Original Article

Modified minimally invasive two-incision total hip arthroplasty using large diameter femoral head

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Abstract

Background: Minimally invasive (MI) total hip arthroplasty (THA) is an alternative to standard THA, but has created much controversy among orthopedic surgeons. The authors modified the original minimally invasive two-incision THA technique and used large-diameter (32 mm, 36 mm) ceramic-on-ceramic articulation.

Materials and Methods: One hundred and seventy patients that underwent unilateral MI two-incision THA were retrospectively reviewed, and surgical morbidity, functional recovery, radiological properties, and complications were assessed.

Results: Mean Harris hip score (HHS) improved from 41.8 to 96.1 at last followup, and mean Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score from 66.2 to 26.9. The mean lateral opening angle of the acetabular component was 38.2° and the mean stem position was valgus 1.9°. There was an intraoperative femur fracture and one revision surgery due to stem subsidence. No patient had dislocation.

Conclusions: Our data suggest that this modified technique combined with large ceramic femoral head is safe and reproducible in terms of achieving proper implant positioning and early functional recovery.

Key words: Complication, hip, joint replacement, minimal invasive

Introduction

Although total hip arthroplasty (THA) remains the cornerstone of surgical treatment for degenerative joint disease, dislocation continues to be a relatively common complication, and is second only to late prosthetic loosening.[1] Approximately 80% of dislocations following THA occur in the posterior direction with a reported incidence of 0.7% to 5.5% following primary surgery and of 5% to 20% following revision.[2] Femoral component stem design,[3] acetabular component orientation,[4,5] surgical approach,[6] soft tissue laxity,[7] femoral component head size,[8] and patient factors[9] have all been reported to contribute to total hip dislocation.

Minimally invasive (MI) THA is an alternative to standard THA, but has created much controversy among orthopedic surgeons. Advocates insist it offers the patient a smaller incision, shorted rehabilitation, and better functional recovery, but skeptics resist this stance because the reduced visualization offered can increase complications and compromise long term results. MI two-incision THA was introduced in 2002,[10] and was developed to avoid transection of any muscle or tendon which resulted in faster physical therapy and rehabilitation.[10-12] Furthermore, the dislocation rate is theoretically less for MI two-incision THA if the component is implanted in its proper position and patients can move quickly resume normal activities. But, MI two-incision THA is indisputably more technically demanding.[10-12]

It is generally accepted that range of motion of an artificial hip prior to impingement increases with femoral head diameter. However, due to increasing recognition that osteolysis is a major cause of long term THA failure, some authors have advocated the routine use of smaller diameter femoral heads to reduce volumetric wear rates when a polyethylene liner is used.[13-15] On the other hand, the advents of alternative bearings, such as, metal-on-metal and ceramic-on-ceramic articulations, may allow a larger femoral head size to be used to increase stability

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without compromising wear properties.[16,17] In 2003, one of the authors (TRY) modified the original two-incision minimally invasive technique[18,19] and the technique modifications included; patient position, muscle intervals for the anterior and posterior approaches, the use of a Biolox Delta (Biolox®, Osteo AG, Selzach, Switzerland) liner and Biolox Forte (Biolox®, Osteo AG, Selzach, Switzerland) large-diameter (>32 mm) femoral head.

This study was undertaken to evaluate the effect of modified two-incision technique combined with large femoral head in terms of perioperative morbidity, functional recovery, radiological implant position, and incidences of complications, especially dislocation.

Materials and Methods

We retrospectively reviewed the records of 182 patients who had undergone unilateral modified MI two-incision THA from June 2006 to July 2007. Indications for the modified MI two incision approach were: Fulfillment of the criteria for primary THA, a body mass index (BMI) of <30 kg/m^2, and a leg length discrepancy of <2 cm. Four patients were lost to followup and eight patients were excluded because they were followed for less than one year which left 170 of the 182 patients (93%) available for analysis. The cohort contained 113 men and 57 women of mean age 50.4 years (range, 22-83 years). Ninety-five left and 75 right hip arthroplasties were performed. Indications for THA were avascular necrosis of the femoral head in 97 (57%), osteoarthritis in 38 (22%), fracture-associated complications in 28 (17%), rheumatoid arthritis in 5 (3%), and ankylosing spondylitis in 2 (1%). Ninety-six patients (57%) received a 36 mm diameter femoral head and 74 (43%) received a 32 mm diameter head. Mean BMI was 23.9 kg/m^2 (range, 16.2-29.8 Kg/m^2). Mean patient weight and height were 65.4 kg (range, 40-100 kg) and 167.4 cm (range, 148-186 cm), respectively [Table 1]. Hundred and seventy patients were followed for a minimum of one year (mean, 24.8 months; range, 12.0-36.0 months).

Table 1: Demographics of the patients

Parameters	MI 2-incision THA
Number of patients (hips)	170 (170)
Gender (male/female)	113/57
Age (years)	50.40 (22-83)
Body mass index (kg/m^2)	23.86 (16.16-29.75)
Preoperative HHS	46.82 (11-72)
Preoperative WOMAC score	85.42 (50-108)
Diagnosis	
Osteonecrosis	97
Osteoarthritis	38
Complications of fracture	28
Rheumatoid arthritis	5
Ankylosing spondylitis	2

MI indicates minimal invasive; THA - Total hip arthroplasty, HHS - Harris hip score, ROM - Range of motion, WOMAC - Western Ontario and McMaster Universities Osteoarthritis Index

All operations were performed by a single hip surgeon (TRY) using the modifications of the original MI two-incision approach.[10-12] Before surgery, the surgeon explained the operation method and obtained consent for surgery from all patients. In all cases, a cementless acetabular shell with a porous coating was used (Delta PF®, Lima-Lto, Lima, Udine, Italy). The liner inserted was truncated Biolox Delta liner and ceramic head was Biolox Forte ceramic head. Acetabular cup diameters were 44 mm in 14 cases (8%), 46 mm in 21 (12%), 48 mm in 39 (23%), 50 mm in 27 (16%), 52 mm in 45 (26%), 54 mm in 15 (9%), and 56 mm in 9 (5%). For this implant system, the 32 mm head matched cup sizes 44, 46, and 48 mm, and the 36-mm heads matched cup sizes exceeding 50 mm. M/L taper (Zimmer, Warsaw, Ind.) cementless femoral stems which have a proximally coated, tapered design, were used in all cases.

Surgery was performed in the lateral position under general or epidural anesthesia. The trunk and pelvis were firmly secured to the operating table with a rigid stabilization system and the affected hip was prepared and draped using contemporary techniques which allowed the affected leg to be mobilized during the procedure. The tip and anterior and posterior borders of the greater trochanter and trochanteric (vastus) ridge were used as landmarks for the incisions. The first incision of 6 to 8 cm was made over the anterolateral aspect of the hip. This incision started from a point approximately one finger breadth posterior to the anterior border of the trochanter, just distal to the trochanteric crest, and extended cranially and anteriorly at an angle of 30° to the long axis of the femur. The incision was directed approximately at a point on the iliac crest 3 cm posterior to the anterior superior iliac spine [Figure 1]. Subcutaneous tissue and fascia lata along the anterior border of the gluteus medius which was palpated at its insertion on the greater trochanter were divided and intermuscular dissection between the gluteus medius and tensor fascia lata was performed. After carefully ligating the lateral circumflex femoral vessels and anterior joint capsule incision, the femoral neck was osteotomized and the femoral head removed. To improve acetabular visualization, we inserted one or two Steinmann pins at the posterosuperior side of the acetabulum to retract the gluteus medius. In addition, two or three curved Hohmann retractors were placed around the acetabulum, usually anteroinferiorly, posteroinferiorly, and inferiorly, and after exposing the acetabulum, reaming was performed [Figure 2].

A posterior skin incision was then placed over the posterolateral aspect of the hip by flexing the hip to 90° and placing a 4 to 6 cm incision over the greater trochanter. After

dissecting through the muscle fibers of the gluteus maximus, fat layer separating the gluteus maximus and medius was exposed. The piriformis which was used as a key landmark for intermuscular dissection was identified after excising fat [Figure 3]. Intermuscular dissection between fibers of the piriformis and gluteus medius then exposed the joint capsule, and under direct visualization, the joint capsule on the posterosuperior side of the hip joint was incised, and a starting reamer was introduced into the femoral canal. After preparing the proximal femur with a rasp, femoral component size was determined under fluoroscopy, and the femoral component inserted [Figure 4a and b]. The femur was then brought anteriorly by applying traction, external rotation, and extension to the hip. With the hip in external rotation and a bone hook around the neck of stem, we inserted a trial femoral head via an anterior incision. After trial reduction, we evaluated leg length and range of hip joint motion clinically and fluoroscopically (by comparing the levels of the lesser trochanters and the obturator foramina). An appropriately sized final femoral head was then inserted and the joint was reduced. At this stage, tight soft tissues may prevent joint reduction after inserting a large femoral head component, and when this was encountered, we first placed the femoral head into the acetabular cup and then engaged the trunnion into the head with traction and gentle manipulation [Figure 5a-c]. After reduction, leg length and range of motion were rechecked. A negative suction drain was then placed, the posterior joint capsule, and the anterior joint capsule, fascia lata, and subcutaneous tissues were repaired, and the skin closed [Figure 6].

Postoperatively, patients used an abduction pillow between the legs for one month when in bed to reduce the risk of dislocation, and elastic stockings to minimize the risk of deep vein thrombosis. Quadriceps strengthening exercises were started on the day of surgery, and sitting alongside the bed was allowed on the day of surgery as determined by patient comfort. Depending on general condition, mobilization was recommended with weight bearing, as tolerated, on postoperative day 1. Patients were discharged when they were able to used walking aid properly.

Patients were followed at six weeks, three months, 6 months, and 1 year, and then annually. At each visit Harris hip score (HHS)[20] and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores[21] were recorded. Two of the authors not involved in the surgery (KSP, SYH) checked range of motion (ROM) at the last followup visits. Patients were specifically asked about episodes of instability or dislocation which might have been treated elsewhere. In addition, information on hospital stay, operation time, fluoroscopy time, blood loss (obtained by checking hemoglobin and hematocrit changes), and intraoperative, and postoperative complications was recorded.

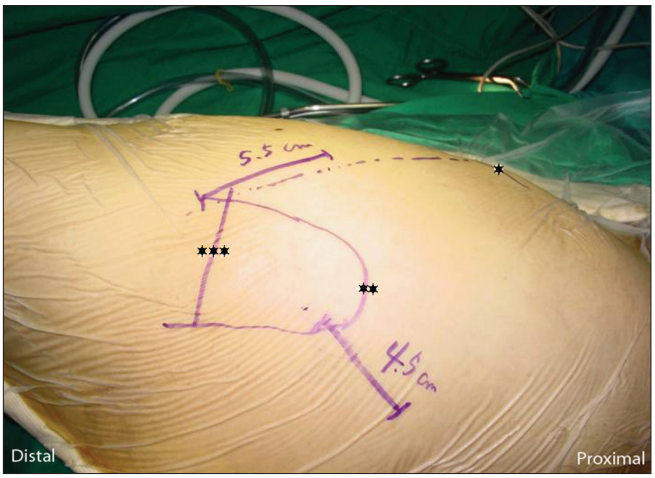

Figure 1: Landmarks and sites of the anterolateral and posterolateral skin incisions. * = anterior superior iliac spine; ** = tip of greater trochanter; *** = vastus ridge

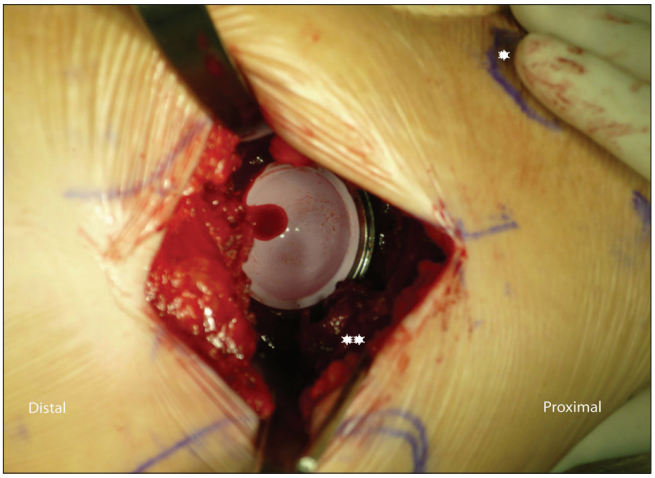

Figure 2: Acetabular cup and liner inserted through the anterior incision. * = anterior superior iliac spine; ** = gluteus medius which was retracted posteriorly by one Steinman pin and curved Hohmann retractor

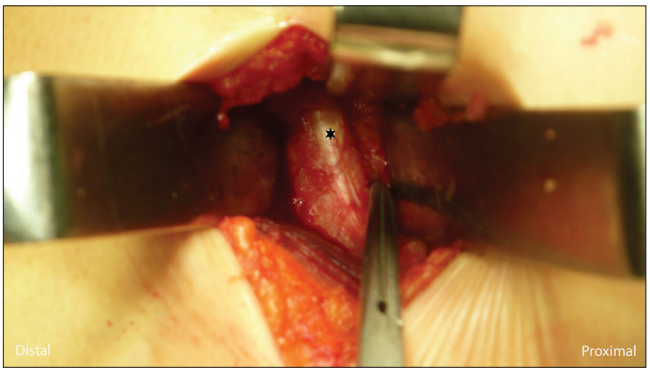

Figure 3: Interval between piriformis and gluteus medius. * = piriformis

Anteroposterior radiographs of both hips and lateral radiograph were checked at every visit. All radiographic measurements were made by two independent observers (KSP, KBL) immediately after surgery and at last followup

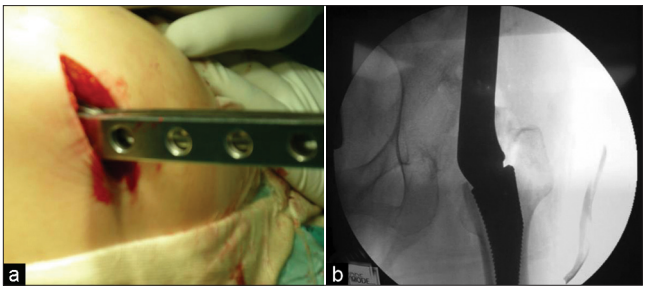

Figure 4: (a) The femoral reamer was inserted through the posterior incision. (b) Its final position and stem size was evaluated fluoroscopically

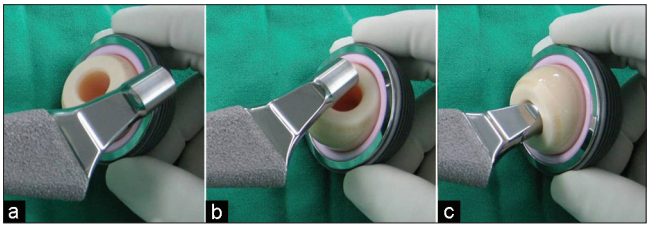

Figure 5: Head reduction procedure when the soft tissues are tight. (a) Head was placed into the acetabular cup before reduction. (b) Through gentle traction and manipulation, the trunnion of the stem is inserted into the femoral head. (c) After reduction

Figure 6: Immediate postoperative photograph shows the incision wounds of MI two-incision THA

visits. Radiographic evaluations included lateral opening angle, anteversion of the acetabular component,[22] femoral component alignment within the femoral canal, radiological leg length discrepancy, and femoral component subsidence.[23] Vertical settling of the femoral component exceeding 3 mm was defined as subsidence. Mean radiographic follow-up after index surgery was 16.2 months (range, 12-26.6 months).

Results

Mean duration of surgery was 71.2 minutes (range, 48-91 minutes) and mean intraoperative fluoroscopy exposure time was six seconds (range, 2-19 seconds). Preoperative and postoperative hemoglobin and hematocrit levels, total blood losses, and transfusion requirements were noted [Table 2].

The mean duration of hospitalization was 8.5 days (range, 3-28 days); one patient with hepatocellular carcinoma and liver cirrhosis remained hospitalized for 28 days. Excluding the patient with an intraoperative femoral fracture, ambulation with a walker started at a mean 1.6 days postoperatively (range, 1-3 days) and with crutches at a mean 3.8 days (range, 1-14 days). Mean HHS improved from 41.8 (range, 10-59) preoperatively to 96.1 (range, 73-100) postoperatively, and WOMAC scores improved from a mean of 66.2 (range, 49-96) preoperatively to 26.9 (range, 24-39) postoperatively. Mean ROM also improved at last follow-up visits versus preoperative values [Table 3]. At last follow-up visits, except for two patients with ankylosing spondylitis, all patients were able to squat and sit cross-legged which is an integral part of the Asian lifestyle.

Radiographically, the acetabular component mean lateral opening angle was 38.2° (range, 32.1°-47.7°) and mean angle of anteversion was 15.4° (range, 4.9°-28.9°). There was no evidence of cup migration. Mean stem position was valgus 1.9° (range, varus 2.3° to valgus 4.8°), and was within valgus or varus 5° in all cases. No patient had a limb-length discrepancy of more than 5 mm at last follow-up and with the exception of one revision case, no femoral component showed subsidence of more than 3 mm. There was no osteolysis observed during follow-up. The one case of intraoperative femoral fracture encountered was treated using three cerclage cables (Dall-Miles®, Stryker Orthopaedics Inc., Mahwah, NJ, USA). Nonweight-bearing ambulation was maintained for four weeks in this case [Figure 7a-d]. No perioperative complication was encountered. In particular, during follow-up, no patient experienced hip dislocation. One patient experienced a postoperative periprosthetic fracture at three months due to a fall during a drunken state. This was treated using cerclage wiring and a plate; subsequently the patient recovered uneventfully. One patient had loosening and stem subsidence of 10 mm. He was treated by stem revision one year after primary surgery. Four patients complaining of squeaking (2.3%). No patient developed heterotopic ossification, deep vein thrombosis, pulmonary embolism, or infection.

Discussion

The advocates of MI two-incision THA claim that versus the traditional posterior approach, the smaller incision and minimal soft tissue injury, adequately explains why MI two-incision THA decreases hospital stay and permits faster

Table 2: Perioperative parameters

Parameters	MI 2-incision THA
Duration of operation (minutes)	71.2 (48-91)
Total skin incision (cm)	11.6 (8.9-17.1)
Blood loss (ml)	927.9 (480-1450)
Intraoperative	473.4 (290-915)
Postoperative	454.5 (175-850)
Transfusion (no of units)	0.8 (0-3)
Hemoglobin (mg/dl) change	
Preoperative	13.9 (9.1-17.5)
Postoperative	10.9 (6.9-14.3)

MI indicates Minimal invasive, THA - Total hip arthroplasty

Table 3: Comparative assessment of average ROM of hip at last follow-up with preoperative values

	Preoperative hip ROM	Postoperative hip ROM
Flexion	95.5°	113.1°
Internal rotation	2.2°	22.3°
External rotation	28.8°	56.7°
Abduction	21.7°	38.8°
Adduction	14.0°	24.9°

ROM indicates Range of motion

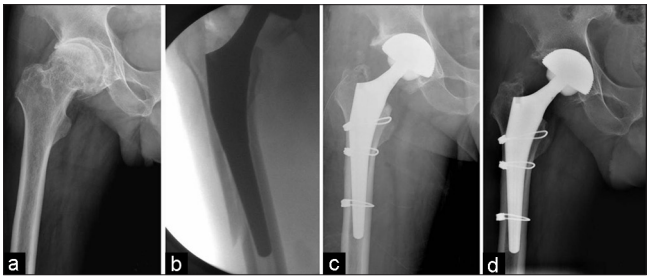

Figure 7: (a) Preoperative anteroposterior (AP) radiograph of a 56-year-old male patient reveals severe osteoarthritis of the right hip. (b) A femoral fracture developed intraoperatively during stem insertion. (c) The fracture was treated using cerclage wiring and a 54 mm cup, and a 36 mm femoral head was used. (d) At final follow-up, the radiograph showed good bony ingrowth and bone union

recovery.[10-12] So, theoretically, if implantation is performed properly, MI two-incision THA has the benefit of a lower rate of dislocation. Furthermore, it is generally accepted that the ROM of a THA prior to impingement increases with increased femoral head diameter, because it increases head-to-neck ratio. In this study, we assessed perioperative morbidities associated with the described large femoral head diameter MI two-incision technique, short-term functional recovery, the radiological characteristics of implanted prostheses, and the incidences of complications.

When considering the results of this study, readers should be aware of the following limitations. First, this was not a prospective study and follow-up was limited to a minimum of 12 months, and second, no control group was included. Nevertheless, here, we introduce a new surgical technique of THA combined with using large diameter femoral head. One hundred and seventy patients were included and procedures were performed by a single hip surgeon who had experience of more than 500 cases.

MI two-incision THA has been previously reported by Mears and Berger.[10-12] In these studies, one incision was used for placing the acetabular component and another for the femoral component. Fluoroscopy was employed during surgery to identify insert placement sites. In previous reports,[10-12,24,25] average MI two-incision THA operation times varied from 90 to 148 minutes and incision sizes from 6.4 to 13.0 cm. In the present study, the mean operation time was 71.2minutes and incision sizes varied from 8.9 to 17.1 cm [Table 4]. We believe that this reduction in operation time was due to the adoption of a lateral position and increasing the skin incision which allowed soft tissue to be mobilized more easily and surgery to be conducted entirely under direct visualization. In terms of the radiographical implant position evaluations, all cases were implanted in the acceptable range, even though cup implantation was performed without fluoroscopy. It could be argued that the duration of hospitalization was relatively long as compared with other MI two-incision THA series, but our patients were not sent to another rehabilitation facility after discharge from our institute. Insurance providers also allow longer stays at our hospital than other countries, and patients' who reside distance from the hospital, and thus, preferred to stay at hospital until wounds had completely healed.

In Berger's study of MI two-incision THA,[10] the complication rate for the first 100 cases was only 1% (one proximal femoral fracture), and no dislocation, ingrowth failure, reoperation, or other notable complication occurred. Archibeck and White[24] reviewed the surgical experiences of a large number of surgeons who had been trained to perform MI two-incision THA using a technique developed by Mears and Berger. In this previous report, 49 (10.2%) key complications occurred among 479 cases undertaken by trained surgeons. Accordingly, the authors concluded that MI two-incision THA is technically difficult and associated with a high incidence of complications. Two other reports concluded that the two-incision technique described by Mears had higher complication and reoperation rates than conventional technique.[17,25] In the present study, as described above, we used the space between the gluteus medius and tensor fascia lata to avoid injuring the lateral femoral cutaneous nerve. Furthermore, the lateral decubitus and anterolateral approach provides better visualization and orientation of the acetabulum which eliminates the need for fluoroscopy during the implantation of the acetabular component. With the patient in the lateral decubitus position and the hip flexed and adducted, the intermuscular interval between the gluteus medius and piriformis is

Table 4: The comparison of other author's MI 2-incision THA

Years	2003	2003	2004	2005	2006	Present study
Authors	Berger[11]	Duwelius *et al.*[12]	Archibeck *et al.*[24]	Bal *et al.*[25]	Yoon *et al.*[18]	
Incision length						
Total	2.75 inch	7-10 cm	9.5 cm	2.5 ~ 5.1 inch	11.9 cm (9.0-17.5)	11.6 cm (8.9-17.1)
Anterior	1.5 inch	4-6 cm	5.8 cm	-	7.4 cm (5.5-10)	7.3 cm (5.5-10)
Posterior	1.25 inch	3-4 cm	3.7 cm	-	4.5 cm (3.5-7.5)	4.3 cm (3.5-7.5)
Case	100	100	851	89	225	170
Age (years)	56	57/60	61	58.5	51.5	50.4
BMD (kg/m^2)	26.8	-	26	30.7	-	23.9
Duration of surgery	101 minutes	90 minutes	148 minutes	127 minutes	70 minutes	71.2 minutes
Admission time	-	1-2 days	-	4.5 days	8.4 days (5-13)	8.5 days (3-28)
Femoral head size	28 mm	28 mm	28 mm	28 mm	39 cases: 32 mm 186 cases: 28 mm	96 cases: 36 mm 74 cases: 32 mm
D/L and other complications	D/L- 0 (0.0%) Femoral Fx - 1	D/L -2 (2%) Stem subside - 1 Intraoperative Fx - 1	D/L - 8 (0.9%) Fx - 62 (7.3%) Nerve injury -27 (3.2%)	D/L- 1 (1.1%) Fx - 7 Numbness - 22 Stem loosening - 4	D/L- 2 (0.9%) Intraop fx - 2 DVT - 2 Stem subsidence - 2 Femoral nerve neuropraxia -1	D/L- 0 (0.0%) Intraop Fx-1 Stem subsidence and loosening -1
Total complication cases and rate	1 (1%)	4 (4%)	97 (11.4%)	34 (38.2%)	9 (4%)	2 (1.2%)

MI indicates Minimal invasive, THA - Total hip arthroplasty, BMD - Body mass index, D/L - Dislocation, Fx - Fracture

better visualized which avoids muscle damage and surgical instruments impinging soft tissues during femoral stem insertion. Furthermore, when we compared complication rates in the present study with those of other studies, we found them comparable [Table 4].

Dislocation often occur secondary to impingement, and impingement type depends on femoral head size. For 22 mm diameter femoral heads, impingement between components most often occurs between the femoral neck and the acetabular component,[8] and bony impingement symptoms commonly occur for femoral heads larger than 32 mm between the proximal femur and pelvis. This is attributed to an increase in the head-to-neck ratio due to an increase in femoral head size which allows a greater curvature of arc before the neck contacts the acetabulum. Furthermore, the jump distance is higher for larger femoral heads, and thus, they are less prone to dislocation. Accordingly, larger femoral heads add substantially to the stability of hip reconstruction.[8,16] None of our patients experienced hip dislocation which is better than that reported for other MI two-incision THA series [Table 4]. In a previous study, we reported the results of 225 modified MI two-incision THAs with a 28 mm or 32 mm head and found a dislocation rate of 0.9% (two cases).[18] The lower incidence of dislocation found in the present study could be attributed to MI two-incision surgery per se or to the use of a large femoral head. However, to accurately determine the nature of the relation between MI two-incision with a large femoral head and dislocation rates, more case comparisons are needed.

The findings of the present study suggest that the described modified two-incision THA technique is safe and reproducible and that it enables proper implant positioning and early functional recovery. Furthermore, the complication rate was low and using large femoral head, no dislocation occurred. Nevertheless, we believe the described modified MI two-incision THA technique requires adequate experience and that low complication rates depend on proper patient selection.

References

1. Mahoney CR, Pellicci PM. Complications in primary total hip arthroplasty. Avoidance and management of dislocations. Instr Course Lect 2003;52:247-55.
2. Eftekhar NS. Dislocation and instability. In: Eftekhar NS, editors. Total hip arthroplasty. St. Louis CV: Mosby; 1993. p.505.
3. Turner RS. Postoperative total hip prosthetic femoral head dislocations: Incidence, etiologic factors, and management. Clin Orthop Relat Res 1994;301:196-204.
4. Barrack RL, Butler RA, Laster DR, Andrews P. Stem design and dislocation after revision total hip arthroplasty: Clinical results and computer modeling. J Arthroplasty 2001;16:8-12.
5. Lewinnek GE, Lewis JL, Tarr R, Compere CL, Zimmerman JR. Dislocations after total hip-replacement arthroplasties. J Bone Joint Surg Am 1978;60:217-20.
6. Masonis JL, Bourne RB. Surgical approach, abductor function, and total hip arthroplasty dislocation. Clin Orthop Relat Res 2002;405:46-53.
7. Robbins GM, Masri BA, Garbuz DS, Greidanus N, Duncan CP. Treatment of hip instability. Orthop Clin North Am 2001;32:593-610.
8. Byström S, Espehaug B, Furnes O, Havelin LI. Norwegian Arthroplasty Register. Femoral head size is a risk factor for total hip luxation: A study of 42,987 primary hip arthroplasties

from the Norwegian Arthroplasty Register. Acta Orthop Scand 2003;74:514-24.
9. DeWal H, Su E, DiCesare PE. Instability following total hip arthroplasty. Am J Orthop (Belle Med NJ) 2003;32:377-82.
10. Berger RA. Mini-incisions: Two for the price of one! Orthopedics 2002;25:472-98.
11. Berger RA. Total hip arthroplasty using the minimally invasive Two-incision approach. Clin Orthop Relat Res 2003;417:232-41.
12. Berry DJ, Berger RA, Callaghan JJ, Dorr LD, Duwelius PJ, Hartzband MA, *et al*. Minimally invasive total hip arthroplasty. Development, early results, and a critical analysis. J Bone Joint Surg Am 2003;85:2235-46.
13. Kesteris U, Ilchmann T, Wingstrand H, Onnerfalt R. Polyethylene wear in Scanhip arthroplasty with a 22 or 32 mm head. Acta Orthop Scand 1996;67:125-7.
14. Learmonth ID, Hussell JG, Smith EJ. Inadequate polyethylene thickness and osteolysis in cementless hip arthroplasty. J Arthroplasty 1997;12:305-9.
15. Lee PC, Shih CH, Chen WJ, Tu YK, Tai CL. Early polyethylene wear and osteolysis in cementless total hip arthroplasty: The influence of femoral head size and polyethylene thickness. J Arthroplasty 1999;14:976-81.
16. Bragdon CR, Greene ME, Freiberg AA, Harris WH, Malchau H. Radiostereometric analysis comparison of wear of highly cross-linked polyethylene against 36- vs 28-mm femoral heads. J Arthroplasty 2007;22(6, Suppl 2):125-9.
17. Muratoglu OK, Bragdon CR, O'Connor D, Perinchief RS, Estok DM 2nd, Jasty M, *et al*. Larger diameter femoral heads used in conjunction with a highly cross-linked ultra-high molecular weight polyethylene: A new concept. J Arthroplasty 2001;16(8, Suppl 1):24-30.
18. Yoon TR, Bae BH, Choi MS. A modified two-incision minimally invasive total hip arthroplasty: Technique and short-term results. Hip Int 2006;16 Suppl 4:28-34.
19. Yoon TR, Park KS, Song EK, Seon JK, Seo HY. New two-incision minimally invasive total hip arthroplasty: Comparison with the one-incision method. J Ortrhop Sci 2009;14:155-60.
20. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: Treatment by mold arthroplasty. An end-result study using a new method of result evaluation. J Bone Joint Surg Am 1969;51:737-55.
21. Boardman DL, Dorey F, Thomas BJ, Lieberman JR. The accuracy of assessing total hip arthroplasty outcome: A prospective correlation study of walking ability and 2 validated measurement devices. J Arthroplasty 2000;15:200-4.
22. Widmer KH. A simplified method to determine acetabular cup anteversion from plain radiographs. J Arthroplasty 2004;19:387-90.
23. Sutherland CJ, Wilde AH, Borden LS, Marks KE. A ten-year follow-up of one hundred consecutive Muller curved-stem total hip-replacement arthroplasties. J Bone Joint Surg Am 1982;64:970-82.
24. Archibeck MJ, White RE. Learning curve for the two-incision total hip replacement. Clin Orthop Relat Res 2004;429:232-8.
25. Bal BS, Haltom D, Aleto T, Barrett M. Early complications of primary total hip replacement performed with a two-incision minimally invasive technique. J Bone Joint Surg Am 2005;87:2432-8.

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