrees in 95% of THA's. The femoral component was placed in neutral in 90% of patients, varus in 3% and in valgus in 7%.

Statistical analysis revealed a significantly higher Harris hip rating in patients with osteoarthritis and CDH compared to osteonecrosis and rheumatoid arthritis ($p<0.0001$). A significantly lower hip rating was found with advancing age ($p<0.0001$) and length of follow-up

HARRIS HIP RATING (CHARNLEY A)

Yr Follow-up	Average	% G + E
1	96	95
2	96	97
3	96	94
4	95	92
5	93	86
6	97	100

Table 6
Harris Hip rating for the 230 patients with unilateral hip osteoarthritis.

PAIN RATING (OVERALL)

Yr Follow-up	Average (of 44)	% N or Sl
1	42	92
2	42	93
3	41	90
4	40	88
5	40	88
6	41	89

Table 7
Pain score, average and percentage who had none or slight pain, for all patients with minimum 2-year follow-up.

($p = 0.046$). The presence of heterotopic ossification did not significantly affect the hip rating score ($p = 0.3$).

Heterotopic ossification was significantly more common in males ($p < 0.001$), and was not affected by the type of fixation ($p = 0.6$).

DISCUSSION

The current era of investigation in total joint arthroplasty has focused on biomaterials, implant fixation and the avoidance of particulate debris and osteolysis. Although these issues are of paramount importance to the long term functioning of total hip arthroplasty, it should be remembered that a well performed arthroplasty with accurate placement of components is the first prerequisite for satisfactory results. In addition, the avoidance of complications and untoward effects is critical to the success of any surgery, and especially in total hip arthroplasty.

For example, a dislocation might be a simple, one-time occurrence requiring only a closed reduction, bracing and modification of physiotherapy. The morbidity to the patient is minimal in this case and cost to the system is less than $2,000.00 Cdn at our institution. However, complications such as nerve palsies, thromboembolism and decubiti can occur in up to 40% of dislocations and may compromise results.[10] If the dislocation becomes recurrent and a revision is necessary, the morbidity is excessive[5] and the cost is generally greater than $20,000.00 Cdn. if the procedure and rehabilitation are uncomplicated. Therefore, it seems imperative to avoid complications that are potentially attributable to the surgical approach and are associated with excessive morbidity and medical cost.

In this regard, we felt the need to convert from a posterior to a lateral approach in order to limit the rate of postoperative instability in total hip arthroplasty. The approach described here differs from many other direct lateral approaches in several ways. First the patient is placed in the lateral decubitus position, allowing direct downward visualization of the relevant anatomy. Secondly, only the anterior one-third of the gluteus medius is split in line with its muscle fibers, and this is done using blunt retractors and not sharply using a scalpel or electrocautery. Third, the incision is taken anterior to the greater trochanter into the combined tendon and periosteum of the gluteus medius and vastus lateralis, allowing a tight soft tissue closure. Fourth, division and elevation of the vastus lateralis is carried out posteriorly, to avoid the anteromedially directed nerve supply. Finally, the split in the gluteus medius and minimus is limited to three cm cephalad to the greater trochanter and this is done under direct vision to avoid injury to the superior gluteal nerve and artery. Currently, the approach described here is used for all primary THA's and most revision THA's at our institution. We have been very satisfied with the ability to avoid most complications as discussed below.

Dislocation

The acceptable rate of postoperative instability following THA has not been established. Woo and Morrey reported an incidence of 3.2%, more than twice as common using the posterior versus the anterolateral approach.[50] The incidence in primary THA was 2.4%. Khan reported an incidence of 2.1% unaffected by the surgical approach.[24] Lewinnek et al reported a prevalence of 3% using a posterior approach.[30] McCollum and Gray were able to decrease the rate of dislocation to 1.14% using the posterolateral approach with careful positioning of components.[33]

The likelihood of recurrent instability following an initial dislocation has ranged from 33% to 59%.[9,10,24,38] The functional cost of recurrent dislocations has been studied

by Chandler et al, who found that patients had a much worse outcome one year following the initial dislocation.[5] The majority of patients with recurrent instability will require an operation, most commonly a revision of one or both components.[10,50] Daly and Morrey reported successful eradication of the instability in only 61% of hips following reoperation for recurrent postoperative instability.[9]

The prevalence of dislocation after direct lateral approaches is not well known. Scheck et al reported two dislocations of 67 THA (3%) using the "Kocher-McFarland" direct lateral approach.[43] Frndak reported one dislocation of 65 hips using their muscle "split" approach.[12]

We have observed a postoperative dislocation in only 0.4% of all primary THA's performed during the period of study, with a similar prevalence of 0.3% of the hips with minimum two year follow-up. As would be predicted, two of the three hips were treated successfully closed and one required a reoperation. Uncharacteristically, two of three dislocations occurred late, approximately two years after the index procedure. We might attribute the lack of postoperative instability to two or more factors. Because the posterior capsule is left intact and the anterior structures, excluding the capsule, are preserved and approximated anatomically, a tight soft tissue envelope is created during closure. In addition, correct acetabular component positioning is not difficult using this approach in the lateral decubitus position, even if the patient rolls forward or backward, as the surgeon is afforded direct downward vision of the pertinent anatomical landmarks. Well over 95% of the acetabular components in this series were within the "safe zone" of inclination of 30 degrees to 50 degrees as described by Morrey.[38] Appropriate acetabular component version was probably achieved in a similar percentages of cases, but this measure was not taken from the radiographs as we feel it is often inaccurate. Other factors such as patient compliance and skilled nursing and physiotherapy personnel are obviously important. The prevalence of 0.4% in primary THA and 1.1% in revision THA is less than other published reports and is certainly within acceptable limits for postoperative instability. This approach has tremendously limited the morbidity and additional medical cost we previously experienced while using a posterior approach.

Abductor Weakness

Abductor weakness has remained a persistent concern in using direct lateral approaches. Orthopaedic texts typically describe the Hardinge modification, stating there is a risk of gluteal weakness and the approach threatens to denervate a large mass of gluteal muscle.[18,22,40] Abductor weakness may result from three sources in direct lateral approaches. The superior gluteal nerve (SGN) may be injured directly or through traction. The suture line in the abductors may dehisce postoperatively during rehabilitation. Finally, the portion of abductors that is elevated and retracted may be defunctionalized and not recover. Baker and Bitounis found electromyographic (EMG) evidence of SGN injury in 10 of 29 hips operated through a Hardinge approach and that this finding correlated with a limp.[1] Svennson et al reported dehiscence of the abductor suture line of greater than two cm in one-third of patients after the Hardinge approach, and that limp correlated with a separation of greater than 2.5 cm.[47] In the clinical setting, McCollum and Gray found the lateral approach to cause a postoperative limp and be time consuming.[33] Callaghan et al found a significant association of postoperative limp with the direct lateral approach compared to the posterolateral approach, using the Porous Coated Anatomic total hip system.[3] Heekin et al later found the difference not significant in the same patients.[21]

On the other hand, Hardy and Synek reported normal abductor power and EMG studies after a direct lateral approach in seven patients.[16] Horwitz et al found no difference in limp or abductor strength in a randomized clinical trial of the Hardinge and Transtrochanteric approaches.[17] Minns et al reported that the strength of the abductor muscles recovered equally after these two approaches and was comparable to the non-operated side.[36] Frndak et al demonstrated a normal Trendelenburg test and no limp attributable to the approach in 50 patients undergoing 65 THA's using their modified direct lateral approach.[12]

In this series, we observed a moderate or severe limp in 10% of patients at two years, increasing to 21% at five years or greater. Similarly, 7% of patients required more than part time cane use at two years, increasing to 13% at five years or greater. Generally, this limp has been attributed to other conditions such as contralateral hip disease or ipsilateral knee or ankle arthritis, limb length inequality or neurologic disorders. In the subset of 230 patients with unilateral osteoarthritis of the hip, the prevalence of moderate or severe limp after a timed six-minute walk was a modest 4% at two years, increasing to 12% at five years. The increasing prevalence of limp over time is most likely a sign of advancing age with the development of coexistent conditions such as spinal stenosis or polyarticular arthritis. Some THA's have also deteriorated due to early aseptic failure.

Clearly, a thorough knowledge of the anatomy of the superior gluteal nerve and abductor muscles is necessary prior to proceeding with this approach. Jacobs and Buxton showed in cadavers that the superior gluteal nerve most commonly courses between the gluteus medius and minimus, and runs at least five cm cephalad to the tip of the trochanter. Therefore, division of the gluteus medius

should be kept within this safe zone and preferably done bluntly and under direct vision. Retraction of the gluteus medius will allow direct visualization for division of the gluteus minimus. Elevation of only the anterior one-third of the gluteus medius and minimus limits the defunctionalization of the abductors postoperatively allowing quicker mobilization, perhaps limiting the incidence of postoperative limp. Close attention to a tight soft tissue closure is also critical. Using these techniques, abductor weakness and limp is not a problem in the great majority of patients undergoing primary THA using this approach.

Heterotopic Ossification

Heterotopic ossification has been reported in between 8 and 90% of total hip replacements, and rated severe in between 1 and 24%.[27,45] Severe HO has been associated with increased pain, decreased range of motion and ultimate failure of the THA. Although there are methods of preventing HO with low dose radiation therapy and anti-inflammatory medication,[20,41,45] the best course is to eliminate factors responsible for HO. Many authors have reported the surgical approach to be an important factor. Morrey et al reported a higher incidence and more severe grades of HO following the anterolateral and lateral approaches compared to the posterior approach.[37] Errico and Fetto reported a higher incidence of HO after the transtrochanteric lateral compared to the posterolateral approach.[11] Horwitz et al observed HO more commonly using the direct lateral than the transtrochanteric approach, but this was not clinically significant.[23] Testa and Mazur demonstrated similar results in a non-randomized series of patients.[48] Scheck found HO was more common following a lateral approach when compared to reports of other approaches.[43] Finally, Martell found HO present in 70% of patients undergoing uncemented THA using a direct lateral approach.[32] From these reports, it seems HO may be more common after lateral approaches, but the clinical significance is unclear.

In our series less than 3% of patients had grade III or IV HO, and this was clinically significant in only seven of the 687 patients studied (1%). A distinct form of HO occurs after this modified direct lateral approach, consisting of bone spicules emanating from or around the greater trochanter, presumably arising from the elevated combined periosteum and tendon of the gluteus medius and vastus lateralis (Fig. 10). Of note, the prevalence and severity of HO was similar in cemented, hybrid and cementless THA. This finding is in contradiction to that of Maloney et al, who reported that HO occurred more commonly after cementless stem insertion, and agrees with the report of Rockwood and Horne.[31,42]

This relatively low occurrence of HO might be attributed to careful, blunt in-line fiber spreading of the gluteus medius and tissue protection during acetabular femoral canal preparation. It might help dispel the belief that HO is more common after lateral approaches, given that HO prophylaxis was not used in these patients.

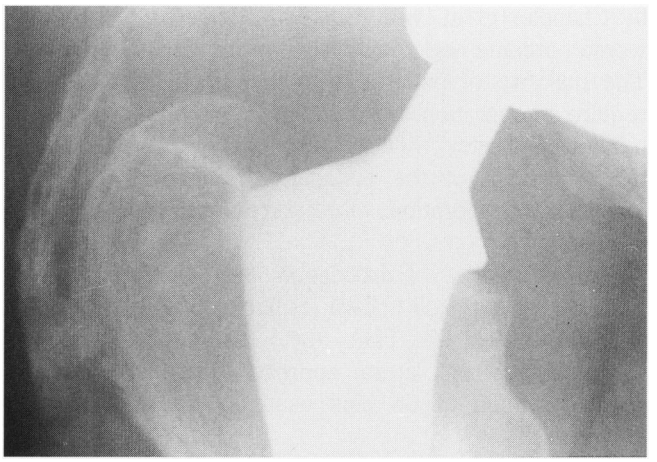

Figure 10
Typical appearance of HO following this approach.

Nerve Palsy

The reported incidence of femoral or sciatic nerve palsy following total hip arthroplasty is between 0 and 3%.[49] Schmalzried et al reported a 1.3% incidence after primary THA and 5.2% after primary THA for CDH. They reported that all patients with postoperative nerve palsies had decreased walking ability at last follow-up.[44] Even patients with partial recovery may have a compromised result and ongoing neurogenic pain. Four nerve palsies occurred as the result of 712 THA's reported here that had a minimum two year follow-up. All palsies were partial neuropraxias of the sciatic nerve, and all showed some recovery at last follow-up. Each palsy was thought due to retraction, and none occurred in a patient who had significant lengthening or had the THA done for CDH. Whether these palsies could have been avoided, or the incidence lowered using a different approach, is difficult to assess.

Utility

Measures of utility of a surgical approach are difficult to define. Those reported here, including applicability in THA, OR time, hip rating and pain scores deserve comment, but may only have usefulness if compared directly to other approaches. Regarding applicability, this approach has proven reliable and predictable in accessing the hip and is currently the approach used for all primary and revision THA's at our institution, including those for CDH. The average OR time of one hour, thirty-eight minutes has been comparable to that of a posterior approach, and is considered acceptable at our teaching institution. The finding that greater than 90% of acetabular and femoral components were positioned well is support

for the adequacy of the exposure using this approach. Finally, although hip rating scores are not valid measures of the success of THA, it appears that no untoward effects such as pain or decreased walking ability could be attributed to the approach. It has been our observation, supported by statistical analysis here, that hip scores and walking ability (as judged by a limp and the need for walking aids) deteriorate over time, as patients become older and more debilitated. This should be remembered when evaluating patients longitudinally in this manner.

Disadvantages

There are severe potential disadvantages of this modified direct lateral approach. The skin incision is generally longer than that required for a posterior approach. One or two surgical assistants are required, depending on the size of the patient and expertise of the surgeon. A sterile pouch must be maintained. If the anatomy is poorly understood, the SGN is in danger, and the femoral neurovascular structures can be injured by excessive dissection or retraction. Finally, trochanteric bursitis may be more common than with other incisions not coursing over the trochanter, an issue not addressed here.

Several limitations to this study exist. It is a retrospective review and is subject to the observations and interpretations of the reviewers. No information is available for the 12 patients lost to follow-up, who potentially have had complications. However, the 98% retrieval (712/724) of available hips is excellent, and even if some of those hips lost to follow-up had complications, it would not likely change the significance of the results. This is a relatively short term follow-up, and a longer period of time will be required to exclude some complications, such as late instability.[7] Finally, this report reflects the experience of two senior surgeons who have supervised over 1000 THA's via this approach at one institution, with nursing and ancillary personnel who are familiar with the procedure and rehabilitation. The results may not be applicable to other circumstances.

CONCLUSION

In conclusion, we describe a modified direct lateral approach for use in primary THA's and most revision THA surgeries. This approach provides excellent exposure and allows accurate placement of components in a timely fashion. In our experience, it has greatly diminished the potentially devastating complication of postoperative instability and is associated with an acceptable incidence of postoperative limp, heterotopic ossification and nerve palsy. A thorough knowledge of the relevant anatomy and surrounding neurovascular structure is a requisite prior to proceeding with this approach. However, with careful technique and attention to detail, a satisfactory outcome can be achieved in nearly all patients.

The authors thank Robert Hardie, M.D. for his assistance in the statistical analyses.

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