

# International Journal of Orthopaedics Sciences

ISSN: 2395-1958  
IJOS 2018; 4(1): 810-815  
© 2018 IJOS  
www.orthopaper.com  
Received: 07-11-2017  
Accepted: 08-12-2017

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## Midterm follow-up study of metal on metal total hip replacement

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**DOI:** <https://doi.org/10.22271/ortho.2018.v4.i11.118>

### Abstract

**Background:** Metallosis and pseudotumors are long discussed complications with metal on metal bearing total hip replacement which has increased the rate of revision total hip replacements in these patients.

**Aims and Objective:** To evaluate the levels of metal ion (Cobalt and Chromium), factors affecting these metal ion levels and incidence of pseudotumors in metal on metal total hip replacement patients.

**Materials and Methods:** Prospective descriptive study done on 25 patients who had metal on metal bearing surface replacement and total hip replacement with a mean post-op period of 6 years. Serum metal ion levels (Cobalt and Chromium), MARS-MRI (Metal Artifact Reduction Sequence) and acetabular cup inclination angle on X-rays and functional score were recorded in these patients on two follow-up visits with mean follow-up period of 1 year.

**Result:** Mean cobalt was 1.64 and mean chromium was 3.06. 28% of the study population showed asymptomatic pseudotumors but were less than 5cm. Mean cup inclination angle was 41.8° on X-rays which did not have any influence on serum metal ions and functional score. Gender (Male / Female) and type of arthroplasty (Articular surface replacement / Total hip replacement) has no effect on serum metal ions. Functional scores of these metal on metal patients comparable to metal on polyethylene bearing patients. Revision total hip replacement done in one metal on metal THR patient who had a dislocated cup in his second follow-up.

**Conclusion:** Metal on metal hip arthroplasty patients were functionally doing well like the regular metal on polyethylene patients. Chromium values were significant and higher than cobalt. Incidence of asymptomatic pseudotumors was 28%.

**Keywords:** Midterm follow-up, metal, hip replacement, asymptomatic pseudotumors

### Introduction

Hip replacement has become the commonest treatment in most of the hip pathologies in adults in this era. In metal-on-metal implants increased head-neck ratio provides increased range of motion, decreased potential for femoral neck impingement, decreased dislocation rates, and greater stability compared to smaller head metal-on-polyethylene (MoP) implants [1]. However, complications that can develop with MoM implants such as increase in metal ions in the body, aseptic lymphocytic vasculitis associated lesion (ALVAL) and pseudotumor.

These metal particles and ions disseminate throughout the body and are nanometers in size and high in number [2]. Increases in cobalt and chromium ions in serum, urine, and red blood cells of patients with a metal-on-metal bearing hip due to these metal particle dissolution [3]. Hypersensitivity, carcinogenicity and fetal exposure to metallic ions in pregnant women are great concerns regarding the effects of prolonged exposure to increased metal ion levels [4, 5]. Pseudotumors, defined as a solid or fluid mass which has developed in the peri-prosthetic soft tissue, are considered a severe complication of these MoM implants, which may cause pain, swelling, deep vein thrombosis and extensive soft tissue damage [6, 7].

Interestingly, not all MoM prostheses seem to develop these pseudotumor sequelae, and a debate exists on the prevalence of these pseudotumors, which ranges from less than 1% to 39% [7, 8]. Currently the only treatment option in case of pseudotumors is revision surgery, during which the MoM articulation is replaced by a non-MoM articulation. However, outcome of revision surgery for pseudotumor is poor compared to MoM revision surgery for other reasons [9].

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The Medicines and Healthcare products Regulatory Agency (MHRA) in February 2012 issued updated advice to surgeons that patients with a particular type of metal-on-metal hip replacement should be monitored annually for the life of the hip replacement. This updates previous advice from April 2010 that patients with this type of hip replacement need only be monitored for a minimum of five years after their operation.

The updated advice is included in a new MHRA Medical Device Alert that has been issued to clinicians today for the management of patients with these hip implants to minimize the risk of having to undergo further surgery to correct complications.

An expert advisory group was set up by the MHRA to look at the management of patients with soft tissue swelling associated with metal-on-metal hip implants.

### Materials and methods

From 2005 to 2009, 35 patients had undergone metal on metal bearing surface replacement and total hip replacement in our department. This a prospective study including all metal on metal on metal bearing hip arthroplasty patients. Patients who expired and lost follow-up after the primary surgery were excluded. Ethical approval for the study was sought from our institution's medical research ethics committee. All of their procedures had been performed by two surgeons, using, according to their preference, either a posterior or anterolateral approach.

35 patients were informed in December 2013 about the study and were asked to participate. Out of 35 patients only 25 patients came for follow-up. Out of 10 patients who did not come for follow-up, 6 patients were expired and 4 patients contact details were lost from the hospital system. These 25 patients were followed-up for a year with two follow-up visits. A total of 30 hips with mean post-op period of 5.5 years. 7 were females and 18 males in the study population. There were 10 patients with hip resurfacing and 15 patients with total hip replacement. 6 patients had bilateral hip replacement and 19 were unilateral. Mean age was study population was 50 years (ranges, 32-66 years). Pre-operative diagnosis were avascular necrosis in 8, ankylosing spondylitis

in 4, rheumatoid arthritis in 3, post-traumatic OA in 6, Post-infection OA in 1 and failed AMP in 3.

At follow-up, all patients were examined carefully and their complaints were noted. Their functional outcome was determined with a standard scoring system of "Harris Hip Score". Clinical evaluation was done using this scoring system to assess their activity scale and pain associated with operated hip with total score out of 100.

At the same visit, standard standing anteroposterior radiograph of the pelvis is taken. These radiograph were interpreted by a consultant surgeon and consultant radiologist to calculate the inclination angle of the acetabular cup.

Serum cobalt and chromium are checked to assess the metal ion levels in the blood. For chromium, the reference values in serum is 0.50 microg/L according to the National Institute for Research and Safety. For cobalt, the usual value in se-rum and whole blood, respectively, is 0.4 microg/L according to Lauwerys <sup>[10]</sup> and 0.8 microg/L according to the INRS. Patients with metal implants in them, serum cobalt and chromium is taken as 2 microg/L.

All these patients had to undergo Metal artefact reduction sequences (MARS) MRI of the operated hip. Metal components of hip implants typically degrade MR image quality due to distortion of magnetic field. Metal artefact reduction sequences (MARS) MRI utilises a wide receiver bandwidth, view angle tilting (parallel to long axis of implants) and increased gradient strength to reduce the size and intensity of artefact. They do not require any additional imaging time. MARS MRI has allowed for visualisation of periprosthetic tissues in the presence of metallic implants. The images were analysed again by a single fellowship trained musculoskeletal consultant radiologist who was blinded to metal ion levels. Several pathologies were evaluated on MRI including the presence of a periprosthetic mass, periprosthetic bone marrow oedema, periprosthetic fluid collection, trochanteric bursitis, muscle oedema, muscle atrophy and the level of destruction of abductor musculature. Pseudotumour findings were classified according to the grading system described by Anderson <sup>[11]</sup> (Table 1), which has a good inter observer reliability ( $\kappa = 0.78$ , 95% confidence intervals: 0.68–0.88).

**Table 1:** Anderson classification of MARS MRI.

Grade	Description	Criteria
A	Normal or Acceptable	Normal post-op appearances including seromas and small haematomas
B	Infection	Fluid-filled cavity with high signal T2 wall; inflammatory changes in soft tissues, $\pm$ bone marrow oedema
C1	Mild MoM Disease	Periprosthetic soft tissue mass with no hyperintense T2W fluid signal or fluid-filled peri-prosthetic cavity; either less than 5 cm maximum diameter
C2	Moderate MoM Disease	Peri-prosthetic soft tissue mass/fluid-filled cavity greater than 5 cm diameter or C1 lesion with either of following: (1) muscle atrophy or edema in any muscle other than short external rotator or (2) bone marrow edema: hyperintense on STIR
C3	Severe MoM Disease	Any of the following: (1) fluid-filled cavity extending through deep fasci, (2) a tendon avulsion, (3) intermediate T1W soft tissue cortical or marrow signal, (4) fracture

15 Metal on polyethylene bearing total hip replacement patients were also followed-up with two follow-up visits in a year to check their functional outcome scores using Harris Hip Score system to be compared with metal on metal arthroplasty patients.

### Statistical analysis

Mann Whitney test was used to test the statistical significance in serum cobalt/chromium levels with respect variables like gender, type of arthroplasty, cup inclination angle and

functional score.

Chi – square test was used to test the statistical significance of the association of functional outcome scores (Group) and the cup inclination angle (Group) and serum metal ions (Group) with MRI (Group).

Mc-Nemar test is used to compare the functional outcome (Group) score in first and second follow-up visit.

### Results

The prognosis of the study population is checked by

comparing functional outcome score and serum metal ion levels. 68.4%-72.7% patients are having good prognosis but was not statistically significant due small sample size.

28% of the study population had pseudotumours detected on MRI out of 25 patients. But the size of the collection was too small (less than 5cm) or classified as B or C1 according to Anderson classification of MARS-MRI. Patients who had pseudotumours were also functionally doing well without any complaints.

Metal on metal articular surface replacement and total hip replacement has shown an increase in metal ions levels compared to the normal values. But there is a statistically significant increase in the serum chromium levels compared to cobalt in the study population with mean chromium of 3.04 and mean cobalt of 1.65. Serum cobalt and chromium levels does not have any influence on gender, type of arthroplasty i.e. articular surface replacement or total hip replacement and acetabular cup inclination angle on X-rays.

In this study population there is no correlation found between functional outcome scores and cup inclination angle on X-rays.

Functional outcome scores between the 1<sup>st</sup> and 2<sup>nd</sup> follow-up visit with a mean follow-up period of 1 year is comparable except for 1 patient who had a dislocated cup of the left hip in his 2<sup>nd</sup> follow-up visit. This patient had a bilateral metal on metal total hip in 2007 and 2009. He was taken for a revision THR of left hip, intra-operatively the cup was removed and replaced with new uncemented acetabular cup. The femoral component was well fixed which was retained. Only 1 patient underwent revision in this follow-up period.

Functional outcome scores were compared with metal on polyethylene bearing patients and found have comparable functional score.

## Discussion

Metal ion levels were measured by Vendittoli *et al.* [12] during a 2-year period and showed that steady state was reached at 1 year in patients with hip resurfacing and at 3 months in patients with THA.

Allan *et al.* [13] reported serum metal ion levels after hip resurfacing with the Cormet cup up to 3 years. At 1 year, peak levels were observed whereas levels at 3 years were showing a downward trend, but this decrease was not statistically significant.

The serum metal ion levels in patients with hip resurfacing was reported by De Souza *et al.* [14] during a 10-year period. The cobalt and chromium levels rose steeply over the initial 2 years. But a steady overall decline for both metals was observed up to 5 years. However, there then appeared to be another increase between 5 and 10 years.

In our study the mean cobalt value was 2.96 and mean chromium value was 3.12 which is comparable with previous studies on cobalt and chromium levels in metal on metal bearing total hip patients.

It was observed that Women typically have higher circulating metal ion levels than do men [15]; however, some studies showed no difference in metal ion levels between men and women. In another study, univariate analyses showed that men had a higher cobalt levels at 1 and 2 years and chromium levels at 2 years. It was also observed that men were associated with large-head diameter.

In current study there was no correlation found between gender and serum metal ions levels [16] According to a study done by Clarke *et al* median of 16 months, there was higher concentrations of cobalt and chromium serum levels in

patients with either a Birmingham hip resurfacing or Cormet 2000 resurfacing arthroplasty compared with patients who had 28-mm MOM THA. Our study did not show any significant difference in cobalt and chromium levels in the metal on metal articular surface replacement or metal on metal total hip replacement.

Incidence of pseudotumours in metal on metal articulation hip arthroplasty was 32% in metal on metal total hip arthroplasty and 25% in metal on metal hip resurfacing in a study done Daniel H Williams *et al.* [17] in 2011. They also did not find any correlation between the serum metal ion levels and the size of pseudotumor abnormality. This is comparable to our study, incidence of pseudotumour was 28% in study population. There was also no correlation was found between the pseudotumour and metal ions. The median serum metal ion level was greater in patients with pseudotumor formation than it was in those without pseudotumor formation, but the difference was not significant.

Zijlstra *et al.* [18] in 2010 found that ten years postoperatively, mean Harris Hip Score was 86 in the metal-on-metal patients and 87 in the metal-on-polyethylene patients. This is comparable to our study where the mean Harris Hip Score was 74.1 in metal on metal group and 74.6 in metal on polyethylene group.

Metal on metal articular surface replacement was a popular type of arthroplasty for young patients with pathologies. It has been suggested that accurate placement of the acetabular component is essential to avoid high failure rates. Langton *et al.* [19] found that acetabular inclination angle correlated significantly with metal ion levels with ASR implants with femoral components smaller than 53 mm. however, others have found that femoral head size does not affect the metal ion levels. In our study the cup inclination angle does not affect metal ion levels and all the patients had an acceptable cup inclination angle which ranges from 30°-50° with a mean cup inclination angle of 41.8°.

## Conclusion

Metal on metal total hips or resurfacing is not done anymore in our hospital since 2009 and hence only a small sample size could be included. But most of the study population is showing 68%-70% good prognosis. None of the patients required a revision surgery due to pseudotumors (28%) in the study population because size of the pseudotumors were B or C1 according to Anderson classification which was less than 5cm. Chromium levels in our study population were more than cobalt levels. Metal ions more than 5 micro g/L-7 micro g/L was considered toxic and need to be cautious. Most of study population showed normal cobalt levels and maximum chromium levels of 5 micro g/L. Male and female gender did not affect the serum metal ions levels. Type of arthroplasty (Articular surface replacement or total hip replacement) with metal on metal articulation did not prove to affect the metal ion levels. Most of the patients were having good acetabular cup inclination angle with mean cup inclination angle of 41.8. Our study did not found a relation between acetabular cup inclination angle and serum metal ions. Except for 1 patient who had a revision THR in the study population, rest all patients were functionally doing well in this follow-up period. In our study, metal on metal arthroplasty patients were functionally doing well with similar functional scores when compared to the regular total hip replacement metal on polyethylene patients. One of the limitation of this study included a small sample size with respect to serum metal ions levels.

### 1) Harris Hip Score vs Serum Cobalt/Chromium

Harris Hip Score is compared with serum cobalt and chromium levels to evaluate the prognosis. The study population is divided into two groups according to Harris Hip Score

(Group 1 - <70 score & Group 2 - >70 score)

Normal and abnormal values of serum cobalt and chromium levels are taken.

Normal cobalt values is taken as 2 microgram/L

Normal chromium levels are taken as 2.5 microgram/L

HSS	Cobalt (N-2.0 microgm/L)			P-Value
Cup Inclination Angle	Normal (n%)	Abnormal (n%)	Total	
<70	6(28.6%)	2(50%)	8	0.578
>70	15(71.4%)	2(50%)	17	
Total	21 (1100%)	4 (100%)	25	

HSS	Chromium-2 (N-2.5 microgm/L)			P-Value
Cup Inclination Angle	Normal (n%)	Abnormal (n%)	Total	
<70	3 (27.2%)	5 (35.7%)	8	1.000
>70	8 (72.7%)	9 (64.2%)	17	
Total	11 (100%)	14 (100%)	25	

The table showing no association between functional outcome score and serum chromium levels.

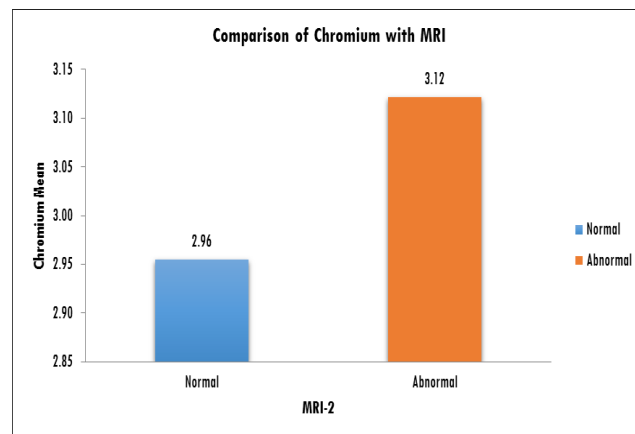
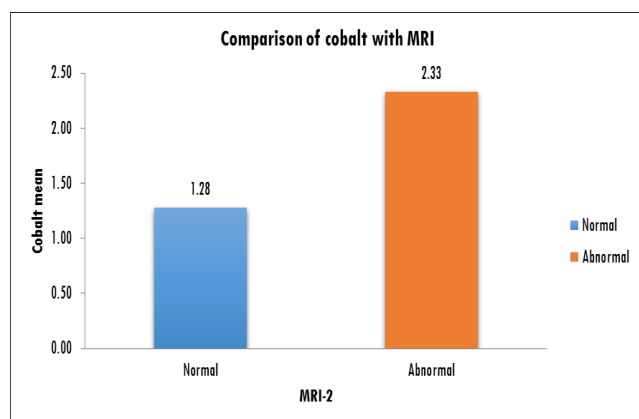
### 2) Comparison between MRI vs Serum Cobalt/Chromium

Presence of Pseudotumors are looked into each MRI of the study population. Prevalence of pseudotumors are compared with serum metal ions (Cobalt and Chromium) to evaluate the prognosis.

MRI	N	COBALT_Test		P Value
		Mean	SD	
Normal	18	1.28	0.47	.114
Abnormal	7	2.33	1.73	

MRI	N	Chromium_Test		P Value
		Mean	SD	
Normal	18	2.96	1.50	<1.000
Abnormal	7	3.12	1.79	

This table shows the influence of pseudotumors on serum cobalt/chromium levels. There is no statistical significance between the presence of pseudotumors and serum cobalt levels.

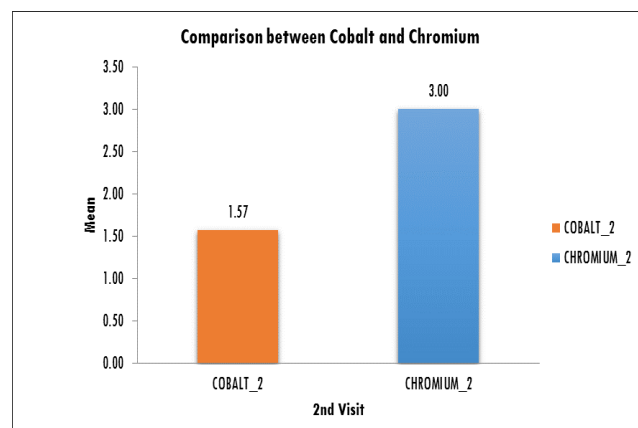
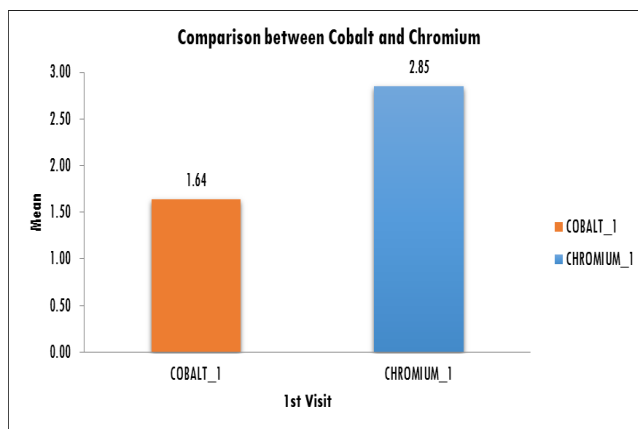


### 3) Serum Cobalt Vs Serum Chromium

Serum cobalt and chromium levels measured with a mean follow-up period of 1 year. Serum cobalt and serum chromium lab measures were done on first and second follow-up.

Visits	Lab Parameters	N	Mean	SD	P Value
1st Follow-up	Cobalt_1	25	1.64	1.16	.001
	Chromium_1	25	2.85	1.40	
2nd Follow-up	Cobalt_2	25	1.57	1.07	.001
	Chromium_2	25	3.00	1.55	

The comparison table shows increase in cobalt and chromium levels in the follow-up period with statistically significant increase in chromium levels compared to cobalt in the study population.



### 4) Gender vs Serum Cobalt/Chromium

Male and female gender in the study population is statistically compared with cobalt and chromium levels to check if the gender influences on the metal ion levels.

Metal Ions	Gender	N	Mean	SD	P-Value
Cobalt	Male	18	1.571	1.214	1.000
	Female	7	1.568	0.605	
Chromium	Male	18	3.008	1.680	1.000
	Female	7	2.984	1.257	

There is no association between gender and serum cobalt or chromium ion levels.

### 5) Type of metal on metal bearing replacement vs Serum Cobalt/Chromium

There are 10 patients who underwent metal on metal articular surface replacement and 15 patients who underwent metal on metal total hip replacement.

Metal Ions	Type	N	Mean	SD	P-Value
Cobalt_2	Total hip	15	1.7847	1.32341	0.642
	Resurfacing	10	1.2490	.33930	
Chromium_2	Total hip	15	3.1113	1.31477	0.642
	resurfacing	10	2.8370	1.91070	

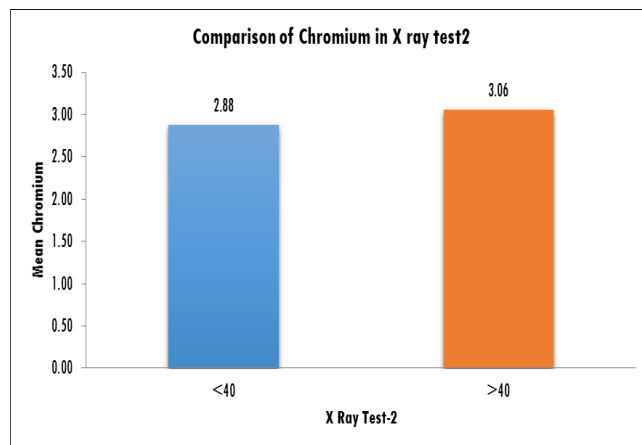
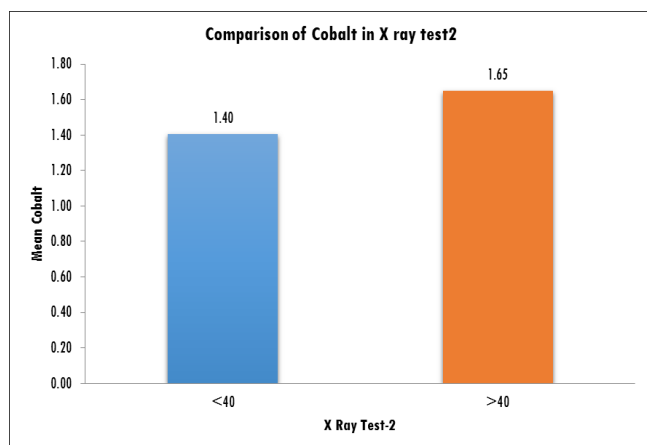
The table shows association between the type of arthroplasty and serum cobalt/chromium levels in the study population. There is no statistical significance between the type of arthroplasty (Articular surface replacement or Total hip replacement) with serum cobalt chromium levels

### 6) X-rays vs Serum Cobalt/Chromium

In X-rays, cup inclination angle is taken as a reference to compare with serum cobalt and chromium levels. The ideal cup inclination angle for total hip replacement ranges from 35° -45°. The mean cup inclination angle is 41.8°. We have grouped the patient according to the degree of cup inclination angle as Group 1 (<40°) and Group 2 (>40°). These two groups are compared with mean cobalt and chromium levels in the study population.

Metal Ions	Xrays (Cup Inclination Angle)	N	Mean	SD	P-Value
Cobalt	<40°	8	1.40	0.44	<1.000
	>40°	17	1.65	1.26	
Chromium	<40°	8	2.88	2.14	0.600
	>40°	17	3.06	1.26	

The table is not statistically significant showing no significant association between cup inclination angle and serum cobalt or chromium levels.



### 7) X-rays vs Harris Hip Score

The cup inclination angle on the X-rays are compared with the functional outcome score using Harris Hip score. The cup inclination angle on the X-rays are divided into 2 groups:- (Group 1: <40° & Group 2: >40°).

The study population is also divided into two groups according to the Harris Hip score (a score out of 100), Score less than 70 or more than 70

(Group 1 HHS: <70 score & Group 2 HHS: >70 score)

Xrays_2	HHS_2		Total	P-Value
Cup Inclination Angle	<70 (n%)	>70 (n%)		
<40°	0(0)	7(100%)	7	0.057
>40	8(44.4%)	10(55.6%)	18	
Total	8(32%)	17(68%)	25	

This table shows that there is no correlation between the cup inclination angle on X-rays and HHS.

### 8) Harris Hip Score – First Visit vs Second Visit

The functional outcome in the study population is compared on the first and second follow-up with a mean follow-up period of 1 year

HSS-1	HSS-2		P-Value
	<70*(n%)	>70*(n%)	
<70*	8(100%)	0(0%)	1.0000
>70*	0(0%)	17(100%)	

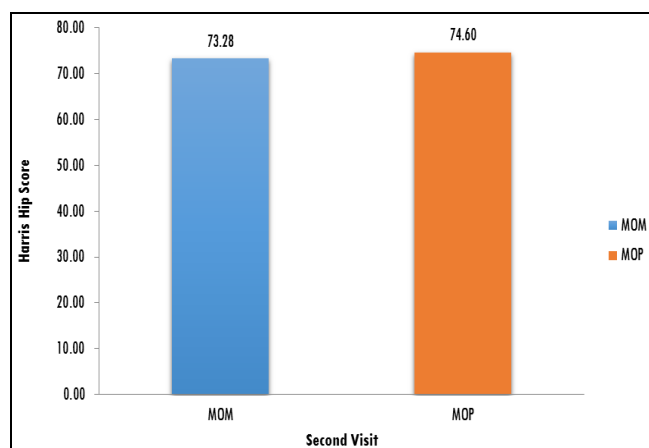
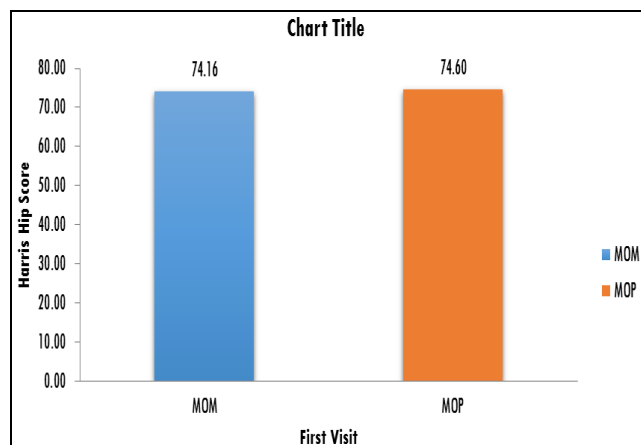
Mc nemar test is used to compare the functional outcome score for the first and the second visit.

Patients had similar functional outcome score over the first and second follow up period (mean follow –up period: 1 year) except for 1 patient with dislocated cup on the left side which eventually went for a revision total hip replacement.

### 9) Harris Hip Score in Metal on Poly Patients Compared with Metal on Metal Patients

15 metal on polyethylene bearing total hip replacement patients are followed up for a year with two follow-up visits to get their functional outcome score using HHS which is compared with metal on metal bearing total hip replacement study population.

HSS		N	Mean	SD	
First Visit	Metal On Metal	25	74.1	10.18	0.966
	Metal On Poly	15	74.6	8.83	
Second Visit	Metal On Metal	25	73.28	13.35	0.966
	Metal On Poly	15	74.6	8.83	



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