

MINIMALLY INVASIVE AND CONVENTIONAL HIP ARTHROPLASTY- A COMPARATIVE ANALYSIS

**DISSERTATION FOR THE AWARD OF MCh IN ORTHOPAEDICS,
UNIVERSITY OF SEYCHELLES AMERICA INSTITUTE OF MEDICINE**

APRIL 2008

DR.SHIVALIK KAPOOR

INTRODUCTION

Total hip arthroplasty is the most frequently performed reconstructive procedures in orthopaedic surgery today.

Conventional approaches to THA even in modified versions use incisions of around 25 cm in length and result in substantial soft tissue disruption.

The term MIS THA may be applied to any hip replacement procedure in which the length of the wound and the surgical access are deliberately modified in an attempt to reduce the tissue trauma associated with hip replacement, thereby limiting the length of the skin incision of less than or equal to 10 cm, with use of anterior or posterior approach⁴

However we have used single incision posterior approach in our study.

Considering the paucity of research work on Indian population in the field of MIS-HA, this study was conducted to compare the Minimally Invasive

surgical approach with its traditional counterpart in hip arthroplasty.

MATERIALS AND METHODS

The study was conducted in the Department of Orthopaedics at a tertiary care hospital, New Delhi from January 2008 to April 2008. All patients attending the out patient department were screened and a total of 23 patients, managed with unilateral hip replacement, were included in this prospective study after applying specific inclusion and exclusion criteria.

Inclusion criteria

- BODY MASS INDEX $< 30 \text{ kg/m}^2$
- LOW FAT DISTRIBUTION AROUND GLUTEAL AND UPPER THIGH REGION
- PRIMARY HIP ARTHROPLASTY, WHICH CAN BE CEMENTED, UNCEMENTED OR HYBRID TYPE.

Exclusion criteria

- BODY MASS INDEX $> 30 \text{ kg/m}^2$
- VERY MUSCULAR
- COMPLEX ACETABULUM
- REVISION HIP SURGERY
- REMOVAL OF HARDWARE

Patients selected were randomized into two groups:

- **Study Group**---Comprised of 12 patients who underwent hip replacement via mini-incision technique.
- **Control Group**--- Comprised of 11 patients who underwent hip replacement via standard hip incision.

Posterior capsulorrhaphy was routinely performed in all patients.

BASELINE PATIENT CHARACTERISTICS

For each patient in the Study and Control group demographic and baseline data were collected, including age, sex, diagnosis, and body mass index. Preoperative physical function was scored for each patient by summarizing the available data from self-reporting and following clinical examination using Harris Hip Score.

OPERATIVE DATA

Operative data, including measured incision length, estimated blood loss, and operative time (from incision to closure) was obtained.

POST OPERATIVE DATA

Post-operative data, including hemoglobin deficit, complications, total number of units of blood transfused, duration of analgesia, and duration of stay in hospital were obtained.

After discharge, patients were followed up at two weeks, four weeks and monthly thereafter. Data were analyzed and evaluated for first and second month post-operatively using Harris Hip Score. Patients treated with uncemented arthroplasty were not included in the scoring system at one-month post operatively as they were not allowed to bear weight on the operated limb for at least 6 weeks.

HARRIS HIP SCORE¹⁵ -The normal hip is rated as scoring 100 points, while the hip being examined is described as being so many percent of this normal. **Pain** is allocated 44 points; **Function** is broken down into gait, and activities, and merits 47 points. **Range of motion** merits 5 points, and **Absence of deformity** 4 points.

A scoring was analyzed as follows---

90 to 100 ---- Excellent Result

80 to 90 ---- Good Result

70 to 80 ---- Fair Result

< 70 ---- Poor Result

POST OPERATIVE RADIOGRAPHIC ASSESSMENT

Radiographs taken at two months post operatively were assessed for each patient in both MIS and Control group.

Three standard radiographs were included: AP view of the pelvis and AP and LATERAL view of the hip.

Stem alignment was determined using standard AP and lateral hip radiographs.

Acetabular inclination was measured on a standardized AP radiograph of the pelvis. Acetabular inclinations of 35°-55° degrees were classified as good; those outside this range were classified as poor.

Limb length discrepancy was referenced from the inter-ischial line. The difference between the two sides was reported as limb length discrepancy.

STATISTICAL ANALYSIS

Parameters were compared between the MIS and Control groups using the two-tailed independent samples *t-test*. A p-value of < 0.05 was considered to be significant.

OUTCOMES

TABLE 1 **BODY MASS INDEX**

BMI (kg/m ²)	MIS HA		Conventional HA	
	No.	%	No.	%
15 – 18	1	8.4	0	0
18.1 – 21	2	16.6	0	0
21.1 – 24	4	33.4	3	27.3
24.1 – 27	3	25	6	54.5
27.1 – 30	2	16.6	2	18.2
Total	12	100	11	100

Average Body Mass Index of the patients in the MIS-HA group was 24 kg/m². The average Body Mass Index of the patients in the conventional HA group was 24.8 kg/m². On comparing them using the student's 't' test, p value was 0.24 (statistically insignificant).

TABLE 2 **INDICATION OF SURGERY**

Indication	MIS HA		Conventional HA	
	No.	%	No.	%
Fracture neck of femur	7	58.4	6	54.6
Osteonecrosis	2	16.7	1	9.1
Post traumatic O.A	1	8.3	1	9.1
Ankylosing spondylitis	1	8.3	1	9.1
Rheumatoid Arthritis	1	8.3	2	18.1
Total	12	100	11	100

Most common indication of surgery in MIS HA group was fracture neck of femur (58.4%). Same indication was also found to be the most common (54.6%) in the conventional HA group.

TABLE 3 **DURATION OF SURGERY**

Duration (mins)	MIS HA		Conventional HA	
	No.	%	No.	%

31 – 60	1	8.3	0	0
61 – 90	7	58.4	0	0
91 – 120	3	25	3	27.3
121 – 150	1	8.3	6	54.5
151 – 180	0	0	2	18.2
Total	12	100	11	100

Average duration of surgery in MIS HA group was 94.8 mins. While average duration of surgery in conventional HA group was 136.6 mins,, the difference being highly significant statistically (p value – 0.00).

TABLE 4 TOTAL BLOOD LOSS

Total blood loss (ml)	MIS HA		Conventional HA	
	No.	%	No.	%
0 – 200	2	20.1	0	0
201 – 400	8	70.1	0	0
401 – 600	2	9.8	3	27.2
601 – 800	0	0	5	45.5
801 – 1000	0	0	1	9.1
1001 – 1200	0	0	1	9.1
1201 – 1400	0	0	0	0
> 1401	0	0	1	9.1
Total	12	100	11	100

Average total blood loss in the study group (MIS HA group) was 290 ml while the average total blood loss in the control group (conventional HA

group) was 733.6 ml, the difference being highly significant statistically (p value 0.00).

TABLE 5 HAEMOGLOBIN DEFICIT

Haemoglobin deficit (gm%)	MIS HA		Conventional HA	
	No.	%	No.	%
0 – 0.4	2	16.7	0	0
0.5 – 0.8	5	41.7	3	27.2
0.9 – 1.2	4	33.3	3	27.3
1.3 – 1.6	1	8.3	3	27.3
1.7 – 2.0	0	0	1	9.1
2.1 – 2.4	0	0	1	9.1
Total	12	100	11	100

Average haemoglobin deficit in MIS HA group was 0.75gm% while the average haemoglobin in the conventional HA group was 1.13gm%. On comparing them using the student's 't' test, the difference was found to be highly significant (p value - 0.001).

TABLE 6 COMPLICATIONS

Complications	MIS HA		Conventional HA	
	No.	%	No.	%
None	10	83.4	8	72.7
Fracture medial cortex femur	1	8.3	0	0
Local hematoma	1	8.3	1	9.1
Paralytic ileus	0	0	1	9.1
Superficial infection	0	0	1	9.1

Total	12	100	11	100
--------------	-----------	------------	-----------	------------

Majority of the patients in MIS HA group (83.4%) had no post-operative complications. Though, there is minor difference in the number of complications in both the groups but it was found to be statistically insignificant (p value – 0.18).

TABLE 7 DURATION OF HOSPITAL STAY

Duration of hospital stay (days)	MIS HA		Conventional HA	
	No.	%	No.	%
0 – 3	6	50	1	9.1
4 – 6	5	41.7	8	72.7
7 – 9	1	8.3	1	9.1
10 – 12	0	0	1	9.1
Total	12	100	11	100

Average duration of hospital stay for MIS HA group was 3.71 days while average duration of hospital stay for patients subjected to conventional HA was 5.23 days, the difference being highly significant (p value – 0.003).

TABLE 8 DURATION OF ANALGESIA

Duration of Analgesia (days)	MIS HA		Conventional HA	
	No.	%	No.	%
1 – 2	7	58.4	2	18.2
3 – 4	4	33.3	5	45.5
5 – 6	1	8.3	4	36.3

Total	12	100	11	100
--------------	-----------	------------	-----------	------------

Average duration of round the clock analgesia in the patients subjected to MIS HA was 2.87 days while the average duration of round the clock analgesia required by the patients who underwent conventional HA was 3.82 days, the difference being significant (p value = 0.008).

TABLE 9 LENGTH OF INCISION

Length of incision (cm)	MIS HA		Conventional HA	
	No.	%	No.	%
5 – 7.5	3	25	0	0
7.6 - 10	9	75	0	0
10.1 – 12.5	0	0	0	0
12.6 – 15	0	0	0	0
15.1 – 17.5	0	0	0	0
17.6 – 20	0	0	1	9.1
20.1 – 22.5	0	0	4	36.3
22.6 – 25	0	0	4	36.3
25.1 – 27.5	0	0	2	18.3
Total	12	100	11	100

Average length of incision in MIS HA group was 8.4 cm while the average length of incision in conventional HA group was 22.8 cm, the difference being statistically highly significant (p value = 0.00).

TABLE 10 NUMBER OF BLOOD TRANSFUSIONS

Number of blood transfusions	MIS HA		Conventional HA	
	No.	%	No.	%

0	5	41.6	1	9.1
1	5	37.6	4	36.4
2	2	20.8	5	45.4
3	0	0	1	9.1
Total	12	100	11	100

Average number of transfusions required in the study group (MIS HA group) was 0.79 while average number of transfusions given in the control group (conventional HA group) was 1.53, the difference being highly significant (p value = 0.004).

TABLE 11 PRE-OPERATIVE HARRIS HIP SCORE (HHS)

Pre-operative HHS	MIS HA		Conventional HA	
	No.	%	No.	%
<70	12	100	11	100
70 – 80	0	0	0	0
80.1 – 90	0	0	0	0
90.1 – 100	0	0	0	0
Total	12	100	11	100

Average pre-operative HHS in MIS HA group was 17.21 while that in conventional HA was 18.47, the results being statistically insignificant (p value = 0.78).

TABLE 12 POST-OPERATIVE HARRIS HIP SCORE (HHS) AT

1 MONTH (Only for cemented and hybrid component)

Post-operative HHS (1 month)	MIS HA		Conventional HA	
	No.	%	No.	%
Not evaluated	1	8.3	3	27.2
<70	1	8.3	6	54.6
70 – 80	7	58.4	2	18.2
80.1 – 90	3	25	0	0
90.1-100	0	0	0	0
Total	12	100	11	100

Average post-operative HHS at one month in MIS HA group was 76.61 while that in conventional HA was 60.62, the results being statistically highly significant (p value = 0.00).

TABLE 13 POST-OPERATIVE HARRIS HIP SCORE (HHS) AT 2 MONTH

Post-operative HHS (3 months)	MIS HA		Conventional HA	
	No.	%	No.	%
<70	0	0	0	0
70 – 80	1	8.3	0	0
80.1 – 90	3	25	4	36.4
90.1 – 100	8	66.7	7	63.6
Total	12	100	11	100

Average post-operative HHS at two month in MIS HA group was 93.48 while that in conventional HA was 94.04, the results being statistically insignificant (p value = 0.77).

RADIOLOGICAL-ASSESSMENT

(AT 2 MONTHS POST OPERATIVE PERIOD)

TABLE 14 ACETABULAR INCLINATION

Acetabular Inclination	MIS HA		Conventional HA	
	No.	%	No.	%
< 35°	0	0	0	0
35° - 55°	8	89	9	100
> 55°	1	11	0	0
Total	9	100	9	100

Average inclination in MIS HA group was 46.3° while that in conventional HA group was 44.4°, the difference statistically insignificant (p value = 0.41).

TABLE 15 FEMORAL STEM ALIGNMENT

Inclination	MIS HA				Conventional HA			
	AP		Lateral		AP		Lateral	
	No.	%	No.	%	No.	%	No.	%
Varus	1	8.3	1	8.3	0	0	0	0
Slight varus	2	16.7	2	16.7	2	18.2	1	9.1
Neutral	6	50	6	50	5	45.5	4	36.4
Slight valgus	3	25	3	25	4	36.3	6	54.5
Valgus	0	0	0	0	0	0	0	0
Total	12	100	12	100	11	100	11	100

In both the view (AP and lateral), percentage of arthroplasties in neutral or slight deviation was 91.7% in MIS HA group and 100% in Conventional HA group. Arthroplasties in varus alignments in MIS group was 8.3% while in Conventional HA it was 0%.

TABLE 16 **LIMB LENGTH DISCREPANCY**

Limb length discrepancy (mm)	MIS HA		Conventional HA	
	No.	%	No.	%
≤ 5 mm	8	66.7	7	63.6
6 – 10 mm	3	25	4	36.4
> 10 mm	1	8.3	0	0
Total	24	100	22	100

Average limb length discrepancy in MIS HA group was found to be 5.04 mm while in conventional HA group it was 5.32 mm, the difference being statistically insignificant (p value – 0.70).

ANALYSIS

- The two groups were evenly matched in terms of age, Sex distribution and Body Mass Index. P-value was statistically insignificant in all three.

- Average age in the study group (MIS HA) was 61.12 years while average age in the control group (Conventional HA) was 63.3 years.
- The sex ratio in the MIS HA group was 50:50 while the sex ratio in the Conventional HA group was 45:55.
- Average Body Mass Index of the patients in the MIS HA group was 24 kg/m². The average Body Mass Index of the patients in the conventional HA group was 24.8 kg/m².
- Most common indication of surgery in MIS HA group was fracture neck of femur (58.4%). Same indication was also found to be the most common (54.6%) in the Conventional HA group.
- Average duration of surgery in MIS HA group was 94.8 mins while average duration of surgery in Conventional HA group was 136.6 min.
- Average total blood loss in the study group (MIS HA group) was 290 ml while the average total blood loss in the control group (Conventional HA group) was 733.6 ml.
- Average haemoglobin deficit in MIS HA group was 0.75gm% while that in the Conventional HA group was 1.13gm%.
- Majority of the patients in both the groups had no post-operative complications. Only one patient in MIS HA group had fracture medial cortex of femur.
- Average duration of hospital stay for MIS HA group was 3.71 days while average duration of hospital stay for patients subjected to Conventional HA was 5.23 days.

- Average duration of round the clock analgesia in the patients subjected to MIS-HA was 2.87 days and to Conventional HA was 3.82 days.
- Average length of incision in MIS HA group was 8.4 cm while that in Conventional HA group was 22.8 cm.
- Average number of transfusions required in the study group (MIS HA group) was 0.79 while the same given in the control group (Conventional HA group) was 1.53.
- Average pre-operative HHS in MIS HA group was 17.21 (Poor) while that in Conventional HA was 18.47 (Poor).
- Average post-operative HHS at one month in MIS HA group was 76.61 (Fair) while that in Conventional HA group was 60.62 (Poor).
- Average post-operative HHS at two month in MIS HA group was 93.48 (Excellent) while that in Conventional HA was 94.04 (Excellent).
- Average inclination in MIS HA group was 46.3° while that in Conventional HA group was 44.4°. Only one patient in MIS group had poor acetabular inclination (57°).
- In both the view (AP and lateral), percentage of arthroplasties in neutral or slight deviation was 91.7% in MIS HA group and 100% in Conventional HA group. In both the views (AP and lateral), arthroplasties in varus alignments in MIS HA was 8.3% while in Conventional HA it was 0%.
 - Average limb length discrepancy in MIS HA group was found to be 5.04mm while in Conventional HA group it was 5.32 mm.

DISCUSSION

A total of 23 patients who fulfilled the selection criteria (as mentioned in Materials And Methods) were selected and were randomly divided into **Study Group** and **Control Group**.

DEMOGRAPHIC PROFILE

On entry into the study, the characteristics of patients in both the groups were comparable in regards to age, sex ratio, BMI, diagnosis and pre-operative Hip score.

Mean age of subjects of study group was 61.12 yrs and control group was 63.31 yrs, which is statistically, well matched. Mean age of the study conducted by **Berger R.A** in **2003**¹⁶, which were operated by MIS-THA was 58 yrs and compared favorably with our study.

The sex ratio compared favorably in both the groups (study group-6 men, 6 women; control group-5 men, 6 women with p-value 0.76). The sex ratio of our study compared favorably with sex ratio of the study conducted by **Gore et al¹¹** in **1982**.

Average BMI in study group was 23.3 kg/m² and in control group was 24.8 kg/m² and both were statistically insignificant (p-value-0.02). Average BMI of 100 patients recruited in the study by **Hartzband et al⁷** had a BMI of 27.9 kg/m². In our study we have only included the patients with BMI < 30 kg/m², while in the above stated study no such upper limit has been fixed. Also our study was conducted on Indian population, which has

consistently lower BMI as compared to their western counterpart.

Most common indication for hip arthroplasty in our study was fracture neck of femur (58.4% of patients in study group and 54.6% patients in control group). This is in contrast to the most common indication of surgery in the study by **Berger R.A**⁶, where the most common diagnosis was osteoarthritis of hip joint. This can be explained by the fact that primary osteoarthritis of the hip joint is very uncommon in our population.

Average duration of surgery in MIS-HA group was 94.8 min. while in conventional HA group, it was 136.6 min. The difference was highly significant statistically. Similar results were also obtained by **Wenz et al**² where mean

operative time in conventional group was 164 min. and in MIS group was 124 min.. However the results of the comparative study performed by **Woolson et al**¹² in **2004** showed statistically insignificant difference. Average duration of both the operative procedures is shorter in our study as compared to the above quoted study because it was conducted in 2004 when the technique of MIS had just evolved and most surgeons were in initial part of learning curve.

Total blood loss in MIS-HA group was 290 ml while that in conventional group is 733.7 ml. Similar results were obtained in the study by **Howell et al**⁴ in 2004 who reported significant difference in the estimated blood loss in between the two groups.

Average hemoglobin deficit in MIS hip arthroplasty group in our study is found to be 0.75gm%, which was significantly lower than that found in conventional hip arthroplasty group (1.13gm%). **Howell et al⁴** reported that though there is significant difference in the estimated blood loss in between the two procedures (MIS THA = 387ml vs. Conventional THA = 469ml) but there was no significant difference in between the hemoglobin deficit. Thus the MIS approach to hip arthroplasty significantly reduced the blood loss, thus reducing the morbidity associated with excessive blood loss.

Majority of patients in both the groups had no post-operative complications (91.6% in MIS group and 77.2% in Conventional HA group). Only one patient in the MIS HA group suffered from fracture of medial cortex of femur, another

developed local hematoma. One patient from conventional HA group developed local hematoma, one developed paralytic ileus and one developed superficial infection of the surgical wound. Almost similar rate and type of complications were observed by **Woolson et al¹²** and **Wenz et al²**.

All these studies have failed to

show any difference in the rate of post-operative complications in between the two groups. Thus the concern regarding inadequate exposure, unfamiliar approach and instruments and instability of the joints due to posterior capsulorrhaphy are unfounded and purely theoretical.

Average duration of hospital stay for the patients subjected to MIS HA was 3.71 days, while that in patients of conventional HA was 5.23 days. The difference statistically was significant. Similar

results were obtained in the study by **Berger et al**⁶. Thus, by performing hip arthroplasty via MIS technique, the duration of nursing care required in the post-operative is drastically reduced, thereby reducing the economic pressure on the patient as well as healthcare provider.

Average duration of round the clock analgesia required in MIS-HA group was 2.87 days while in Conventional HA group was 3.82 days, the difference being statistically significant. Thus indicating that in post-op period, patients subjected to MIS-HA suffered less pain and discomfort. This can be explained on the basis of smaller incision and lesser soft tissue trauma. Also smaller length of the scar also has positive impact on patient's psychology. **Swenson and Hanna**¹⁷ quoted similar results.

Average length of incision in MIS HA group is 8.4 cm while that in conventional HA group is 22.8 cm, the difference being highly significant. Similar results are obtained in the study by ***Sculco et al***³. Thus by modifying the type of incision, we can significantly reduce soft tissue trauma, intra and post operative blood loss and give patient a cosmetically more appealing surgical scar.

The average pre-operative Harris Hip Score in MIS-HA group in our study was calculated as 17.21 as against that of 18.47 in Conventional HA group, the difference being statistically insignificant. Thus the study and the control group are equally matched. Similarly the study by ***Goldstein et al***⁵ also showed evenly matched

pre-operative Harris Hip Score (47 in MIS-THA and 44 in Standard THA), But the score is quite less in our study as compared to that of above quoted study, since the most common indication for surgery in our study was fracture neck of femur.

After 1 month, the HHS score was calculated only for cemented and hybrid components as the patients who underwent cementless component fixation were not allowed to ambulate for 6 weeks. The average HHS was 76.61 in MIS-HA group and 60.62 in Conventional HA group. The difference was highly significant both clinically and statistically. Thus patients subjected to MIS HA fared better than Conventional HA group in immediate postoperative period. No other reference could be sought from the literature in which HHS at 1-month post operatively was compared. Study by **Goldstein et al⁵** compared the HHS at 6 weeks

did not show any advantage of MIS-THA over the Standard incision THA. This gap of 2 weeks i.e. between 4th and 6th week might have caused the difference in the HHS.

At 2 months post-operatively the HHS was again compared in between the groups and the study showed no statistically significant difference in the average score (93.48 in MIS HA group and 94.04 in Conventional HA group). Thus the patients of either of the two groups fared equally well after 2 months of surgery. Only difference was that the recovery of function was faster in MIS-HA group as compared to Conventional HA group. The study by **Goldstein et al**⁵ also

showed similar HHS scores at 3 months postoperatively (85 in MIS and 87 in Conventional group).

The patients were evaluated radiologically 2 months after surgery and comparative analysis was sought on the basis of acetabular inclination, femoral stem alignment, and limb length discrepancy. The average acetabular inclination in our study in MIS HA group was found to be 46.3° , which was almost similar to that in Conventional HA group (44.4°). In a similar study performed by ***Sculco et al*³**, average acetabular inclination measured at 6 weeks post-operatively was 40.6° . Similar results are quoted in the studies by ***Goldstein et al*⁵** and ***Hartzband et al*⁷**.

In our study, femoral stem alignment in AP and Lateral view was found to be in neutral or slightly deviated ($<5^{\circ}$) position in 91.7% patients in MIS-HA group and 100% patients in

Conventional HA group. Similar results were obtained by **Goldstein et al**⁵ and **Sculco et al**³.

Average limb length discrepancy reported in our study in MIS-HA group was 5.04mm and in Conventional HA group was 5.32mm; the difference being statistically insignificant. Similar results were obtained in the study by **Berry et al**⁸ who reported the limb length discrepancy of 4.5mm in the postoperative radiographs. **Wenz et al**² also showed limb length discrepancy of 5 +/- 4mm in mini-incision THA.

CONCLUSION

The current study has shown that not only accurate and reproducible implantation can be achieved with the mini-incision; it also facilitates recovery, decreases blood transfusion requirements without increase in complication rates or operative time and permits earlier postoperative rehabilitation thereby reducing the hospital stay after hip arthroplasty. This technique

thus has become standard approach for hip arthroplasty in selected group of patients at our institution.

REFERENCE

1. Charnley J, Ferrora A: Transplantation of the greater trochanter in arthroplasty of the hip. *J Bone and Joint Surg*, 46A: 191-197, 1964
2. Wenz J.F, Gurkan I, Jibodh S.R: Mini-incision total hip arthroplasty: a Comparative assessment of perioperative outcomes. *Orthopaedics* 2002; 25(10): 1031-1043.
3. Sculco T.P, Jordan L.C, Walter W.L: Minimally invasive total hip arthroplasty: The hospital for special surgery experience. *Orthop Clin N Am* 35(2004): 137-142.
4. Howell J.R, Garbuz D.S, Duncan C.P: Minimally invasive hip replacement: rationale, applied anatomy, and instrumentation. *Orthop Clin N Am* 35 (2004): 107-118.
5. Goldstein WM, Branson JJ, Berland KA, Gordon AC: Minimal-Incision Total Hip Arthroplasty. *J Bone Joint Surg (Indian Ed.)* 85A (4): 1-8, 2005.

6. Berger R.A: Mini-incision total hip replacement using an anterolateral approach: technique and results. *Orthop Clin N Am* 35 (2004): 143-151.
7. Hartzband M.A: Posterolateral minimal incision for total hip replacement: technique and early results. *Orthop Clin N Am* 35 (2004): 119-129.
8. Berry DJ, Berger RA, Callaghan JJ, Dorr LD, Duwelius PJ, Hartzband MA, Lieberman JR, Mears DC: Symposium: Minimally invasive total hip arthroplasty. Development, early results and a critical analysis. *J Bone Joint Surg* 85A: 2235-2246, 2003.
9. Howell J.R, Masri A.M, Duncan C.P: Minimally invasive versus standard incision anterolateral hip replacement: A comparative study. *Orthop Clin N Am* 35 (2004): 153-162.
10. Canale S.T: *Campbell's Operative Orthopaedics*, 10th edition, Vol. 1: 315-322.
11. Gore DR, Murray MP, Sepic SB et al: Anterolateral compared to posterior approach in hip arthroplasty, *Clin Orthop*, 165:180-187, 1982.
12. Woolson S.Y, Mow C.S, Syquia J.F: Comparison of primary total hip replacements performed with a standard incision or a mini-incision. *J Bone Joint Surg* 86A: 1353-1357, 2004.
13. Wright JM, Crocket HC, Delgado S, Lyman S, Madsen M, Sculco TP: Mini-incision for total hip arthroplasty: a prospective, controlled

investigation with 5-year follow-up evaluation. J Arthroplasty 19 (5): 538-545, 2004.

14. Chimento GF, Pavone V, Sharrock N, Kahn B, Cahill J, Sculco TP: Minimally invasive total hip arthroplasty: a prospective randomized study. J Arthroplasty 20 (2):139-144, 2005.
15. Harris W.H: Traumatic arthritis of hip after dislocation and acetabular fractures: Treatment by Mold Arthroplasty. J Bone Joint Surg 51A, No.4 (June): 737-755, 1969.
16. Berger R.A: Total hip arthroplasty using the minimally invasive two-incision approach. Clin Orthop 417: 232-241, 2003
17. Swanson TV, Hanna RS: Advantages of cementless THA using mini-incision surgical technique. Am. Acad. Orthop. Surgeons: 70th annual meeting proceedings, 2003: 369-372.