Primary total hip arthroplasty: a comparison of the lateral Hardinge approach to an anterior mini-invasive approach

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Abstract

The anterior mini-invasive (MI) approach to performing total hip arthroplasty (THA) is associated with less soft tissue damage and shorter postoperative recovery than other methods. Our hospital recently abandoned the traditional lateral Hardinge (LH) approach in favour of this new method. We compared the first 100 patients operated after the changeover to the new method (MI group) to the last 100 patients operated using the traditional method (LH group). Clinical and radiological parameters and complications were recorded pre- and postoperatively and the collected data of the two groups were statistically compared. There were no statistically significant differences between either group with regard to patient demographics or procedural data, placement of the femur component, postoperative leg discrepancy, prosthesis dislocation, blood transfusion, or postoperative dislocation of the components. The MI group had a significantly longer operating time, more bleeding, higher rate of nerve damage, and a higher percentage of acetabular component malposition whilst having a significantly shorter hospital stay and significantly fewer infections of the operative site in comparison to the LH group. Additionally, and perhaps most worrying was the clinically significant increase in intraoperative femur fractures in the MI group. The changeover to the anterior mini-invasive approach, which was the surgeons' initial experience with the MI technique, resulted in a drastic increase in the number of overall complications accompanied by less soft tissue damage and a shorter period of rehabilitation. Our results suggest that further analysis of this surgical MI technique will be needed before it can be recommended for widespread adoption.

Introduction

Total hip arthroplasty (THA) using the direct lateral Hardinge approach has become one of the most frequently performed and successful reconstructive procedures in orthopaedic surgery since its introduction, more than sixty years ago.[1,2] Whilst there have been many changes in implant designs and biomaterials, surgical approaches have remained relatively unchanged over the years. Recently, in response to the evolution of minimally-invasive procedures such as angioplasty, laparoscopic abdominal surgery, and arthroscopy, orthopaedic surgeons have also expressed an increased interest in minimally-invasive surgical approaches to THA.

A variety of surgical approaches exists and has been utilized for the performance of total hip arthroplasty; these include anterior, anterolateral, direct lateral, transtrochanteric, and posterior techniques.

Currently, most of the approximately 6700 primary THAs performed annually in Norway are done using the standard posterolateral (26%) or lateral (66%) approaches with good success.[3] These approaches give complete and continuous observation of the entire hip and surrounding structures. The cost of this continuous observation is a large incision, moderate muscle and tendon trauma, potentially more pain and intraoperative bleeding, a higher chance for infection, a slower recovery for the patient, and a higher tendency to develop limp and trochanterbursitis after the postoperative recovery.[4]

Minimally-invasive surgery has the potential to minimize surgical trauma, reduce pain, and improve recovery in many surgical procedures. Although mini-invasive THA has not yet taken off in Norway, many surgeons throughout the world have been using this technique for THA. For example, since the late 1970s, Yale orthopaedic residents have been taught THA using the mini-invasive anterior approach.[5] The approach includes single-incision and two-incision techniques, which limit muscle and tendon trauma, yet still allow complete, albeit intermittent, observation.

The search for an approach avoiding transection of any muscle or tendon, thereby potentially minimizing morbidity and improving recovery from THA, led to the development of the mini-invasive approach to hip arthroplasty. With the development of this novel THA came the introduction of numerous new instruments that have been developed to facilitate exposure and component placement (Figure 1). Standard implants with well-established designs are used to maintain the present expectation for implant durability.

This modified Smith-Peterson anterior approach[6] is the only truly intermuscular and internervous plane of dissection to access the

Figure 1. Special instruments used for anterior mini-invasive total hip arthroplasty.

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hip joint.[7] Our main motivation to switch from the Hardinge approach to the anterior approach was to decrease the length of hospital stay, minimize postoperative pain, and to avoid severe complications such as postoperative limp 4-29%[4,8] and trochanterbursitis 5%[9,10] that are associated with the Hardinge approach. The purpose of this study is to present the perioperative clinical parameters and short-term clinical outcomes documented in our first 100 patients operated using the minimally-invasive approach and compare the results to those of the last 100 patients operated using the traditional approach.

We use the lateral Hardinge approach and the MI anterior approach using a single incision without fluoroscopy, navigation, special operating tables, or special self-retractor systems.

Materials and Methods

This study was completed at Sykehuset Buskerud Vestre Viken (SBVV) in the city of Drammen. Drammen is located near Oslo in the south-eastern part of Norway and SBVV is the main medical hospital for the Buskerud county municipality. It serves a population of 250,000 whilst also functioning as the local hospital for 140,000 in the Greater Drammen area. The hospital has historically used the Hardinge approach to all primary hip arthroplasty which, according to the Norwegian Arthroplasty Register, is the standard approach to hip operations done in Norway. The Department of Orthopaedics performs about 170 primary THAs yearly. Until now, the anterior approach was never introduced in Norway on a large scale. Recently, a radical decision was made at SBVV to operate all THAs through a mini-invasive anterior approach.[6,11] We realize there is a learning curve associated with any new surgical method. However, we felt a proper scientific analysis early in the adoption of this method was imperative to critically evaluate whether or not the new method should be continued or abandoned. Thus, this study compares the first 100 patients to be operated using this anterior approach to the last 100 patients to be operated with the Hardinge approach (Table 1). In both groups, we included only patients that received primary unilateral THA attributed to osteoarthritis, osteonecrosis, rheumatoid arthritis, or developmental hip dysplasia. In contrast to other authors,[12] we did not exclude any patient from the MI group on the basis of BMI or other factors. No patient had his or her surgery aborted or converted to a different approach or procedure. During the entire period of the study, there were five experienced surgeons signing off on all 200 operations. After an adequate introduction, this was all five surgeons' first exposure to the anterior approach. Patients operated using the Hardinge approach were placed in the lateral position whilst patients operated anteriorly were laid in the supine position. The length of the incisions ranged from 13 to 20 cm in the lateral approach and from 7 cm to 9 cm in the anterior approach.

Table 1. Patient demographic characteristics and procedure data.

	Lateral approach	Anterior approach	*p*
No. of hips	100	100	1
Age	68(32-90)	68(35-90)	0.85
Gender (M/F)	34/66	29/71	0.45
Operated hip (L/R)	42/58	50/50	0.26
ASA (1/2/3/4)	20/65/15/0	12/74/14/0	0.27
BMI	27.0(18-42)	26.6(16-38)	0.53

For this study, different combinations of both cemented and uncemented acetabular and femur stem components were used. The prostheses used were supplied by Stryker (Accolade, Trident) and dePuy (Titan, Pinnacle, Corail). The bearing surface was polyethylene–metal (cobalt-chrome). All patients received a standard 28 mm head; there were only a few exceptions where larger heads were used. Drainage was not used in any of the operations. Perioperatively, all 200 patients received the same standard i.v. antibiotic prophylaxis. If cemented prothesis components were implanted, antibiotic-containing bone cement was used.

The data collected for analysis were age, gender, operated hip, height, weight, body-mass index (BMI), prosthesis, the American Society of Anaesthesiologists score (ASA),[13] surgical time, preoperative haemoglobin (Hb), haemoglobin first postoperative day, difference in haemoglobin between these two, postoperative discharge day, and all surgical and non-surgical complications.

Postoperatively, anterior radiographs were taken of the pelvis along with a true lateral radiograph of the postoperative hip in which the patient was lying with the uninvolved hip flexed at 90°. The data collected were cup inclination angle, cup anteversion angle, stem alignment, and limb-length discrepancy. The inclination angle was measured directly on the anterior radiograph focused on the pubis corrected by the inclination of the whole pelvis. The anteversion angle was measured directly on the lateral radiograph.[14] For the evaluation of cup placement, we used the Lewinnek criteria defining the range of inclination at 30°-50° and the range of anteversion at 5°-25° as the target range.[15] The varus/valgus stem orientation was measured directly on the anterior radiograph defining a stem orientation of ±3° or greater as malalignment.[16] Postoperative limb-length discrepancy was measured on the anterior radiograph by using the inter-teardrop line and the centre of the lesser trochanter as landmarks, comparing the operated limb with the contralateral side.[17]

In this study, there was no attempt made to record the clinical outcome of any patient using hip scores etc. This study was designed only to compare the immediate outcomes and short-term complications of patients when switching from the lateral approach to the anterior approach.

Statistical analysis used to evaluate the results was a two-tailed student's t-test for continuous variables and a χ^2 contingency table for dichotomous values. A $p<0.05$ was considered to be statistically significant.

Results

Clinical results

Both groups (LH & MI) had 100 patients. There was no significant age, gender, or operated hip difference between the two groups (Table 1).

In hospital time-to-discharge was, expectedly, significantly different between the two groups (Table 2). We had patients in the LH group staying an average of 7.1 days in hospital whilst 5.0 days was the average in the MI group. The range varied from a 3-day hospital stay in the LH group and a 1-day hospital stay in the MI group up to a total of 19 days, the maximum in both groups.

ASA scores in the two groups were not significantly different. Twenty patients in the LH group were assessed as normal healthy patients versus 12 in the MI group. Sixty-five in the LH group were classified as patients with mild systemic disease whereas 74 patients made up the MI group. In the LH group, there were 15 patients who were rated as patients with severe systemic disease along with 14 in the MI group. We had no patients in either group with ASA scores of 4-6.

The BMI was not significantly different between the two groups. The LH group had

patients with an average BMI of 27.0 opposed to the MI group with an average of 26.6. Minimum and maximum BMI in the LH group was 18 and 42 with 16 and 38 in the MI group.

The surgical data for the two groups varied greatly with respect to operational time. The lateral approach had a minimum operation time of 60 min. and a maximum operation time of 165 min. The average operating time of this group was 98 min. On the other hand, the average operating time for the anterior approach group was 115 min. The times for this group varied greatly, with a minimum operation time of 67 min and a maximum of 220 min. These times, obviously, were significantly different from the LH group ($p<0.001$).

Our hospital does not estimate blood loss in the traditional sense; instead we used the change in hemoglobin levels between the preoperative value and the value measured on the first postoperative day to assess patients' loss of blood. The change in hemoglobin was significantly different between the two groups ($p=0.036$); the average was 2.05 g/dL for the LH group and 2.36 g/dL for the MI group. The largest change in both groups was a 4.8 g/L decrease. We had three patients in the LH group and five in the MI group who ultimately required blood transfusions. This difference in the amount of patients needing blood transfusions was statistically not significant.

Regarding complications (Table 2), infection was prevalent in the LH group. In the MI group, we did not have any infections in our first 100 patients. The seven infections reported in the LH group were divided into superficial wound infections with four instances and deep infections with three. The superficial wound infections were all treated successfully with only antibiotics. The deep infections went on to surgical revision. The difference in the amount of infections between the two groups is, thus, significant.

Conversely, postoperative nerve dysfunction was prevalent in the MI group with six affected patients reporting postoperative paraesthesia over the lateral femoral region because of damage to the lateral femoral cutaneous nerve. The LH group did not have any nerve dysfunction whatsoever. This difference is significant ($p=0.013$).

The frequency of postoperative hip dislocation was 1% total in the LH group and 2% in the MI group. In terms of early loosening of uncemented prosthetic components, both groups had the same number of complications meaning that both acetabular and stem dislocations gave rates of 1% and 2%, respectively. The two hip dislocations in the MI group could not be successfully treated with only repositioning and went on to revision surgery. There was one isolated case of hip dislocation in the LH group that was successfully treated with a single repositioning. In cases of dislocation of the prosthetic components, all were successfully reoperated.

Figure 2. Postoperative x-ray of a patient after a mini-invasive-total hip arthroplasty showing a trochanter fracture, varus malalignment of the femur component, and poor cementing technique of the acetabular component.

Table 2. Results and complications.

	Lateral approach	Anterior approach	*p*
Discharge post-OP day	7.1 (3-19)	5.0 (1-19)	<0.001
Average surgical time (min)	98 (60-165)	115 (67-220)	<0.001
Change in haemoglobin	2.05 (0.1-4.8)	2.36 (0-4.8)	0.036
Blood transfusions (in patients)	3	5	0.473
Superficial wound infections	4	0	0.043
Deep infections (patients)	3	0	0.081
Total infections	7	0	0.007
Nerve damage	0	6	0.013
Postoperative dislocations (patients)	1	2	0.561
Postoperative acetabular dislocations	1	1	1
Postoperative stem dislocations	2	2	1
Intraoperative femur fractures	2	8	0.052
Acetabular medial wall damage	1	3	0.312
Major surgical complications	9	13	0.366
Other major non-surgical complications	3	1	0.312

The amount of intraoperative femur fractures (Figure 2) differed appreciably between the two groups. Although not significant ($p=0.052$), in terms of pure numbers the LH group contained two patients who experienced an intraoperative femur fracture alongside eight patients in the MI group. All the fracture cases were treated with either cerclage or weight-bearing restriction.

The difference in the amount of acetabulum medial wall damage was not significant; we had one case in the LH group and three in the MI group.

In performing THA, we consider deep infections, hip dislocations, dislocations of the prosthetic components, damage to major nerves and vessels, and intraoperative femur fractures all as major surgical complications. Speaking quantitatively, there were more complications in the MI group (13) than in the LH group (9). Clinically, this is a notable increase in complications. However, statistically speaking, the difference between the two groups is not significant.

In the LH group, there were a total of two patients who developed urosepsis and one who experienced a hypertensive crisis. In the MI group, there was one patient with a postoperative intestinal perforation. These are referred to as major non-surgical complications in Table 2 and their amounts were not significantly different between the two groups.

Radiographic results

The average cup inclination angle of the acetabular component was similar in both groups (Table 3). Using the Lewinnek criteria,[15] the number of outliers (cup inclination angle <30° or >50°) were also similar.

The average angle of anteversion when

changing from the lateral approach to the anterior approach increased by 8° (from 16° to 24°). Using the Lewinnek criteria[15] with a target range for cup anteversion between 5° and 25°, the number of outliers also increased significantly from 18 to 45.

With regard to the varus/valgus alignment of the femur component, there was no difference between the two groups. Furthermore, the number of outliers with a varus/valgus malalignment of ≥3° was not different. The postoperative limb-length discrepancy between the two groups was also not significantly different. Overall, the amount of patients having a postoperative limb-length discrepancy of <1 cm and <2 cm were similar in both groups.

Discussion

SBVV was the first to introduce the anterior mini-invasive approach to THA on a large scale in Norway. None of the five participating hip surgeons responsible for THA operations here had any prior experience with this approach.

As previously reported by other authors,[7,16] we are confirming that the length of hospital stay decreases significantly from 7.1 d to 5.0 d (30%) when the mini-invasive approach was employed. We are, of course, aware of the fact that the length of hospital stay depends highly on socio-cultural factors and can hardly be compared to other socio-cultural factors in other countries. We believe, generally, as it is shown by other authors,[18] that the length of hospital stay depends much more on factors like patient preconditioning, postoperative pain management, and preoperative and postoperative rehabilitation regimens. The choice of the surgical approach or the length of the incision, on the other hand, is not as decisive. The observation and recording of complications, to a certain degree, is also dependent on whether or not the surgeon is following up the patient closely on either an inpatient or outpatient basis. The length of hospital stay is also important to some surgeons in assessing the rate of post-surgical complications. The shorter hospital stay for the MI group could artificially lead to an under-reporting of complications.

We could not confirm the other authors' finding that mini-incision doesn't lead to a decrease of length in hospital stay but leads to poorer skin-healing and more wound complications.[12] Although not measured quantitatively, we instead observed that patients operated using the mini-invasive approach with intracutaneous skin sutures were more satisfied with the cosmetic result of the incision.

We also found that the MI group had significantly fewer overall postoperative infections (7 vs. 0) in spite of the increase in operative time. We explain this observation by the fact that during the mini-invasive operation there is less internal exposure to air, and that we leave less devitalized tissue behind as a nutrient medium for potential bacterial growth. Our results confirm the low infection rate reported in the literature for the mini-invasive anterior approach: 0%[7] and 0.5%.[19] Our rate for deep infection in both groups was, after all, in the range of the average infection rate of 2.23% reported in the literature for 16291 THAs in England.[20]

The average operative time as a result of the switch to a mini-invasive approach increased significantly from 98 min to 115 min (13%). Contrary to other authors,[7] in examining our first 100 MI operations we could not find any significant learning curve in operative time. This could be due to our relatively small study (100), the large number of participating surgeons (5), and the flat learning curve for the technique. It is shown that for the mini-invasive technique, there is still significant improvement in the learning curve after the first 25 operations performed.[21]

The difference in pre- and postoperative haemoglobin is proportional to the perioperative blood loss and was significantly higher for the MI group. This simultaneously lead to an increase in patients receiving blood transfusions (3% vs. 5%), but this change was not statistically significant. We explain the slightly higher blood loss (ca. 15%) in the MI group by taking into consideration the longer operative time and the position in which the patient is operated (lateral vs. supine). Our transfusion rate after the MI procedure (5%) is comparable to the 3% transfusion rate described by others for the same procedure.[7] It is, however, below the transfusion rates described in other studies: 6%[22] and 17%-94%[23] for THA using other approaches.

The evaluation of the radiographic results shows that there is no significant difference in the positioning of the prosthetic components or the postoperative leg length discrepancy between the two groups albeit with one solitary yet important exception. Our evaluation revealed the anteversion of the acetabular component to be less accurate in the MI group with regard to the Lewinnek criteria.[15] Alarmingly, the percentage of acetabular component malpositioning increased significantly ($p<0.001$). Clinically, this was leading to an increase in prosthetic hip dislocations in the MI group (2% vs. 1%) even if this difference is statistically not considered significant. Since we consider the correct positioning of the prosthetic components with respect to anteversion essential not just to postoperative dislocation rate but also to the long-term survival of the primary prosthesis, we are very concerned about this result. Taking into account that patients in the MI group are operated in the supine position, we are not sure whether the increase of the amount of outliers regarding anteversion is due mainly to the change of approach, position, or a combination of both. This should be subjected to future study. Generally, the percentage of postoperative hip dislocation presented in this study correlate to other authors: 0.96%[19] and 1.2%[24] for postoperative prosthesis dislocation. The sole case of dislocation in the LH group was treated successfully just with one reposition. Meanwhile, we considered the two dislocations in the MI group to be due to soft tissue imbalance[25] and reoperated both patients with prolongation of the femoral head. No further dislocation occurred after the reoperation.

Whilst there was no nerve injury in the LH group, we found that 6% of the MI group sustained at least a partial laceration of the lateral femoral cutaneous nerve. This percentage correlates with the results reported by other authors for this procedure, 4%,[7] and 10-20%.[21] Typically, at least 50% of these lacerations lead to a complete resolution of nerve deficit and, apart from that, most patients who experienced hypoaesthesia did not consider it to be a major complication.

The sum of all major surgical complications (i.e. deep infections, hip dislocations, dislocations of the prosthetic components, damage to major nerves and vessels, and intraoperative femur fractures) in the two groups (9 for LH vs. 13 for MI) was statistically not significantly different. This is partially due to the small number of patients in both groups (100 in each). Be that as it may, the increase in serious surgical complications related to the changeover to the MI approach left a troubling impression clinically. For instance, the increase in trochanteric fractures (Figure 2) is by itself unsettling. The anterior mini-invasive approach usually gives a good view of the acetabulum (Figure 3), but adequate exposure of the proximal femur sometimes becomes a challenge (Figure 4), depending on the patient's anatomy, the surgeon's skill, and whether or not there are time constraints imposed on the operation. This could very well explain the increase in trochanteric fractures. Our number of trochanteric fractures (8%) correlates with the numbers reported by other authors for mini-invasive THA: 7%[24] and 6%.[21] Generally, these rates are less-than-optimal and should result in motivation to improve the techniques and instruments utilized in the mini-invasive approach to THA.

Moreover, even after taking into consideration the flat learning curve associated with the MI approach, the substantial increase in overall complications may give doubts as to the safety of this procedure. The conversion to mini-invasive techniques sometimes, and especially during the adjustment period,

results in frustration on the part of the surgeon and the emergence of new and different complications.[12] The mini-invasive approach is unquestionably more challenging and stressful.[21] It's worth noting that the complications presented in this study were found not only in the initial patients operated with the mini-invasive approach, but were homogeneously spread over the group. Therefore, this gives the impression that these complications are not dependent on the skill of the surgeon but may instead be a function of several aggregating factors inherent to the technique and not under anyone's control, such as prohibitively poor visualization of the operative site. As a consequence, authors comparing the mini-invasive posterior approach to the standard posterior approach have expressed these same concerns.[12]

This study shows that the introduction of a relatively new approach to THA, the mini-invasive anterior approach, leads not only to a statistically significant increase in overall complications when compared to the traditional lateral method, but also to clinically unacceptable results. Although this was only a short-term study to test the safety of the surgical approach, we can honestly say that we experienced the benefits of the mini-invasive technique fully. When abandoning a well-established standard surgical approach to THA in favour of the faster postoperative recovery and less soft tissue damage[7] associated with the mini-invasive anterior approach, one must weigh benefits with the complications. Here, the advantages of mini-invasive THA truly do not outweigh the numerous drawbacks and should not be the deciding factors. Furthermore, by utilizing the mini-invasive anterior method in favour of a faster rehabilitation, we are accepting the high rate of complications observed in this study and sacrificing the well-known long-term benefits of prosthetic hip replacement by forgoing a standard, time-tested approach to THA.

Worldwide, the standard posterior approach is the most widely used approach to THA. In Norway, historically the direct lateral approach is leader. When taking into account every study done, expertise with different approaches and instruments, and millions of operations performed worldwide, in more than 70 years not one approach to the hip joint has emerged as champion. According to the literature, all approaches commonly in use today have about the same overall complication rate; it's just that there are specific complications associated with each approach. In the long run, we doubt the mini-invasive anterior approach to THA will find its place in orthopaedic surgery as an equivalent approach to standard approaches. Future randomized, prospective studies including functional scores and a large body of patients will be imperative to show whether the two different approaches discussed in this paper are equivalent. Until that day, we are concerned about the risks involved in widespread use of this technique.

Table 3. Radiographic results.

	Lateral approach	Anterior approach	*p*
Average inclination	44 (27-58)	44 (28-63)	0.768
Inclination 30-50° (target range)	82	83	0.85
Average anteversion	16 (-6-37)	24 (4-42)	<0.001
Anteversion 5-25° (target range)	82	55	<0.001
Average alignment	1.64 (-2-10)	1.38 (1-7)	0.357
Alignment -3°<a<+3° (target range)	73	73	1
Average postoperative leg length discrepancy	5.1±2 mm (0 -19 mm)	4.0±2 mm (0-19 mm)	0.110
Postoperative leg length discrepancy < 1cm	82	84	0.71
1 cm < postoperative leg length discrepancy < 2 cm	18	16	0.71

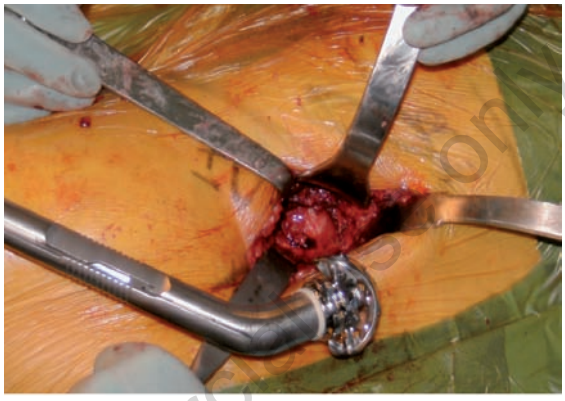

Figure 3. Reaming the acetabulum during mini-invasive-total hip arthroplasty.

Figure 4. Reaming the femur during mini-invasive-total hip arthroplasty.

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