

Journal Club: 18 July 2011  
Chairman: Mr H Sandhu  
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### **Fixation of Intracapsular Fractures of the Femoral Neck in Young Patients: Risk Factors for Failure**

A.D. Duckworth, S.J. Bennett, J. Aderinto and J.F. Keating  
J Bone Joint Surg [Br] 2011;93-B:811-16.

**Reviewers:** Oliver Bradford and John Matthew Owen

#### **Introduction**

##### **Summary**

Prospective single-centre case-series to determine co-morbid, peri-operative and surgical risk factors that contribute to failure of fixation in patients  $\leq 60$  years of age undergoing fixation of intra-capsular femoral neck fractures.

##### **Originality and Design**

The authors recognise other published work reviewing the factors contributing to outcome of intra-capsular femoral neck fixation in young patients, but have identified the paucity of data on co-morbid conditions in particular, thus justifying requirement for this study. The design attempts to include all significant co-morbidities medications and define surgical variables.

#### **Methods**

##### **Aims and Hypotheses**

The aim of the study was clearly stated as determining the prevalence of co-morbidities in patients  $\leq 60$  years and their association with outcome from fixation of intra-capsular hip fractures. The unstated aim was clearly to guide readers in managing this cohort of patients, defining which co-morbidities must be accounted for when deciding (and consenting patients for) appropriate management of their hip fracture. Previous co-morbidities reviewed were summarised from relevant literature, but any association to outcome of hip fracture fixation was not described.

Though not formally stated as secondary aims the study also reviewed surgical and peri-operative factors, such as time to surgery following admission, quality of reduction, and grade of surgeon, in order to allow independent predictors of failure of fixation to be identified through multivariate analysis.

##### **Ethics**

No statement regarding ethical approval was presented within the study write-up.

##### **Study type/level of evidence**

This was a single-centre prospective case-series study presenting level IV evidence.

### Preliminary Statistics

The authors describe appropriate tests used for the different types of data analysed. Univariate analysis was initially performed, with a p-value of <0.10 set to include all significant or 'nearly significant' factors predicting failure of fixation. This allowed subsequent multivariate analysis to determine independent factors predicting failure, with p-value significance resolving to <0.05.

### Subject recruitment and criteria

A prospective database was used to identify consecutive patients from 1995 to 2008 who underwent fixation of intra-capsular hip fractures with cannulated screws. 122 patients were included in the results. Fracture type for inclusion was limited to Garden type III and IV. Patients with fractures sustained over 7 days before presentation were excluded, again with no reason described. Demographic data included time to fixation, grade of operating surgeon and type of reduction, complications and revision. No data was collected for supervision of operating surgeon if other than Consultant, and closed reduction methods were not defined.

### Variables/Interventions/Outcome Measures

Medical co-morbidities, medications, alcohol intake and smoking were quantified for each patient. Alcohol intake, pre-existing mobility, time to fixation and quality of reduction were all defined and categorised into binary data. Mental test scores, ethnicity, social class and employment status were not included.

All patients underwent closed reduction where possible, but no preferred method was described. Open reduction was used if closed reduction attempts failed. A standardised surgical technique for placement of cannulated screws was described and used for all, as was the post-operative weight-bearing protocol.

Follow-up was deemed adequate if documented  $\geq 18$  months post-operatively, but their subsequent aim stated at least two years follow-up to be achieved. Clinical and/or radiological assessment was performed, but both were not required for.

Outcome measures were union, failure of fixation, non-union and AVN. Chronic medical co-morbidities included renal failure, chronic respiratory disease and liver failure, but there was no definitions of diagnostic criteria for these conditions.

### Results

39 (32%) of patients had failure of fixation (16 loss of fixation (13%); 9 non-union (7%); 14 AVN (12%)), representing a union rate of 68% at a mean of 58 months. Neither age nor gender was predictive of failure, despite mean age at fracture being significantly higher in women (52 years versus 45 years in men,  $p < 0.001$ ). Although all patients with failure of fixation had revision surgery, with types of revision described, no breakdown was given as to which patients underwent which type of revision surgery.

Univariate analysis revealed alcohol excess to be the variable most predictive of failure ( $p < 0.001$ ). Of note, smoking did not increase risk of failure. Pre-operative renal failure,

respiratory disease and liver failure were predictive of failure ( $p=0.03$ ,  $0.03$  and  $0.04$  respectively), but again were not defined in terms of diagnostic criteria.

Mal-reduction was not predictive of failure, but this is based on small numbers due to the low level of radiological documentation, and therefore must be interpreted with caution.

Delay in time to fixation was the only peri-operative factor predictive of failure of fixation ( $p=0.005$ ).

Multiple regression analysis revealed alcohol excess, renal disease and respiratory disease to be independent variables predictive of failure of fixation.

## Discussion

### Strengths

This paper presented data for a standardised procedure protocol for fixation of displaced intra-capsular neck of femur fractures in young patients with cannulated screws, across a range of different grades of surgeon. This allows the results to be applicable and generalizable to surgeons, both trainees and trainers, in any Orthopaedic department dealing with trauma.

With a large cohort of approximately 1 patient per month presenting with a relatively infrequent injury, this provides a useful evidence-base for surgeons encountering this pathology.

### Limitations

There was a 20% loss to follow up from the prospective cohort, with only 32% of remaining patients having radiological examinations available for interpretation. Definition of union, failure of fixation, non-union and AVN all included radiological parameters. However, as radiological assessment was not mandatory to fulfil minimum follow-up criteria, and with only 39 patients (32%) with radiographic documentation of outcome, the figures quoted for union, failure of fixation, non-union and AVN may not represent the actual rates of each outcome measure for the whole case-series. How the data presented in Table II would breakdown if only including the patients in Table III would have been a useful sub-analysis.

Garden type I and II fractures were excluded as only displaced fractures were included. This was presumably to see if there was any correlation between the chosen outcome measures, the covariates and displacement. If this were so it would have been advantageous to see if the grade of injury, i.e. the degree of displacement affected the outcomes.

The surgical technique described is not the current standard technique described in the AO handbook and would probably represent a less frequently used construct when compared with the technique employed by other institutions. How differences in the biomechanics and subsequent transferability of results to this construct may alter outcome is unknown.

Mechanism of injury data was presented, but no analysis was provided using this as a variable to predict failure. Young patients (<60 years) with intra-capsular hip fractures vary

in their co-morbid state. Whether a link between com-morbidities and mechanism of injury exists to predict failure of fixation, for example a young fit motor-cyclist involved in a road traffic collision, versus a patient with chronic renal impairment sustaining a fall from standing height, would be extremely useful to ascertain.

Although fractures were graded using the Garden classification, no review of fracture pattern was defined. Further analysis of prediction of failure might include the use of a classification such as Pauwels (1935) to assess the effect of fracture pattern as a predictor of failure of fixation, due to the different stresses experienced across the fracture site and screws depending on the orientation of the fracture line.

### **Conclusion**

A useful study to aid decision-making in this cohort of patients, who may present with significant co-morbidities, thus requiring consideration of different management options.

The low prevalence of co-morbidities in the cohort, combined with paucity of radiological data requires a degree of caution when interpreting the results. We would advocate further research reviewing both mechanism and fracture pattern as further variables to consider as potential predictors of failure of fixation.

This study will change our practice in terms of careful consideration of alternatives to fixation in young patients (<60) with significant medical co-morbidities presenting with displaced intra-capsular neck of femur fractures.

### **Soft-tissue changes in hip abductor muscles and tendons after total hip replacement; comparison between the direct anterior and the transgluteal approaches.**

Bremer AK, Kalberer F, Pfirrmann CWA, Dora C.

J Bone Joint Surg [Br] 2011;93-B:886-9.

**Reviewers:** William Thomas and James Berstock

### **Introduction**

We were particularly interested in this paper because the anterior approach to the hip is currently being introduced at our unit.

A proportion of patients remain symptomatic following THR. A previous comparative MRI study showed more extensive soft tissue damage in symptomatic post THR patients compared with a similar asymptomatic cohort. This iatrogenic soft tissue injury may account for a proportion of the 26% of patients who are unable to return to sports following THR.

## Methods

A retrospective study from Zurich of 50 patients having a THR via either an anterior or transgluteal approach. MRI was performed at one year post operatively and soft tissue changes in the abductors were graded.

The 25 patients undergoing direct anterior approach were derived from a population of 145 patients having primary direct anterior approach THR using uncemented components between Feb and Oct 2005. Eleven were excluded because of complex pathology necessitating a trochanteric osteotomy. A further 54 were excluded because of previous hip surgery or because of other co-morbidities such as spinal pathology which can alter the pelvitrochanteric musculature. 80 patients were invited to MRI scan at one year of which only 25 patients agreed to participate.

The control group were 25 patients who had undergone transgluteal THR with transosseus repair between Nov 2001 and May 2002. These patients were additionally rehabilitated with 6 weeks of partial weight bearing. They were only included if they had no hip rest pain, no limp, no previous hip surgery, no tenderness on palpation of the greater trochanter, and had to demonstrate equal abductor strength as compared with the non-operated side.

An MRI was performed at one year and soft tissue changes in the abductors were graded by a single radiologist. Twenty five patients had a direct anterior approach and twenty-five a transgluteal approach.

Appropriate statistics were performed with Chi squared for categorical variables such as tendon defects, and Mann-Whitney U test for comparison of continuous variables such as the grading of fatty atrophy.

## Results

The two groups of twenty-five patients were broadly similar in terms of demographics. However, the anterior approach was associated with significantly less tearing, detachment, fatty atrophy and tendonitis of the abductor muscles.

## Discussion

### Strengths

- This is the first study of its kind attempting to quantify the abductor injury associated with both the transgluteal and anterior approaches.
- The study question is relevant. Surgeons are adopting the anterior approach in an effort to reduce injury to the soft tissues. This paper adds weight to their assertions.
- Patients with previous hip surgery / spinal pathology were excluded - as this may affect the peri-trochanteric musculature.

- The control group were highly selected asymptomatic patients with no limp – this may reduce the observed benefits of the anterior approach.
- Demographics of both the study and the control groups were very similar, with a similar prognosis expected for both groups.
- The gluteal repair in the control group was transosseus and patients were mobilised with protected weight bearing for six weeks to prevent detachment of the abductors. Every attempt was made, it seems, to resuscitate the abductors in the post op period.
- No significant demographic difference between the case and control groups.
- Statistical analysis seemed appropriate as previously discussed.
- No funding

#### Limitations

- Study design:
  - Retrospective with historical controls. This was NOT the study they were hoping to perform.
  - No randomisation or blinding
- Methodology:
  - Study group had uncemented components, whereas the control group had hybrid components? Artefact difference (but deemed negligible by radiologist)? Thermal effect of cement.
  - Selection bias: Of the 80 anterior approach patients invited to attend MRI, only 25 agreed.
  - No pre-op MRI
  - Interobserver variation
- Outcomes:
  - No functional outcome measures (e.g. WOMAC, OHS)
  - Damage to lateral cutaneous nerve of the thigh not measured

- Other important outcomes (dislocation, malposition, fracture, leg length) not measured.

### **Conclusion**

By their own admission, the authors are now keen advocates of the anterior approach. The measured outcome is a surrogate for post op function as suggested by their prior work. This outcome is probably relevant to the overall result but only in the otherwise uncomplicated cases. When deciding which approach to use in ones own practice however, the additional risks of adopting a new technique are more important. Particularly, there is increased morbidity associated with the learning curve. The risk of lateral cutaneous nerve injury and neuroma formation, the difficulties of achieving component length and alignment and avoiding femoral fracture should all be carefully considered before changing. We felt a more appropriate comparison would have been between the mini-posterior approach and the direct anterior, as it seems somewhat obvious, although previously unproven, that the transgluteal approach causes some soft tissue injury to the abductors.

### **What are the radiological predictors of functional outcome following fractures of the distal radius?**

Ng CY, McQueen M

J Bone Joint Surg [Br] 2011;93-B:145-50

**Reviewers:** Riaz Ahmad and David Hughes

### **Paper Summary**

#### **Introduction**

Distal radial fractures are the most common injury treated by orthopaedic surgeons. With a high association with osteoporosis, malunion and symptomatic malunion. However there is little consensus on what is satisfactory radiological position which should lead to a good functional outcome, particularly when anatomical reduction is not always possible.

#### **Methods**

This paper reviews published research on this topic looking at radiological measurements and their outcomes.

Published radiological indices they review are: Radial Height, Ulnar Variance, Radial Inclination, Dorsal Tilt, Carpal Alignment, Teardrop Angle and Anteroposterior(AP) distance. Results on articular incongruity are also reviewed.

### **Conclusion**

The reviewers were again unable to find a level of consensus in published literature as to what constitutes acceptable radiological indices for surgeon faced with displaced distal radial fracture in casualty or fracture clinic. They felt this was due to the large variance in the injury pattern.

Greatest consensus of opinion was the effect of radial shortening or ulnar-plus deformity, with high associations of pain and diminished grip strength in the literature. Whilst articular incongruity from review of published literature appeared not to be significantly linked with an inhibition of function. They concluded this might be due to adaptations by the patient and still recommended surgeons should try and achieve a step or gap of 2mm or less.

### **Discussion**

#### **Strengths**

- This very relevant paper to most people's practise with distal radial fracture being significant proportion of patients we will encounter in our clinical practise
- As an Educational tool is very strong with good clear explanations and diagrams of the radiological indices and of the best positions for radiographs to be taken
- It suggests latest evidence advises associated ulnar styloid fractures do not require intervention.
- No Funding

#### **Limitations**

- Not a Systematic review
- Literature Review:
  - Over 2000 papers on distal Radial Fractures only looked at 40.
  - No inclusion or exclusion criteria of the papers that were chosen
- No Structured Effectiveness Quality Evaluation Scale of the papers reviewed.
  - Does the level of evidence of some the papers justify drawing the conclusions they reach
  - How much weight were individual papers given in drawing their conclusions

- Most were retrospective papers e.g Forward et al JBJS 2008 at best Sackett level III
- Functional Outcome
  - One the key points in the title and introduction was functional outcome this was only briefly touched upon in the paper.
- Radiological Indices
  - Introduces concept of teardrop angle however this parameter is not routinely studied and potential significance is not known.

### **Conclusion**

The authors admit that there is a conflicting message in published literature to date with regards to this question. Therefore they are unable to fully answer the question of what are the key radiological predictors for functional outcome. They do highlight the importance of radial height and articular incongruity with regard to improved outcome. Overall it has good educational value as does explain the concepts of the indices and what we need to look for on radiographs in a clear and concise way.

### **An analysis of metal ion levels in the joint fluid of symptomatic patients with metal-on-metal hip replacements**

K. Davda, F. V. Lali, B. Sampson, J. A. Skinner, A. J. Hart  
J Bone Joint Surg [Br] 2011; 93-B:738-45.

Reviewers: Alex Riddell and Deepu Bhaskar

### **Summary**

Retrospective analysis of metal ion levels in synovial fluid collected from all patients referred for problematic hip replacements with metal on metal (MoM) bearing surface over a two year period. Comparison is made of Cobalt and Chromium levels pre- and post-acid digestion in a group of the patients. Also synovial fluid levels have been correlated with category of failure, type of hip, femoral head size, inclination angle of the acetabular component and blood metal ion levels.

### **Originality and Design**

The authors recognise two previous studies that were conducted on the same lines (De Smet et al and Langton et al) and acknowledge the contribution of these papers to our understanding of MoM bearings. However these studies involved smaller numbers of

patients and results showed wide variation in the ion levels between the two studies and therefore limits the applicability of the conclusions.

This is a retrospective study over two years of all patients referred with problematic MoM hips all referred to a joint replacement service.

## **Methods**

### **Aims and Hypotheses**

The primary aim was to validate a method of metal ion analysis in the synovial fluid of symptomatic MoM hip joints and to investigate the relationship of these values to several clinical variables.

### **Ethics**

Ethical approval reportedly sought and received but no further details given.

### **Study type/level of evidence**

This is a retrospective analysis using a moderate sized group sample. Level III study based on centre for evidence based medicine, Oxford, UK, (though this was a consecutive sample of patients (level II) there is no universally applied gold standard).

### **Statistics**

Bland-Altman plots were used to analyse the level of agreement between the two methods of sample processing.

A Mann-Whitney U test was used to test for differences between the synovial fluid levels of different groups examined.

Analysis of variance with Tukey's *post hoc* analysis tested for differences between manufacturers of implants.

Scatter plots, Spearman's rank correlation and linear regression were used to examine the relationship between synovial metal ion levels and acetabular component inclination angle.

### **Subject recruitment and criteria**

All patients referred in a two-year period to the joint replacement service for problematic MoM hips were considered.

Exclusion criteria included bilateral hip replacements or other metal implants, those requiring revision surgeries within 12 months and patients with abnormal renal function. Though the authors do not state this it would have been interesting to know the numbers excluded on these criteria.

A control group was created by taking samples from five consenting patients undergoing arthroscopy or arthroplasty of the hip with no metal implants present. It can be argued that a more appropriate control group would be people with asymptomatic MoM hips although we acknowledge the ethical dilemmas this can pose.

A total of 92 consecutive synovial fluid samples from 92 symptomatic MoM hips (83 resurfacing arthroplasty, 9 total hip replacement) were available for analysis, of which 62 were from female patients. The mean age of the patients at the time of revision of the primary MoM replacement was 60 years (30 to 87) and the mean duration of implantation before revision was 36 months (12 to 137).

### Interventions

The method of analysis of blood and synovial fluid with and without acid oxidative digestion is explained in detail.

Few details given of further management/outcomes of the patients – 14 patients identified as having either acetabular or femoral component loosening taken for revision surgery and it is stated that all components were revised.

There is no detail of the intra operative findings which, whilst not objective criteria, would have been immensely helpful in deciphering the metal ion levels. In the absence of description of intra operative findings and the outcomes following revision it's difficult to judge the significance of the metal ion levels especially in view of previous studies that have shown up to 20 times higher metal ion levels in synovial fluid in those with metallosis than in those without (De Smet et al).

### Results

A statistical difference was proven between undigested and acid digested synovial fluid samples for Chromium ions ( $p = 0.002$ ) but not for Cobalt ( $p = 0.083$ ). No significant difference shown between the acid oxidative digestion synovial fluid ion levels when linked to the category of failure, type of implant, femoral head size or inclination angle of the acetabular component. There was a significant difference between synovial fluid and paired blood metal ion levels for both metals.

Though the stated primary aim is to validate a method of analysis there is no description of any techniques used to achieve this.

**Synovial fluid levels and category of failure – 64 of the 92 patients were included in this analysis. The authors' later state that only 56 patients underwent 3D CT scan to study the orientation of the components. This suggests that all 64 patients have not been fully investigated in relation to categories of failure.**

We believe that it is rather important to understand why a large proportion of study population have been excluded from this analysis as well as why this group could contain 64 patients where only a maximum of 56 patients have been fully investigated.

There is no difference between the two groups labelled unexplained cause of pain and defined cause of failure. However, a closer study of the box and whisker chart provided by the authors suggest a much higher metal ion level in patients Acetabular component malorientation ( $n = 5$ ) and Head-acetabular component mismatch ( $n = 3$ ). This is pointed out by the authors during discussion.

Similarly for the type of hip used there is a suggestion that the Cormet hip is producing a much lower metal ion level while this is not corroborated by the P value. Once again the small numbers involved and the choice of ANOVA as an analysis method as opposed to two sample t tests to compare between two manufacturers. In the discussion the authors simply state that there was no difference between the manufacturers.

Manufacturer	Chromium ( $\mu\text{g/l}$ )		Cobalt ( $\mu\text{g/l}$ )	
	Mean	Median	Mean	Median
BHR <sup>+</sup> (36)	12 360	1388	2761	797
ASR <sup>‡</sup> (18)	28 347	1779	2838	1227
<b>Cormet (16)</b>	<b>1955</b>	<b>756</b>	<b>869</b>	<b>258</b>
Other (22)	5762	1655	2472	1468

Once again in this study as well as in previous similar studies the range of metal ion levels found in the synovial fluid of different patients varied widely – ranging from 0 $\mu\text{g/l}$  to 263298 $\mu\text{g/l}$ .

Four patients had extremely high levels of metal ions in their synovial fluid and blood samples – this is commented upon in the discussion and all had ASR implants in situ.

### Discussion

The paper highlights their technique of using acid oxidative digestion and suggests that this method causes a significant increase in the metal ion concentrations in both synovial fluid and blood samples and that this therefore provides a more accurate reflection of actual concentrations. As the difference between the undigested and digested groups was greater for Cr than for Co, they suggest more Chromium is bound to protein. A standardised laboratory protocol is suggested to allow for comparison between studies/clinical centres.

A good review of the two previously published papers is presented. The very wide range of metal ion concentrations in this study is remarked upon and is noted to have been present in the previous studies as well. The upper limit of the range in ion levels in this study were significantly greater than in the previous two (presumably due to the acid oxidative digestion assay) though the mean levels in one study was an order of magnitude lower and about six times higher in the other.

It is noted that the highest median synovial fluid Cr ion levels were in those patients with implant component size mismatch or malorientation but it is also noted that the numbers are too few for statistical significance. They also discuss the fact that because the range of levels is so wide, a discrete threshold would be impossible at this point in time.

The lack of statistical significance found between samples from different manufacturers is put down to the relative uniformity of the alloy composition used – a Cr:Co ratio of 1:2. The

manufacturing method (ie whether implants are cast or forged) seems to have no bearing on the levels found.

The size of the femoral head has previously been linked to higher metal ion levels but no difference was found in this study and instead the authors believe that the primary determinant of wear particle generation is due to the orientation of the acetabular component. This is suggested by a 'significant positive correlation' but not through statistical significance.

The metal ion levels found in the synovial fluid are higher for Cr than for Co – an unexpected finding with the alloy composition of 1:2 Cr:Co. They also note higher blood levels of Co and suggest that Cr is sequestered within the joint whereas Co is more readily disseminated into the circulation. Both these findings are previously reported and also reflect *in vitro* studies.

Several significantly higher results are noted in both joint fluid and blood samples – four patients with high Cr levels and two with high Co levels – all had ASR components in situ. Two failures were attributed to acetabular components malorientation and two to unexplained pain. The authors have not further elaborated on this, considering the recent recall of these components.

The association between synovial fluid levels and blood levels was noted to be not as strong as previously reported. This is suggested to be due to the use in this study of whole blood rather than serum and also due to the use of the acid oxidation protocol.

Authors note that some patients who had very high synovial fluid levels of metal ion had normal blood levels and therefore synovial fluid ion levels may merit further attention in symptomatic patients with normal blood levels.

The limitations of the study are discussed. Firstly that the measured levels are not necessarily physiological and due to the acid digestion step are likely to be higher than the peri-prosthetic tissues are exposed to. Speculation continues as to the trigger of soft-tissue inflammatory reactions and therefore how to link this with unexplained MoM prosthesis failures is noted to be unexplained at present. Secondly the requirement to measure the volumes of synovial fluid present in the hip to further improve the correlation to metal ion levels in blood is also highlighted. Thirdly the failure to detect statistically significant differences in the groups/sample size examined. Fourthly the differences between haemoglobin parameters were noted to have been inadequately reviewed. Finally it is noted that they did not differentiate between resurfacing devices and modular components, although the relative lack of modular components in the study is noted.

### **Strengths**

Larger sample size than previous studies in the area.

Good recruitment and exclusion criteria.

Interesting findings some of which go against the previous evidence available.

Well timed paper – with the Medicines and Healthcare products Regulatory Agency recommendation to investigate symptomatic MoM patients with blood metal ion analysis, it's a good time to study synovial fluid metal ion levels to elucidate whether it would be more helpful than blood levels.

Current lack of information on factors that might influence the relationship between the level of metal ions in synovial fluid and that in blood and only moderate correlation between the two.

Described the acid oxidative digestion method for metal ion level measurement in detail, therefore may be reproducible.

No outside interests.

### **Limitations**

Failure to achieve the primary aim which was to validate a method of metal ion analysis.

We feel that the control group is a poorly selected group as it would have been more useful to have a group of asymptomatic metal on metal hips as a control.

Retrospective nature of the study.

A rather large number of patients seem to have undergone revision for unexplained reasons of pain in spite of all investigations being negative.

Unvalidated technique is suggested to be taken up nationally for comparison of metal ions in a standardised way.

Though only 56 patients underwent 3D CT scans which suggest that all 64 patients who were included in the categories of failure were not fully investigated.

Intra operative findings were unavailable/unreported, therefore correlation with the severity of the disease and blood/synovial fluid concentrations is impossible.

### **Conclusion**

Interesting study which outlines the use of an acid oxidative digestion assay for measuring synovial fluid ion levels in patients with symptomatic MoM hips. A larger sample size than previously available is used.

The primary aim of validating a measurement technique is not achieved. However makes significant contribution in understanding metal on metal bearing surfaces.

It is discussed that, irrespective of the cause of failure, the range of Cr and Co levels in the synovial fluid of failing MoM hips is too wide to establish a discrete threshold that would indicate a harmful level.

The study also points out that some patients with very high joint fluid metal ion levels had normal blood levels and therefore joint fluid analysis may be considered in symptomatic MoM hips with normal blood metal ion levels.

The study highlights requirement of further studies into factors that determine leeching of metal ions from joint fluid to blood stream.