Is the precision of RSA measurements of acetabular cup stability and polyethylene wear increased by the addition of tantalum beads to the polyethylene liner?

Audrey Nebergall (Massachusetts General Hospital, Boston), Meridith Greene (Boston), Henrik Palm (Boston), Henrik Malchau (Boston)

INTRODUCTION : Radiostereometric analysis (RSA) is a tool for measuring femoral head penetration and acetabular cup stability in total hip replacements (THR). Because the polyethylene liner is assumed stable in the shell, the components are often combined into one segment (shell+liner). With beads in the liner, the components can be separated into two segments using a markerless shell.

OBJECTIVE: To determine if RSA measurements were influenced by assigning the shell and liner as one combined or two individual segments.

METHODS: 51 THR RSA hips received tantalum beads in their pelvis and polyethylene liner. RSA radiographs were analyzed to measure motion of the femoral head, liner, and cup. Double exams were taken for each patient and established the precision of the setup. The Wilcoxon paired signed ranks test determined differences among the measurement methods.

RESULTS: 47 hips were included in this analysis. When compared to the shell, the median polyethylene liner translation was within the error of detection as determined by double exams. Head penetration measured into the liner segment was not significantly different from the penetration measured using shell+liner. However, both the head to liner and the head to shell+liner segments measured significantly higher penetration than the head compared to the shell alone ($p \leq 0.03$).

Table 1: Femoral head penetration (mm). Median±SE (95% CI)

RSA Method	PO-6 months	Precision
Liner	0.03±0.01	-0.03, 0.02
Shell	-0.01±0.01	-0.07, 0.01
Shell+Liner	0.03±0.01	-0.09, 0.03

Acetabular cup translation was significantly different when comparing the pelvic segment to the shell+liner versus the shell alone ($p=0.04$). There was no difference in cup rotation between these methods. Precision for wear was highest in the head to liner method. For cup stability, the shell+liner had higher precision.

CONCLUSION: The translations and rotations between the liner and shell were too small to determine if the liners were moving within the shells as they were within the precision. Beads should be placed in the liner because wear measurements of the head into the liner segment were significantly different than comparing the head to the shell alone. The head to liner comparison was able to measure head penetration into the liner, which the head to shell+liner and head to shell alone failed to do. Since the polyethylene beads allowed for additional information defining the cup segment (up to 9 points), versus the shell method (up to 5 points), more of the radiograph's information was utilized which increased the precision of the RSA setup.

Day: Thursday	Time: 08.10-08.20	Location: Grand Hotel

The Center Index Method - An alternative for wear measurements with radiostereometry (RSA)

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Introduction:

Radiostereometry (RSA) is considered to be the most precise and accurate method for wear-measurements in total hip replacement. Postoperative stereoradiographs has so far been necessary for wear measurement. Hence, the use of RSA has been limited to prospective studies planned for RSA measurements. The purpose of this study was to compare a new RSA method for wear measurements that does not require previous radiographs with conventional RSA.

Method:

Instead of comparing present stereoradiographs with postoperative ones, we simulated the postoperative position of the femoral head in the center of the cup on the present examination and use this as the index measurement. We have compared this alternative method to conventional wear measurements with RSA in 27 hips in an ongoing study.

Results:

We found a high degree of agreement between the methods for both mean proximal (1.19 mm vs. 1.14mm) and mean three-dimensional (3D) wear (1.52 mm vs. 1.44 mm) after ten years. Intraclass correlation coefficients (ICC) were 0.958 and 0.955 respectively ($p<0.001$ for both ICCs). The results were also within the limits of agreement when plotted subject-by-subject in a Bland-Altman plot.

Day: Thursday	Time: 08.20-08.30	Location: Grand Hotel

Alternative Radiosterometric Analysis methods for calculating wear when radio-dense cups are used. An experimental study.

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Introduction: For measurement of wear in total hip arthroplasty Radiosterometric Analysis (RSA) is the gold standard. However with the introduction of radiopaque (Tantalum) cups, new ways for wear measurements need to be explored. In this study we investigated two alternative ways to identify the center of the femoral head: the helical axis technique (HAT), and the RSA instantaneous center method (RIC). These methods create a femoral head data point by calculating the location of the head based on kinematic data available from RSA beads located in the femur.

Methods: For the HAT and the RIC, a supine hip phantom with beads implanted in the pelvis, femur and the rim of the polyethylene cup was used. HAT requires the pelvis to be imaged three times and the femur to be abducted between imaging (in this case 0°, 10° and 20°). Helical axes were calculated for the rotations between 0° and 10° and between 10° and 20°. The intersection point of two helical axes represents the estimated location of the femoral head. A total of 15 images were taken resulting in 125 measurements. For the RIC method the phantom was imaged twice and the femur abducted 0° and 20°, which resulted in 75 measurements. The instantaneous center (IC) of rotation was calculated for each bead in the femur. The intersection point of all the ICs was the estimated location of the femoral head center. Results from the HAT and RIC methods were compared to RSA.

Results: Precision calculation for standard RSA, HAT and RIC methods are shown in table 1, these were based on the location difference between the center of the head (as calculated by each method) and the center of the cup as calculated by the RSA program.

Discussion: The introduction of tantalum cups prevents the identification of the center of the head, and thus prevents measurement of polyethylene wear. From our investigation it appears that while for the x and y axes the HAT method produces slightly more precise results, the RIC method produces results that are more precise in the Z axis. This, combined with the requirement for two radiographs as opposed to three with the HAT technique, makes the RIC method preferable over the HAT method.

Table 1:

	X (mm)	Y (mm)	Z (mm)
Standard RSA	¬±0.024	¬±0.012	¬±0.026
HAT	¬±0.038	¬±0.071	¬±1.788
RIC	¬±0.047	¬±0.086	¬±0.010

Day: Thursday	Time: 08.30-08.40	Location: Grand Hotel

Marker based migration measurements with two different RSA systems compared to elementary geometrical shape modelling

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Introduction

Radiostereometric analysis (RSA) is the golden standard to measure *in vivo* three dimensional migration. UmRSA (UmRSA Biomedical, Umeå, Sweden) and Leiden RSA (Medis Special) are the two most commonly used ones. Both offer features to analyse segments defined by markers and by shape. Classic RSA uses tantalum markers to define a segment to represent either an anatomical structure or the implant. Attaching markers to implants is an expensive and time consuming process. Therefore a new module called elementary geometrical shape RSA (EGS RSA) was developed that enables to define implants by different geometrical shapes. To our knowledge no comparing study between different RSA systems has been performed.

The aim of the study is to evaluate the *in vivo* precision of marker based RSA of two RSA systems (UmRSA and Leiden RSA) and compare these to EGS RSA.

Material and Method

Stem migration was measured in 50 patients from an ongoing RCT (Berte et al. 2011) . We performed marker based analysis with the UmRSA system and Leiden RSA and compared these to EGS RSA. All patients underwent THA with the Taperloc uncemented stem and a 28-mm cobalt-chrome modular head. Precision was calculated for 40 double examinations and expressed as abs mean + 1.96 x SD

Results

Precision for subsidence was 0.118 mm for UmRSA and 0.141 mm for Leiden and 0.136 mm for EGS RSA. Retroversion (out of plane movement) with EGS RSA was 1.3 dgr and about twice as high as for the others methods. Interclass correlation coefficient (ICC) was around 0.5 between the marker based systems and EGS RSA for retroversion. Subsidence and varus-valgus rotation had an ICC of 0.9 with all three RSA methods.

Discussion

We found excellent correlation between marker based RSA and EGS RSA for inplane movements (subsidence and varus valgus rotation) independent of the system used. Precision for out of plane movements were inferior for EGS RSA. Retroversion as a failure mechanism might therefore be harder to detect early. This is to our knowledge the first study to compare two different RSA systems.

Conclusion

Marker based RSA has high precision in all planes independent of system used. EGS RSA is inferior in out of plane movements.

Day: Thursday	Time: 08.40-08.50	Location: Grand Hotel

Clinical evaluation of model-based RSA to measure wear in 4 different cup designs

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Abstract

Introduction
The d isadvantage with conventional RSA is that implant has to be supplied with tantalum markers, which may be difficult to visualize. This problem can be resolved with model-based RSA, but it is uncertain if this method has the same precision as marker-based RSA to measure wear. We compared these methods and studied different prosthesis geometries represented by four different uncemented cup designs (Trilogy, TMT-Trabecular Metal, Zimmer, Warsaw, USA, Ringloc, Biomet, Inc., Warsaw , Indiana , and ABG, Howmedica International, Staines , UK).

Patients and Methods

Stereoradiographs of 75 patients (19 Trilogy, 17 TMT, 20 Ringloc, 19 ABG) were exposed postoperatively (2 examinations) and after 2 years. The patients were selected from prospective clinical studies. During operation tantalum markers had been inserted into the liner in all cases. The measurements and analysis of all radiographs were performed with UmRSA Digital Measure and UmRSA Analysis 6.0. We used the differences between the postoperative double-examinations to compute the precision for the two methods and for the different implant designs. The proximal and the total (vectorial sum of medial/lateral, proximal/distal and anterior posterior) femoral head penetration up to 2 years were compared.

Results

The mean differences and the standard deviation of mean obtained from calculations between the double examinations in the total material did not differ between the 2 methods for any of the designs studied. The mean values and SD for marker and model-based RSA were -0, 00 mm ± 0.09 mm and 0.02 mm ± 0.08 mm , respectively ($p>0.05$) . The comparison between Classical marker-based RSA and Model-based RSA in measuring wear up to 2 years did not showed any statistically significant differences for the Trilogy, TMT and ABG cups ($p>0.05$). However the mean difference of the postoperative double examinations were slightly higher for the Ringloc design ($p=0,02$) and the data scatter (SD) at 2 years was higher ($p=0,004$) with use of model-based RSA.

Conclusions

We found small differences between marker and model-based RSA for measurements of proximal and total wear (penetration). In 3 of the 4 cup designs studied the data scatter was about equal for the 2 methods. In the 4 th design (Ringloc) the data scatter was higher when model-based RSA was used.

Day: Thursday	Time: 08.50-09.00	Location: Grand Hotel

A Challenge to the RSA Gold Standard for Measurement of Cemented Acetabular Cup Wear: Validation of a New 2-D Wear Measurement Technique

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RSA is considered to be the "gold standard" for measuring acetabular cup wear: but why? The "out-of-plane" (z) wear is usually very small, and the z measurement error is relatively large. Why can't 2-D measurement systems perform just as well? One reason for the trust in RSA is that the measurements are considered to be independent of changes in pelvic tilt or rotation that might occur over a series of examinations. However, even large variations in pelvic orientation have only a minimal effect on wear penetration values if the femoral head and cup centres are very close.

We have developed a 2-D wear measurement software program for measuring wear of cemented acetabular cups that have circular wire markers. It corrects for variations in cup orientation due to changes in pelvic orientation, and it also corrects the measured orientation for X-ray beam offset from the pubis. In this study, we validated the software, together with marker beaded RSA (UmRSA) using radiographs of a special measurement jig which we have developed.

The measurement jig was used to create radiographic images of a femoral head/cup set at different orientations and with different amounts of "wear". RSA measurements were taken from 6 marker beads on the cup face. The jig could be tilted (± 10°) and the cup could be pegged at different rotations about the polar axis (± 10°) to simulate changes in cup orientation due to pelvic tilt. The nominal anteversion setting was 20°. The 2-D "wear" and "wear direction" were set using a variable number of plastic shims (accurately measured) in the X and Y direction (penetration range: 0.114 mm to 0.835 mm, and 0° to 50.5° relative to the cup face). Each image was measured three times using the new software and a mean value was determined. The errors of the two systems were compared using an unpaired t-test.

The overall mean of the 2D software and RSA measurement errors were 0.006 mm and -0.028 mm, respectively. UmRSA errors were significantly greater than the 2D software errors ($p = 0.0069$; CI: 0.010 mm to 0.059 mm). The RSA system tended to underestimate the measurements at very low wear (XLPE range) between 0.1 mm and 0.15 mm (mean RSA error: -0.047 mm; mean 2D software error: 0.0005 mm).

Although this was a laboratory study, the new software could possibly replace RSA for measurements of XLPE cups in the clinical setting.

Day: Thursday	Time: 09.00-09.10	Location: Grand Hotel

Osteolysis at ten years in hybrid hip arthroplasty with highly cross-linked polyethylene displaying low steady state wear – a prospective randomized study with radiostereometry

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Introduction : Highly cross-linked polyethylene (XLPE) has shown substantially reduced wear when compared to conventional polyethylene (PE) in mid-term follow-up. Osteolysis has been absent or reduced. Long-term wear and osteolysis prevalence is not known.

Objectives: To evaluate if low wear persists and to study the prevalence of osteolysis for XLPE compared to PE liners after 10 years follow up.

Methods: 32 patients received simultaneous bilateral total hip arthroplasty with a cemented Spectron EF Primary ® stem (Smith & Nephew, London, UK) and uncemented Trilogy ® cup (Zimmer, Warsaw, IN, USA). The most painful side was randomized to XLPE or PE liner. The opposite kind of PE was used on the contralateral side. We evaluated wear as proximal and 3D penetration of the femoral head into the liner using radiostereometry (RSA). Steady state wear rate was calculated by subtracting two year penetration from the ten year value. Osteolysis analyzed from CT scans at 10 years was categorized as small (<1 cm) or large (>1 cm). Multiple sclerotic subcortical cysts were accounted for separately. We used non-parametric statistics.

Results: 22 patients had a full bilateral RSA follow-up at 10 years, one declined CT scan. Annual proximal penetration rate was -0.003 mm (SD 0.01) for XLPE and 0.05 mm (SD 0.03) for PE ($p<0.001$, Mann-Whitney). Corresponding 3D penetration rates were 0.001 mm (SD0.02) and 0.04 mm (SD 0.03) respectively ($p<0.001$, Mann-Whitney). In XLPE group there were 2 small and 4 large osteolyses, corresponding numbers in PE group were 1 and 3 ($p=0.8$, Exact test). There were 3 cysts in XLPE and 2 in PE group ($p=1.0$, Exact test).

Conclusions: XLPE continues to display very low steady state wear rate. No difference in osteolysis prevalence could be detected. This observation should be seen against the background of small sample size and possible confounding from stem-derived metal debris. Further research with longer follow-up, larger cohorts and more suitable stem design is needed to evaluate XLPE long-term clinical outcome.

Day: Thursday	Time: 09.10-09.20	Location: Grand Hotel

Multicenter RSA evaluation of vitamin E doped highly cross-linked polyethylene liners and acetabular cup stability

Nanna Sillesen (Boston), Meridith Greene (Boston), Audrey Nebergall (Boston), Poul Nielsen (Aalborg), Mogens Laursen (Aalborg), Anders Troelsen (Copenhagen), Henrik Malchau (Boston)

Introduction

Vitamin E doping of highly cross-linked polyethylene (VEPE) enhances long-term oxidative stability for use in total joint arthroplasty. *In vitro* testing shows that VEPE has improved wear performance, oxidative stability, and fatigue strength. A porous titanium construct for biological fixation was developed for use on acetabular shells. To evaluate *in vivo* wear of VEPE and evaluate the stability of acetabular cups with a porous titanium construct (PTC) using radiostereometric analysis (RSA).

Methods

150 hips in 144 patients were included in a prospective 5 year RSA study at 2 centers. Tantalum beads placed in the pelvic bone allow the measurement of femoral head displacement into the polyethylene and acetabular component stability. All patients received a PTC acetabular cup (Regenerex, Biomet) and either VEPE liners (E1, Biomet) or non-vitamin E stabilized cross-linked liners (XL) (ArcomXL, Biomet). Cobalt-chrome femoral heads were used at Center 1 and ceramic femoral heads were used at Center 2 with two head sizes (32mm or 36mm). RSA radiographs were scheduled immediately post-op, at 6 weeks or 6 months, and at 1, 2, 3, and 5 years post- operatively.

Results

One third of the patients have been followed for 3 years. Patients with 36mm femoral heads do not have sufficient follow-up to be included. At 1 year, the median (±SE) femoral head penetration into the VEPE liners with the metal heads at Center 1 (-0.02±0.02mm) was not significantly different than the ceramic heads into the VEPE (0.02±0.05mm) or the XL liners (0.02±0.04mm) at Center 2. The head penetration into the VEPE was significantly different from 2 to 3 years at center 1 ($p=0.04$). The median proximal cup translation of 0.14±0.03mm at Center 1 was significantly lower than the 0.38±0.05mm at Center 2 at 1and 3 years ($p<0.001$). Median cup migration at both centers remained stable with no increase at 3 years.

Discussion

The early RSA results indicate promising wear performance of VEPE liners. The penetration into the liner is low regardless of head material or size. The movement of the head is due to a combination of poly deformation and settling into the shell. The difference in migration of the PTC cups may be attributed to the different surgical techniques at the centers. The relatively low amount of early movement seen in all cups is encouraging. Continued long-term follow-up is important to evaluate the performance of these devices.

Day: Thursday	Time: 09.20-09.30	Location: Grand Hotel

Alfa-tocopherol Doped Cross-linked Polyethylene Compared to Standard Cross-linked Polyethylene in Total Hip Arthroplasty. Early radiostereometric results of liner wear from a randomized clinical trial.

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Introduction

Polyethylene wear is the major cause of periprosthetic osteolysis and loosening in total hip arthroplasty. To decrease wear, acetab ular polyethylene liners are irradiated to increase polymer cross-linking. Oxidating free radicals are an unwanted side-effect of this treatment and can adversely affect the long-term stability of the ultra-high molecular weight polyethylene (UHMWPE). Vitamin E (alfa-tocopherol) has been shown to neutralize free radicals. In this study we hypothesized that cross-linked vitamin E-doped acetabular liners would show less wear compared to standard cross-linked liners.

Patients and methods

We included 51 p atients (mean age 62 years [40-70]) with primary hip osteoarthritis in a randomized, prospective, single-blinded, clinical trial. Randomization to either an acetabular cup with an UHMWPE vitamin E liner (1) (E1™, Biomet, USA) (E1 group, n=25) or a standard UHMWPE liner (2) (Maraton™, Depuy Johnson&Johnson, USA) (control group, n= 26) was done. A 32 mm metal head was used. The primary outcome variable was wear, i.e. head penetration at 2 years, measured with radiostereometry (RSA). We used a marker-less algorithm (UmRSA 6.0 computer software, RSA Biomedical AB, Sweden) to measure the penetration as maximum total point motion (MTPM) in mm. Secondary outcomes were hip function and quality of life evaluated with Harris Hip Score and EQ-5D. We present the results of the first 33 patients (E1 group n=17, control group n=16) who have been followed for up to 2 years.

Results

The two groups did not differ in demographic parameters, functional capacity or p ostoperative offset . The initial head penetration up to 6 weeks was higher in the control group and still favored the E1 group at 2 years; 0.34 mm (95% CI 0.25-0.42) control group versus 0.24 mm (95% CI 0.17-0.30) E1 group, p=0.057 (Figure 1). Both liners had a low wear rate but was less in the E1 group; 0.044 mm/y (95%CI 0,01-0,08) control versus 0.017 mm/y (95%CI -0,02-0,05) E1. Both groups had excellent clinical results.

Conclusion

Based on these early findings, the initial "bedding-in" and the overall wear up to 2 years is less for alfa-tocopherol doped UHMWPE compared to standard UHMWPE. Patients in both groups functioned very well from a clinical perspective.

1. Oral E et al. Wear resistance and mechanical properties of highly cross-linked, ultrahigh-molecular weight polyethylene doped with vitamin E. J Arthroplasty. 2006;21(4):580-91. Epub 2006/06/20.

2. McKellop et al. Development of an extremely wear-resistant ultra high molecular weight polyethylene for total hip replacements. J Orthop Res. 1999;17(2):157-67. Epub 1999/04/30.

Day: Thursday	Time: 09.30-09.40	Location: Grand Hotel

Wear of highly cross linked polyethylene liners: A review of RSA studies

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Introduction

The wear rate of highly crosslinked polyethylene (XLPE) acetabular components is less than that of conventional polyethylene components but the results vary considerably across published studies. This variation is due, in part, to the different techniques used to measure wear. The XLPE component design may also be a factor but comparison across designs requires a single accurate wear measurement technique with standardised analysis and reporting methodology. Radiostereometric analysis (RSA) is acknowledged as the most accurate and precise method to measure wear. Hence, the aim of this study was to undertake a review of the RSA methodology used in published studies where RSA was used to quantify XLPE wear across different designs.

Methods

A search of Pubmed, Embase and Cochrane databases was performed to find published studies where RSA was used to measure wear of XLPE acetabular components. Inclusion criteria for studies were primary total hip replacement (THR) cohorts; cemented or uncemented acetabular component fixation; and minimum 2 years follow-up. The heterogeneity of RSA methodology across studies was also reviewed as a prelude to a systematic review, not reported here. Data synthesis consisted of a review of study characteristics, approach to analysis and reporting of wear. Summary results were also reviewed.

Results

The search criteria yielded 17 papers reporting the results of 12 THR cohorts. Eight papers reported the longer term follow-up of earlier reports. Three designs of cemented XLPE acetabular components and four designs of XLPE liners of uncemented acetabular components have been investigated to date. Collectively, RSA results were reported for 245 THRs at 2 to 10 years of follow-up. RSA methodology heterogeneity included the use of both supine and standing radiographs; the reporting of precision; and the use of beaded or unbeaded techniques. Most studies reported both proximal and 3D head penetration, however the calculation of a wear rate varied, with the time period allowed for bedding-in ranging from 2 to 24 months. The proximal wear rate ranged from 0.002 to 0.030 mm/year.

Conclusion

Despite the almost universal acceptance of XLPE technology for acetabular components, the *in vivo* wear is only measured in 12 relatively small cohorts using RSA. Within these studies there is methodological heterogeneity, which may limit systematic analyses to compare wear across different designs. Longer term RSA studies, which should aim for use of consensus methodology, are required to determine the relationship of the low early wear with longer term clinical results and osteolysis.

Day: Thursday	Time: 09.40-09.50	Location: Grand Hotel

The history of RSA - did developments over the last few decades improve the method´s accuracy

Soehnke Hinrichs (Erlangen), Raimund Forst (Erlangen), Silke Rottmann (Erlangen), Stefan Sesselmann (Erlangen)

In 1974 Selvik introduced a method to determine micromotions of implants of the skeletal system by X-rays, which he later named Roentgen Stereophotogrammetric Analysis (RSA). He also published the first data on accuracy and precision of RSA. At that time the method was very time consuming and many factors deteriorated accuracy and thus the measurement results.

To overcome these problems, the method has been improved during the last decades. Analysis of RSA images today is conducted faster and less defective on desktop-computers. Other problems like the need of marked prostheses have been solved by developing the model-based RSA using either elementary geometrical shapes (EGS) or surface models of the implants. Attempting to perform completely markerless RSA by even omitting bone-markers, Seehaus et al. showed that this technique is not yet an alternative due to its lack of accuracy .

In 1994 Kärrholm et al. proved by using RSA that early micromotion of implants is predictive for later aseptic loosening and stated this method to be the best for detection of implant loosening, requiring only small patient cohorts and short observation periods due to its high accuracy. Therefore RSA should be applied to assess new implant designs or fixation techniques to prevent patients from disasters like the "Bonelock catastrophe" when a new bone cement failed and thousands of patients had to be revised .

In the Netherlands RSA is already a mandatory part of a so called phased introduction protocol of new implants, and due to its confirmed predictive value there are international efforts to make it mandatory before common use of every new implant and fixation technique.

We analyzed published data on RSA accuracy and found an improvement over the last 40 years. Technical developments like digital image processing help to prevent errors arising from manual measurements, film bending, and scanning. However, a major problem of RSA data evaluation is, that study conditions in different research centers are very heterogeneous and the term "accuracy" is used for values obtained by non-uniform calculation methods. Furthermore, various numbers of markers, unequal distances from film to roentgen foci, as well as different angles between the two roentgen foci are used. Therefore standardization of experimental set-ups is claimed, but not yet used by every research center. The obtained improvement of accuracy will be discussed.

Day: Thursday	Time: 09.50-10.00	Location: Grand Hotel

Growth arrest after percutaneous permanent epiphysiodesis: an evaluation using radiostereometric analysis and computer tomography

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Abstract

Background and purpose: The aim of this study was to determine when definite growth arrest occurred after percutaneous epiphysiodesis in the knee region. We also wanted to study the correlation between the extent of physis ablation and the postoperative growth. Finally we wanted to detect the presence and possible location of bone bridging across the physis.

Methods : Radiostereometric analysis (RSA) was used to measure longitudinal growth in 27 patients (37 physes) with a mean age of 13.3 years, six, 12 and 30 weeks after surgery. Computed tomography (CT) scanning of the knee region was performed 12 weeks after surgery to measure the percentage of the ablated physis and to determine the distribution of bone bridges across the physis.

Results: RSA showed that the growth rate was reduced to less than half of the expected rate after six weeks. During the next six weeks, the growth nearly ceased completely. CT scans revealed a large variation in the postoperative fractions of the ablated physes (17 to 94 %). In the ablated areas tissues of various densities were mixed with mature bone. Bridges were found both laterally and medially across the physes in all of the patients. The extent of ablation correlated significantly with total postoperative growth (rho = - 0.37, p = 0.025).

Interpretation: Growth across the physis is effectively stopped by percutaneous epiphysiodesis. RSA is well suited to observe this phenomenon, and volume CT scanning can be used detect bone bridges that cross the physis and to estimate the extent of physis ablation.

Day: Thursday	Time: 11.10-11.20	Location: Grand Hotel

Static and dynamic RSA imaging of femoral neck fractures stabilized with internal fixation

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INTRODUCTION : The emerging concept is to use stable internal fixation in active patients (physiological age ≤ 75 yrs) with femoral neck fractures. Our hypothesis is that static and dynamic RSA could help in defining the inherent fracture stability achieved during surgery and in detection the exact time of fracture union.

MATERIAL AND METHODS: This single-center exploratory study recruited 16 patients with a fresh low-energy femoral neck fracture. In DXA screening, ten female patients (mean age 65±8 yrs) were osteoporotic (mean T-score -3.6) and six men were osteopenic (mean T-score -1.9). Closed reduction and internal fixation within 48 hours was performed with multiple cannulated screws in fourteen patients and with a sliding hip screw in two patients. Anatomic reduction was achieved in 14 patients (88%). Baseline uniplanar RSA imaging (the patient lying supine on the X-ray table) was performed within 1-3 days after surgery and repeated at 6, 12, 24, and 52 weeks. At each visit, the initial imaging was performed without load (conventional static RSA). Subsequently, the patient was asked to press a force place as tolerated with the foot of the fractured limb and the imaging was repeated (dynamic RSA).The maximum compression force and the pain (VAS-score) were recorded. Micromotion during dynamic RSA was considered to be real when exceeding the precision values (0.25 mm for the translation vector and 0.4 degrees for the rotation vector) determined with double examinations.

RESULTS: The fractures showed significant ($p<0.001$) migration both in translation and rotation during the first 12 weeks after surgery. OTA/AO fracture types 31-B2/B3 (n=7) were characterized by higher rotational migration (mean 10.6 degrees, 95%CI 4.6 - 16.7) than type 31-B1 fractures (n=9) (mean 4.9 degrees, CI 2.0 - 7.7)($p=0.024$). Dynamic RSA detected significant rotation in 88% of the patients and translation in 69% of the patients at baseline. The corresponding numbers were 31% and 38% at 6 weeks. Only one patient showed micromotion during dynamic RSA at 12 weeks. Fracture union was achieved in 14 patients (88%). Total hip replacement was necessary in two patients. These patients showed rotational micromotion during dynamic RSA at baseline and exceptionally large rotatory displacement on static RSA already at 6 weeks.

CONCLUSION: RSA was able to demonstrate both inter-individual differences in initial fracture stability as well as the progression of fracture union in patients with femoral neck fractures.

Day: Thursday	Time: 11.20-11.30	Location: Grand Hotel

Increased migration of cementless cups in total hip arthroplasty of women with low BMD

Sami Finnilä (Turku), Erik Aro (Turku), Niko Moritz (Turku), Satu Timlin (Turku), Hannu Aro (Turku)

INTRODUCTION: We recently found that low BMD (osteopenia or osteoporosis) and age-related geometric changes of the proximal femur affected initial stability and delayed osseointegration of cementless femoral stems in a female patient population. It is possible that low BMD jeopardized also the initial stability of their cementless cups.

MATERIAL AND METHODS: 36 female patients (mean age 64 years, range 41 - 78 years), who underwent cementless total hip arthroplasty for primary osteoarthritis, participated into this two-year RSA study of acetabular cup migration. During the patient recruitment, exclusion criteria included on-going bisphosphonate/corticosteroid therapy and severe osteoporosis (T-score < -3.5). All patients received a custom-modified RSA-marked hip implant (ABG-II, Stryker Inc.) with alumina-on alumina bearing surface. HA-coated titanium cups (ABG II) were implanted using press-fit technique and additional stability was achieved with RSA-marked fixation spikes. Baseline RSA examination was performed within 7 days after surgery and repeated at 3, 6, 12, and 24 months. Based on double examinations, the detection limits were 0.39 mm and 1.93 degrees for translation and rotation vectors, respectively. Based on preoperative DXA of systemic bone mineral density (BMD), the patients were divided into two groups. Ten patients (28%) had normal BMD and 26 patients (72%) had low BMD (osteopenia or osteoporosis). The statistical comparison of RSA migration was performed between the patients with normal or low BMD.

RESULTS: The translational and rotational migration of the cups occurred mainly during the first year. Patients with low systemic BMD showed significantly greater vertical translation of the cup than patients with normal BMD ($p<0.05$). Rotational migration of the cup was no affected by low BMD.

CONCLUSIONS: Low systemic BMD may increase the risk of delayed osseointegration of cementless cups in postmenopausal women.

Day: Thursday	Time: 11.40-11.50	Location: Grand Hotel

An Uncemented Tapered Femoral Stem in Patients with an Acute Femoral Neck fracture. A 4-year follow-up of a single cohort prospective study using RSA and DXA

Olof Sköldenberg (Danderyds sjukhus, Ortopeden, Stockholm), Olle Muren (Stockholm), Helene Sjöö

(Stockholm), Paula Kelly-Pettersson (Stockholm), André Stark (Stockholm), Mats Salemyr (Stockholm)

Introduction:

Uncemented femoral stems rely on initial primary stability to achieve biological fixation to bone. They are popular implants in primary total hip arthroplasty (THA) and excellent long-term results have been reported for patients with primary osteoarthritis of the hip (OA). We have earlier (1) presented an evaluation of a new uncemented femoral stem designed for elderly patients with a femoral neck fracture and found good clinical results and stable implant fixation up to 2 year postoperative despite a significant postoperative periprosthetic bone loss due to stress-shielding. We now present a 4 -year follow-up from this study.

Patients and methods
We included 50 p atients (mean age 81 years [70-92]) with an acute femoral neck fracture (FNF) in a prospective cohort study . They received a total hip replacement

using the new component (Biomet Fracture Stem, Biomet, United Kingdom) and were followed up regularly for 4 years. The primary outcome variables were migration of the femoral stem measured with radiostereometry (RSA) and periprosthetic change in bone mineral density (BMD) measured with dual-energy x-ray absorptiometry (DXA) . Hip function and the health-related quality of life were assessed using the Harris hip score and the EuroQol-5D. At the 4 year follow-up 29 patients were available for clinical follow-up and 19 had complete RSA and DXA-data .

Results

There were no stem revisions or other hip-related complications. At 4 years we found a mean (range) subsidence of 0.03 mm (-1.0 to +0.2), retroversion of -0.9° (-4.3 to +1.0) and a maximum total point motion of 1.8 mm (0.6 to 5.23). No component migrated above the detection limit (resolution) between 2 and 4 years. The patients had a continuous loss of peri-prosthetic bone loss which amounted to a mean of -15% (-37% to +2%) at four years. The mean Harris hip score was 83 (51 to 100) and EQ-5D 0.65 (-0.1 to 1.0) at two years, unchanged from the 2 year follow-up.

Discussion

Despite a large periprosthetic bone loss the stem is firmly fixed in bone after 4 years. However, further comparative studies are needed to ascertain whether uncemented femoral stems are superior, equivalent or inferior to cemented stems in the treatment of FNFs in the elderly.

1. Sköldenberg OG, Salemyr MO, Boden HS, Lundberg A, Ahl TE, Adolphson PY. A new uncemented hydroxyapatite-coated femoral component for the treatment of femoral neck fractures: two-year radiostereometric and bone densitometric evaluation in 50 hips. J Bone Joint Surg Br. 2011;93(5):665-77. Epub 2011/04/23.

Day: Thursday	Time: 11.50-12.00	Location: Grand Hotel

A Randomized Trial Comparing Acetabular Component Fixation of Two Porous Ingrowth Surfaces using RSA

Douglas Naudie (London), Richard McCalden (London), Abigail Thompson (London), Xunhua Yuan (London), David Holdsworth (London), Robert Bourne (London), Matthew Teeter (London)

Introduction: Several new porous ingrowth surfaces for acetabular component fixation have recently been developed. The purpose of this study was to compare the in vivo acetabular fixation achieved by two different porosity ingrowth surfaces using radiostereometric analysis (RSA).

Methods: Sixty-two patients undergoing primary THA were randomized to receive a cementless acetabular component with either a 61% high porosity asymmetric titanium porous surface orâ¨a 45% low porosity sintered bead porous surface. Clinical, radiographic, and RSA examinations were done 6-weeks, 3-months, 6-months, 1-year and 2-years post-operatively.

Results: The two patient cohorts were similar in terms of gender (69% female), age (mean ofâ¨ 75 years), and body mass index (mean of 28). Of the 62 enrolled patients, three patients have died from unrelated causes, three patients were withdrawn from the study due to poor bead visualization, three patients refused further participation for medical reasons, two patients were lost to follow-up, and one patient had an acetabular fracture after 6 weeks and is being treated non-operatively. At 2-year follow-up, the "X," "Y", and "Z" axis translations for High porosity were 0.01±0.28, 0.04±0.20, and 0.00±0.63 mm, and for Lower porosity were -0.16±0.33, 0.15±0.17, and 0.15±0.48 mm; the "X," "Y," and "Z" rotations for High porosity were 0.42±1.42, -0.03±0.67, and 0.17±0.63 degrees, and for Lower porosity were 0.13±0.74, 0.06±0.56, and -0.10±0.57 degrees. There was no statistically significant difference ($p=0.66$) in total 3D translation between groups (High porosity 0.49±0.51 and Lower porosity 0.55±0.33). Curiously, there was a statistically significant difference ($p < 0.05$) in WOMAC pain scores between the two groups (High porosity 84.07±19.32 versus Lower porosity 93.91±12.70) at 2 years.

Discussion: Both the high porosity and lower porosity surfaces provided excellent biologic fixation.

Day: Thursday	Time: 13.00-13.10	Location: Grand Hotel

Effect of removal of the subchondral bone plate in cemented cup fixation. A randomized RSA study with 10 years follow up

Gunnar Flivik (SUS, Lund), Ingvar Kristiansson (Lund), Leif Ryd (Stockholm) There is still uncertainty regarding how the subchondral bone plate should be treated during acetabular preparation for cemented cup fixation in a total hip arthroplasty. We report a randomized controlled study with repeated RSA examinations of 50 patients with primary osteoarthritis divided into two groups, one for removal and one for retention of the subchondral bone plate. The patients have now been followed up for 10 years with RSA examinations and analyses of radiolucent lines as well as clinical follow-ups. We have previously published the 2 year follow up of this study and the results have now been reinforced.

Removal of the subchondral bone plate resulted in a radiographically superior cement bone interface with significantly less development of radiolucent lines. At 10 years we measured a mean of 45% of the cement bone interface being covered with a radiolucent line in the Retention group, but only 6% in the Removal group ($p<0.001$).

The RSA results showed relatively small migrations in both groups. However, from 6 to 10 years the Retention group showed progressive rotation into a more horizontal position (Z-rot 1.1Â°) and slight proximal migration (Y-trl 0.56 mm). The Removal group remained in a slightly vertical position (Z-rot 0.3Â°) and showed virtually no signs of proximal migration (Y-trl 0.05 mm). In the Retention group one patient had a clearly loose cup waiting for revision, and another had already been revised, while there were no cups with clinical signs of loosening in the Removal group.

We conclude that removing the subchondral bone plate, where possible, improves the cement-bone interface and retains a stable cup position. It puts higher demands on the surgical technique but appears to give a better long-term cup survival.

Day: Thursday	Time: 13.10-13.20	Location: Grand Hotel

Early proximal migration of cups is associated with late revision in THA

Bart Pijls (LUMC, Leiden), Marc Nieuwenhuijse (Leiden, The Netherlands), Marta Fiocco (Leiden), Jose Plevier (Leiden), Saskia Middeldorp (Amsterdam), Edward Valstar (Leiden), Rob Nelissen (Leiden)

Background and purpose The association between excessive early migration of acetabular cups and late aseptic revision has been scantily reported. We therefore performed 2 parallel systematic reviews and meta-analyses to determine the association between early migration of acetabular cups and late aseptic revision.

Methods One review covered early migration data from radiostereometric analysis (RSA) studies, while the other focused on revision rates for aseptic loosening from long-term survival studies. Thresholds for acceptable and unacceptable migration were classified according the Swedish Hip Arthroplasty Register and the Australian National Joint Replacement Registry: < 5% revision at 10 years.

Results Following an elaborate literature search, 26 studies (involving 700 cups) were included in the RSA review and 49 studies (involving 38,013 cups) were included in the survival review. For every mm increase in 2-year proximal migration, there was a 10% increase in revision rate, which remained after correction for age, sex, diagnosis, hospital type, continent, and study quality. Consequently, proximal migration of up to 0.2 mm was considered acceptable and proximal migration of 1.0 mm or more was considered unacceptable. Cups with proximal migration of between 0.2 and 1.0 mm were considered to be at risk of having revision rates higher than 5% at 10 years.

Conclusion There was a clinically relevant association between early migration of acetabular cups and late revision due to loosening. The proposed migration thresholds can be implemented in a phased evidence-based introduction, since they allow early detection of high-risk cups while exposing a small number of patients.

Day: Thursday	Time: 13.20-13.30	Location: Grand Hotel

Influence of Bone Allograft in Cemented and Uncemented Revision Cups. 13 years follow up of 90 cups with RSA

Maziar Mohaddes (Sahlgren University Hospital / Mölndal, Mölndal), Peter Herberts (Mölndal), Johan Kärrholm (Mölndal)

Background

There are several surgical techniques available addressing bone defects in cup revision surgery. Bone impaction grafting, introduced more than 30 years ago is a biologically and mechanically appealing method. The aim of this study was to compare the uncemented and cemented fixation when bone impaction grafting is used in cup revision surgery.

Patient and Methods

Between 1993 and 1997 120 cup revisions were performed at Sahlgrenska University Hospital. 90 cases accepted participation in this study. Peroperatively the surgeon assessed the amount of transplanted bone and percentage living bone/implant contact area. In hips with > 50% host bone contact an uncemented cup was used (Group I, 43 hips). If the cup was resting on <= 50% living bone, an uncemented or a cemented cup was chosen according to the surgeons preference (group II and Group III, 21 and 26 hips). In total 82 hips required bone grafting during the surgery, the median amount of transplanted bone in millilitre was 20 (range 0-120), 100 (range 30-200) and 105 (range 60-300) in groups I, II and III. The minimum follow-up was 13 years.

Results

We found an increased risk for rerevision in cases with advanced bone loss in acetabulum, these cups showed early proximal migration measured by RSA indicating poor fixation. There was no significant difference in frequency of rerevisions due to any reason between cemented and uncemented fixation, but the cemented cups had a higher risk of being rerevised because of aseptic loosening.

Discussion and Conclusion:

According to our knowledge, no previous studies compared cemented and uncemented techniques in cup revisions. We found increased risk of re-revision in cases with advanced bone loss in the acetabulum. These cups showed early proximal migration, measured by RSA, indicating poor initial fixation. Cemented technique resulted in inferior results, probably due to excessive bone grafting. The inferior surgical technique employed at the time period for this study, including use of small bone grafts and the reversed reaming technique at impaction of the graft, might also have contributed to increased rate of migration and loosening in the cemented group. RSA was found to be a helpful tool for early detection of loosening also concerning the evaluation of cup revisions.

Summary

A group of 90 cup revisions were included in this study with a minimum of 13 year follow-up. We found increased risk of re-revision in cases with advanced bone loss and in the cemented group.

Day: Thursday	Time: 13.30-13.40	Location: Grand Hotel

RSA Analysis of Early Migration of a Short Metaphyseal vs. Standard Length Metaphyseal Cementless Stem: A Prospective Randomized Controlled Trial

Douglas Naudie (London), Richard McCalden (London), Abigail Thompson (London), Lyndsay Somerville (London), Matthew Teeter (London) Introduction: The purpose of this study was to compare the early clinical outcomes and micro-motion (using radiostereometric analysis - RSA) of a new short metaphyseal fixation stem (short) to that of a standard length tapered metaphyseal fixation stem (standard) with known long-term clinical success.

Methods: Forty-three patients were enrolled in which twenty-two patients were randomized to receive a short stem while twenty-one patients received a standard stem. All patients received the identical cementless acetabular component. Tantalum beads were inserted at the time of surgery and had been placed on the implant by the manufacturer to allow RSA following surgery. RSA was performed at 48 hours (baseline) and at 6 weeks, 3,6, 12 & 24 months following surgery. WOMAC, SF-12 and Harris Hip Scores were documented pre and post-operatively.

Results: At average follow-up of 2.5 years (range 2.0 to 3.2 yrs.) the clinical outcome scores were virtually identical between groups and there were no re-operations. RSA demonstrated no significant differences in micro-motion between groups (subsidence 0.80±1.41 vs. 0.37±0.49 mm, rotation 0.70±1.40 vs. 1.76±3.48 degrees, and total migration 0.96±1.44 vs. 0.75±0.87 mm, for the short vs. standard, respectively). After removing the outliers in each group (4 short stem and 3 standard stem with migration greater than 1.0 mm), micro-motion was very low andâ¨virtually identical between groups (subsidence 0.12±0.09 vs. 0.19±0.18 mm, rotation 0.12±0.49 vs. 0.58±1.00 degrees, total migration 0.26±0.11 vs. 0.43±0.25 mm, for short vs.â¨standard, respectively).

Conclusion: Overall, the early migration patterns were very similar between stems, thus confirming the hypothesis. However, for the outliers in each group (with total migration of > 1.0 mm) the long-term stability of the stem may not be certain. The introduction of this new shorter stem design can now be supported with RSA data, arguably the best way with which to introduce new technology.

Day: Thursday	Time: 13.40-13.50	Location: Grand Hotel

Does migration of short-stem hip prosthesis depend on method of access? Preliminary results of a 2 year clinical trial using Radiostereometry

Michael Schwarze (Hanover Medical School, Hannover), Gabriela von Lewinski (Hannover), Stefan Budde (Hannover), Thilo Flörkemeier (Hannover), Christof Hurschler (Hannover), Henning Windhagen (Hannover), Frank Seehaus (Hannover)

Introduction

Short stem hip prosthesis have become a viable alternative for the treatment of hip osteoarthritis for younger recipients. Several minimal-invasive (MI) surgical techniques have become applicable additionally to conventional approaches. Potential advantages of such techniques are reduced damage of surrounding tissue and faster rehabilitation [1]. However, a drawback of these MI techniques is limited perioperative visibility [2], which may lead to a higher risk of complications as well as a reduction in primary stability compared to conventional techniques. We thus compared the primary stability of short-stem implants with MI and conventional THA surgery by means of Radiostereometry (RSA) [3].

Method

Fifty four (54) THA patients were recruited for the study and randomly assigned to MI (Watson-Jones) or conventional (Bauer) surgery. All patients were treated with a Metha ® short-stem prosthesis (Aesculap AG, Germany) in the individually appropriate size. Dual source radiographs were taken the day after surgery and 3, 6, 12 and 24 months post-operatively. To date, 20 of the recruited patients have reached the 24 month follow-up to date. Resulting migration over time was calculated three-dimensionally using the bone markers as a reference. Statistical analysis utilized Student's t-test and considered p-values less than 0.05 to be statistically significant.

Results

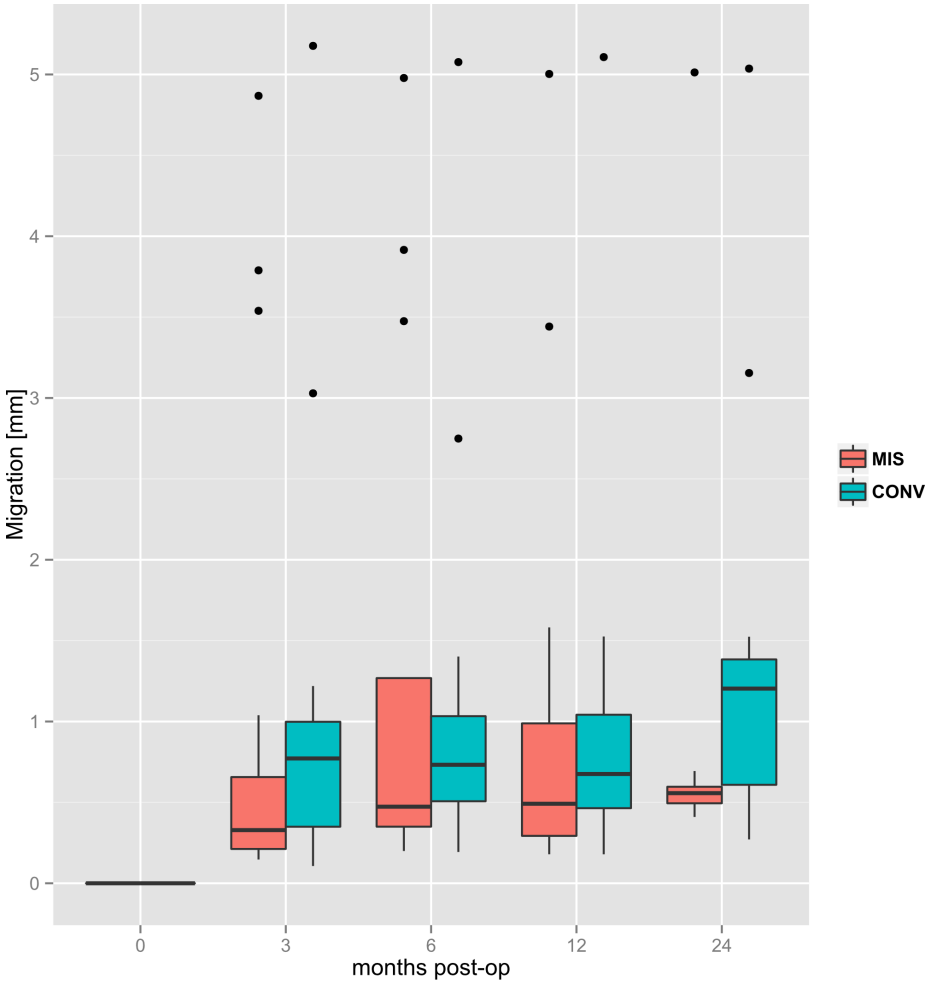


Fig.1: Resulting migration of the short-stem prosthesis over time. Minimal invasive surgery is colored in red, conventional technique in blue

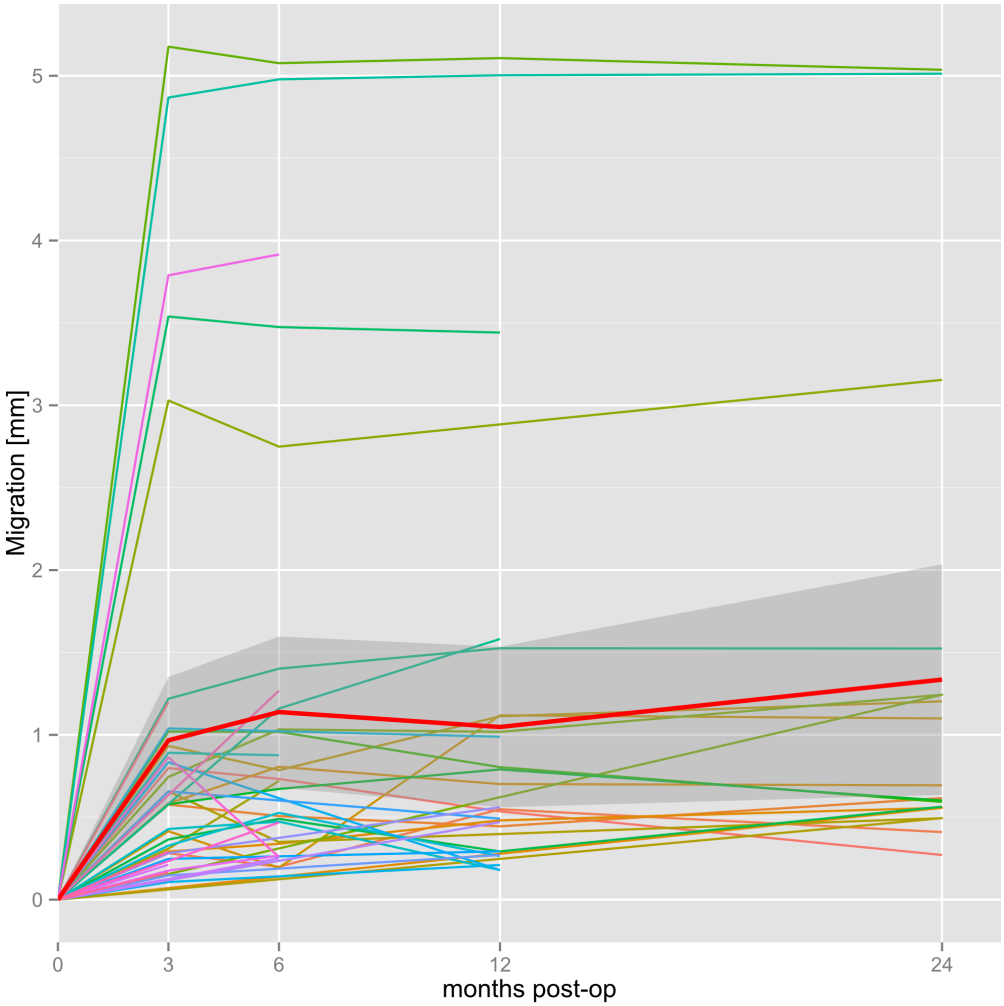


Fig.2: Resulting migration in individual patients. Mean migration is highlighted in red, the corresponding confidence intervall is shaded in grey.

No significant differences in translational migration were observed between the conventional and MI surgery at any of the follow up intervals (Fig. 1). One patient was excluded from the analysis due to possible traumatic fracture. Regardless of surgery technique, in all remaining cases with early migration above 1mm, this was observed between first and second follow-up and migration remained subsequently stable (n=7/54), thus establishing secondary stability (Fig. 2).

Discussion

The aim of this study was to determine whether the surgery technique affects the primary stability of a short-stem THA femoral component. No significant differences between the two groups could be determined. Outliers occurred in similar numbers in both groups and belonged to the group of patients with early migration. Our data did not reveal early signs of differences in implant stability when comparing MI and conventional implantation, and thus suggests that this minimally-invasive technique will not result in a higher risk of implant loosening in the long-term.

References

[1] Howell, JR; Orthop Clin North Am 35: 153-162 , 2004.
[2] Woolson, ST; J Bone Joint Surg Am 86-A(7): 1353-1358, 2004
[3] Selvik, G; Acta Orthop Scand 60 (Suppl. 232): 1-59, 1989.

Day: Thursday	Time: 13.50-14.00	Location: Grand Hotel

A new solution for cementless femoral fixation in total hip replacement: A radiostereometric analysis

Audrey Nebergall (Massachusetts General Hospital, Boston), Meridith Greene (Boston), Aljoša Matejčić (Zagreb), Ante Muljačić (Zagreb), Slobodan Tepić (Au), William Hodge (Jupiter), Henrik Malchau (Boston), Dinko Vidović (Zagreb)

INTRODUCTION: Cement techniques can result in more intense stress-shielding and higher shear loads, leading to increased micromotion of the prosthesis. Scyon Orthopaedics AG (Waedenswil, Switzerland) developed a new mode of cementless fixation of the femoral component that provides immediate anchorage by reducing micromotion and stress-shielding. The stem mimics physiological loading of the proximal femur that diminishes stress-shielding and increases long-term success rates. We aimed to evaluate the stability of the Scyon total hip replacement (THR) stem in-vivo using radiostereometric analysis (RSA).

METHODS: Fifteen patients were enrolled in this clinical study. Each patient received a Scyon THR stem, a Scyon THR press-fit fossa acetabular cup, and a 28 mm cobalt-chromium alloy femoral head. Following insertion of the Scyon THR stem, 5 monocortical locking screws were tapped through the medial cortex and locked in the stem. Tantalum beads were inserted into the pelvic bone, femur, stem and polyethylene for the purpose of RSA. RSA follow-up was obtained 4 to 6 weeks, 6 months, 1 year, and 2 years post-operatively. The Wilcoxon signed rank test was used to determine if migrations were significant over time at $p \leq 0.05$

RESULTS: All patients were followed for 6 months and 1 year, and 13 patients have 2 year follow-up. The median± standard error (SE) stem subsidence (y-translation) was 0.03±0.04 mm at 6 months, -0.07±0.07 mm at 1 year, and -0.06±0.05 mm at 2 years. The median± SE stem rotation (y-rotation) was 0.17±0.17 degrees at 6 months, -0.08±0.24 degrees at 1 year, and 0.52±0.35 degrees at 2 years. The median± SE head penetration into the polyethylene was 0.06±0.03 at 6 months, 0.14±0.04 at 1 year, and 0.22±0.03 at 3 years. The Wilcoxon signed-rank test showed that there was no statistically significant differences in migrations and rotations over time.

DISCUSSION: RSA results indicate that the Scyon stem is stable at 2 years. Immediate surgical fixation of the stem via the screws appears to inhibit early micromotion. Boney in-growth into the femoral component may ultimately decrease the rate of aseptic stem loosening and stress-shielding of the proximal femur in these THR patients. The head penetration continues to increase over time, which is likely due to creep of the material. Longer-term follow-up of this cohort is necessary to definitively determine if this stem will remain stable and eliminate the problems associated with stress-shielding.

Day: Thursday	Time: 14.00-14.10	Location: Grand Hotel

Metal-metal total hip arthroplasty in young patients stay well-fixed at 5-years follow-up

Mette Hjorth (Aarhus University Hospital, Aarhus), Kjeld Soeballe (Aarhus), Stig Jakobsen (Aarhus), Nina Lorenzen (Aarhus), Inger Mechlenburg (Aarhus), Maiken Stilling (Aarhus, Denmark)

Background: The failure mechanism of metal-metal (MoM) total hip arthroplasty has been related to metal wear-debris and pseudotumor, but it is unknown whether implant fixation is affected by metal wear-debris.

Methods: In July-August 2012 a cohort of 42 patients (11 women) at a mean age of 47 (range; 23 - 63)years with a total of 51 cementless MoM hip arthroplasties (ReCap Shell/M2a-Magnum head/Bi-Metric stem; Biomet Inc.) participated in a 5-7 year follow-up. They were followed with stereo-radiographs post-operative and at 1, 2 and 5 years. Model-Based RSA 3.32 was used for analysis. At final follow-up all patients were further examined with blood tests (chrome and cobalt serum measurements), cup and stem position and migration, Oxford Hip Score (OHS), satisfaction score and complications.

Results: 4 patients (6 hips) had elevated metal ion levels (>7ppb). Mean cup inclination of 48 degrees (sd7) for women was higher (p=0.04) than cup inclination of 44 degrees (sd5) for men. Mean cup anteversion of 17 degrees (sd7) degrees was similar for both genders (p=0.48) and mean stem anteversion of 19 degrees (sd7) degrees was similar for both genders (p=0.28).

At 5 years proximal cup migration was 0.44 mm (sd 0.31), which was similar to the 1 year (p=0.73) and 2 year (p=0.41) follow-up. Total translation (TT) for the cups (n=41 hips) was mean 1.49mm (sd 1.10) at 5 years follow-up. There was no association between cup migration and elevated metal ion levels (p=0.28), female gender (p=0.34), cup tilt above 50 degrees (p=0.18), cup anteversion above 25 degrees (p=0.20) or total OHS above 30 (p=0.18). Between 1 and 5 years migration for the cups were mean 0.19mm (sd 1.16) (p=0.29).

At 5 years follow-up the stems (n=42 hips) migrated mean TT 1.01mm (sd 0.82) There was no association between stem migration and elevated metal ion levels (p=0.61), female gender (p=0.70), stem anteversion above 25 degrees (p=0.20) or total OHS above 30 (p=0.45). Between 1 and 5 years the stems migrated 0.001mm (sd 0.93) (p=0.95). The stems up-lifted (p=0.006) 0.13mm between 1 and 5 years but version was unchanged (p=0.45).

None of the patients were revised before the final follow-up. Satisfaction was high (94%).

Conclusion: All cups and stems were well-fixed between 1 and 5 years. We found no association between implant migration and elevated metal ion levels, gender, cup and stem position, and the clinical outcome. Seemingly, metal wear-debris does not influence fixation of hip components with MoM articulation.

Day: Thursday	Time: 14.10-14.20	Location: Grand Hotel

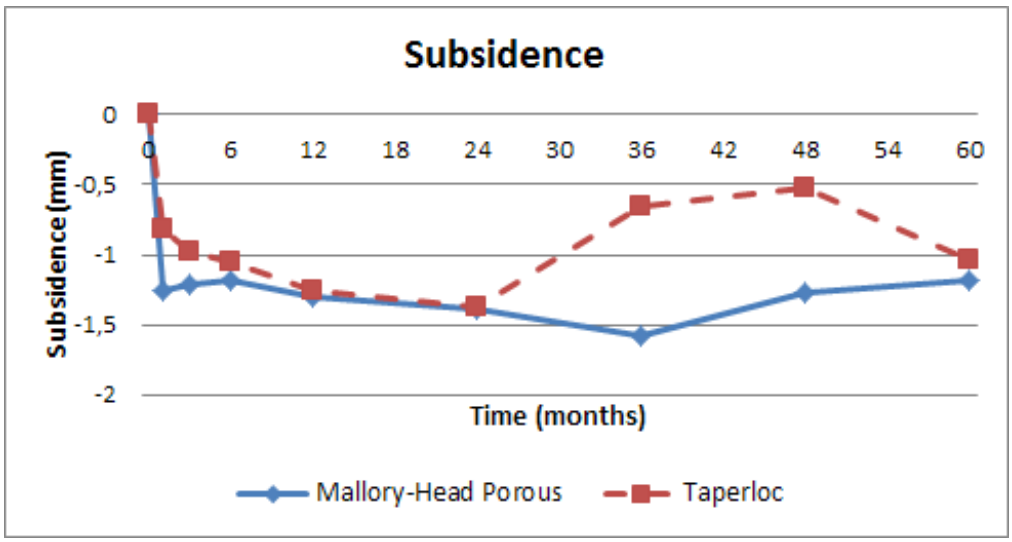
Fixation of Mallory-Head Porous and Taperloc uncemented total hip arthroplasty. Five-year follow-up of a randomized RSA-study comparing two stem designs.

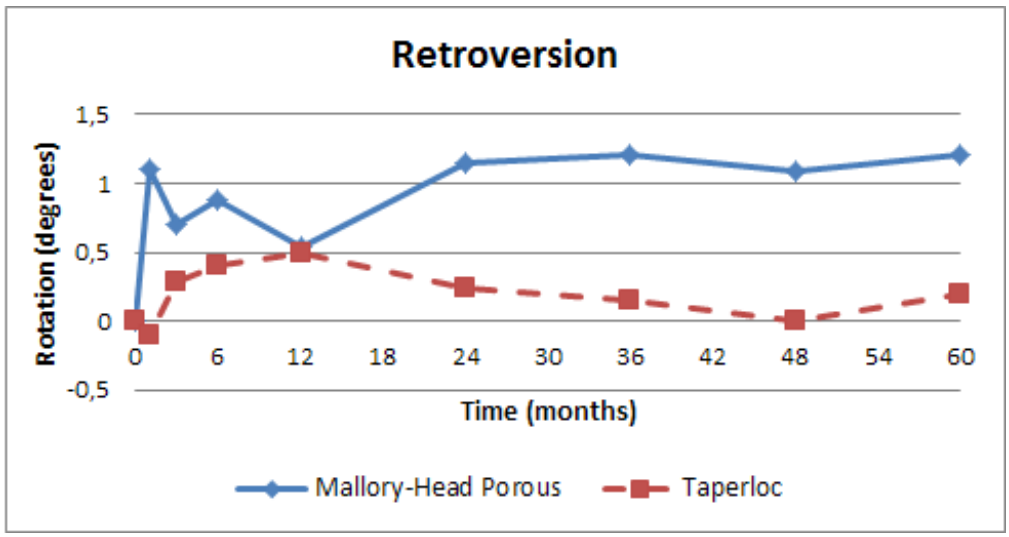
Paul van der Voort (Leiden University Medical Center, Leiden), Moniek Baltes (Leiden), Bart Kaptein (Leiden), Edward Valstar (Leiden), Rob Nelissen (Leiden) INTRODUCTION
Excellent long-term survival has been reported for both the Mallory-Head Porous and the Taperloc cementless total hip arthroplasty (THA). The Mallory-Head Porous (Biomet) hip prosthesis has a bi-planar tapered, wedged, anatomical design providing a "fit and fill" fixation. The Taperloc (Biomet) hip prosthesis on the other hand has a flat, tapered, wedged-shaped design, providing a medial and lateral wedge "fit" in the proximal femur. These two prostheses with different design rationale have proven to be safe choices for THA. However, little is known about the long-term migration behaviour of both designs. Insight into the migration behaviour of these well performing prostheses could be applied to future design of THA. To compare the migration of the cementless Mallory-Head Porous prosthesis to the cementless Taperloc prosthesis we performed a randomized, blinded roentgen stereophotogrammetric analysis (RSA) study.

PATIENTS & METHODS
Forty-two hips in 38 patients scheduled to receive uncemented THA for primary or secondary end-stage osteoarthritis were randomized to either a Taperloc or a Mallory-Head Porous THA. Primary outcome was component migration measured using RSA and secondary outcome was the Harris Hip Score (HHS). Patients were evaluated postoperatively at 6, 12, 26 and 52 weeks and annually thereafter. At 5-year follow-up, 1 patient had died and no patients were lost-to-follow-up. However, in 6 hips migration measurement was not possible due to an insufficient marker configuration.

RESULTS
One patient with a Mallory-Head Porous prosthesis developed an acute infection after 4 months of follow-up and the prosthesis was subsequently removed. At the 5-year follow-up moment the subsidence of both designs was comparable (mean difference 0.02 mm, 95% CI: -1.7-1.3). However, the Mallory Head Porous design migrated more in retroversion in comparison to the Taperloc design (mean difference 1 degree, 95% CI: 0.04-2).Both prostheses had excellent clinical results. The mean HHS at 5-year follow-up was 91 ± 12 points for the Mallory-Head Porous prosthesis and 91 ± 17 points for the Taperloc prosthesis.

CONCLUSION
The excellent long-term survival of both designs was confirmed in this study showing comparable initial migration with subsequent fixation. However the Taperloc design with a flat, wedged geometry showed better initial rotation stability.





Day: Thursday	Time: 14.20-14.30	Location: Grand Hotel

Local coordinate systems alignment for reversed engineering surface models affects model-based RSA accuracy – an experimental phantom model investigation

Frank Seehaus (Hannover Medical School, Hannover), Andreas Sukau (Hannover), Bart Kaptein (Leiden), Stefan Budde (Hannover), Henning Windhagen (Hannover), Michael Schwarze (Hannover), Christof Hurschler (Hannover)

Introduction

The accuracy of Model-based RSA (MBRSA) accuracy depends on the geometry of the implant design [Seehaus, 2009]-in particular for rotational motion about the long axis (superior-inferior-direction) of hip shaft components, accuracy was observed to be lower than for remainder axis. Attempts to improve MBRSA accuracy for this particular axis, have included elementary geometrical shape models and combined models (CM) [Prins, 2008]. Proper alignment of the superior-inferior axis of the implant surface model is crucial when classical stem surface models or stem-head CM are used. However, there is no standard technique for coordinate-system alignment.

The aim of this investigation was thus to investigate the effect of using principal moments of inertia (PMI) for the alignment of the implant coordinate-system on MBRSA migration measurements of a short stem hip arthroplasty femoral component. We hypothesized that there is a significant improvement in accuracy about the superior-inferior axis (Ry) using a PMI-optimized stem model as well as when using a CM when compared the standard technique.

Material & Methods

Implant migration was simulated using an experimental phantom model set up [Seehaus, 2009]. A short-stem femoral hip component (S&N Nanos, Tuttlingen, DE) was investigated. Image pairs were analyzed using the MBRSA software (MBRSA 3.31, Medis specials bv, Leiden, NL) of a single surface-model of the implant, utilizing three different coordinate-system alignment schemes: (A) standard coordinate-system, aligned in the direction of the stem-taper, (B) a PMI optimized stem and (C) a PMI stem-head CM.

Results

Significant improvement in ($p<.001$) migration measurement accuracy were observed about the superior-inferior axis (Ry) of the implant using a PMI- optimized stem model and a stem-head CM when compared to a non-optimized stem coordinate-system.

Discussion

Proper alignment of the surface model coordinate-system is crucial in order to obtain good accuracy. The current study indicates that MBRSA accuracy about the superior-inferior axis could be meaningfully improved by using a PMI optimized and a PMI stem-head CM method. We conclude that the MBRSA method provides sufficient accuracy and precision of migration measurement of the investigated implant. While this should hold true for implants of a similar geometry, this must still be verified.

Day: Thursday	Time: 15.40-15.50	Location: Grand Hotel

Subject-specific models of cemented hip replacements differentiate key group effects determined by RSA: a step towards robust, population-based estimates of implant performance?

Markus Heller (University of Southampton, Southampton), Junfen Shi (Southampton), Mike Strickland (Southampton), Martin Browne (Southampton), Mark Taylor (Adelaide), Gunnar Flivik (Lund)

Introduction

Radiostereometric analysis (RSA) predicts aseptic loosing of total joint replacements (TJRs), but is restricted to focussed cohorts. Computational analyses provide access to TJR mechanics also in larger populations. Combination of the methods could therefore help to better forecast implant performance in the wider patient population. To that end, the simulations' capacity for predicting clinical implant performance needs to be asserted. This study combined RSA with FE analyses to test the hypotheses that cemented stems implanted with solid centralizer exhibit more subsidence but similar movement into retroversion compared to those with hollow centralizer and further, that the FE analyses were able to detect such group effects.

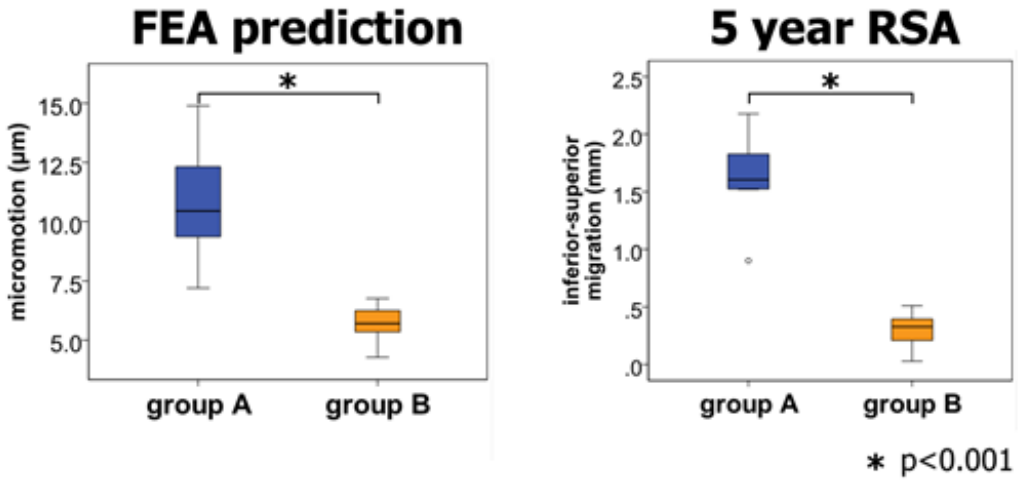
Materials and methods

The study included 17 patients implanted with a cemented stem (MS30, Zimmer) using a hollow (group A, n=10) or solid (group B) centralizer. Clinical status was documented using WOMAC and SF12 scores pre-operatively and at 12, 24 and 60 months post-op. Uni-planar RSA performed immediately post-op (baseline) and at 6, 12, 24 and 60 months post-op provided 6DOF migration/rotation. Pre-op CT-scans and post-op X-rays were used to generate patient-specific models of the THRs. THR mechanics were determined using FE analyses considering muscle and joint forces during walking and stair climbing. Outcome parameters were distal translation and longitudinal stem rotation at 6 and 60 months (RSA) and 95 th percentile values of implant-cement interface micro-motion, contact pressure and shear stress (FEA). T-tests established group differences for RSA and FEA results ($p<0.05$).

Results

All patients showed clinical improvement, exemplified in increased WOMAC ADL-function (26.9±11.7 pre-op to 79.8±20.7 at 5y follow-up). RSA showed the stems moving into retroversion (1.43°±0.97° at 5y), with no difference between groups. Group A exhibited consistently more subsidence than group B, with average differences of 0.83 and 1.33mm at 6 and 60 months post-op, respectively ($p<0.001$). Significant group differences were also found in the FEA results for micro-motion ($p<0.001$), contact pressure ($p<0.05$) and shear stress ($p<0.05$) (Figure 1).

Figure 1: Micromotion values determined from FEA of all 17 patients discriminated the THR groups (left), in agreement with the distinct subsidence patterns observed by RSA (right). Both groups received the same cemented stem (MS30, Zimmer), implanted with a hollow centralizer in group A, and a solid centralizer in group B.



Discussion

Patients exhibited good function and stems appeared well fixed at 5ys. Despite overall small values, RSA revealed a clear group difference in THR migration patterns. The FE analyses demonstrated increased micro-motion, contact pressure and shear stress in the hollow centralizer group, confirming different THR mechanics, and established reference parameters for well-functioning devices. Establishing the discriminative power of FEA is a step towards leveraging the combined predictive power of RSA and FEA for obtaining robust estimates of implant performance in the wider population.

Day: Thursday	Time: 15.50-16.00	Location: Grand Hotel

Adherence of Hip and Knee Arthroplasty Studies to RSA Standardization Guidelines

Rami Madanat (Helsinki University Central Hospital, Helsinki, Finland), Tatu Mäkinen (Helsinki University Central Hospital, Helsinki, Finland), Hannu Aro (Turku), Charles Bragdon (Massachusetts General Hospital, Boston, USA), Henrik Malchau (Massachusetts General Hospital, Boston, USA)

Introduction The guidelines for standardization of radiostereometry (RSA) of implants were published in August 2005 (Valstar et al. Acta Orthopaedica 2005;76:563-72). In this paper, an appendix of 13 main items that should be used to account for the results of a clinical RSA study to facilitate comparison between different centers was presented. Furthermore, since RSA is a highly technical method, the reliability and reproducibility of a study can only be assessed when all guideline items have been adequately addressed. The aim of this study was to evaluate how well studies have adhered to these guidelines.

Methods We carried out a literature search using OVID Medline, OVID Cochrane central register of controlled trials and SCOPUS Embase to identify all articles published between January 2007 and December 2011 that utilized RSA in the evaluation of hip or knee prosthesis micromotion. Study identification was performed according to the PRISMA statement. Only English language clinical studies with at least two follow-up time points were included. Two investigators independently evaluated each of the studies for adherence to the 13 individual guideline points. Since some of the 13 points included more than one criterion, studies were assessed on whether each point was fully met, partially met, or not met. Disagreement was resolved by consensus.

Results A total of 66 studies that met our inclusion criteria were identified. 44 (67%) studies evaluated hip and 22 (33%) studies knee arthroplasty. None of the studies fully met all 13 guidelines. Only 7 (11%) studies published after guidelines adhered at least partially to all guidelines. The highest number of guidelines fully met was 10 and this was achieved in 7 (11%) studies. The most commonly unaddressed guidelines were related to determination of precision from double examinations as well as mean error of rigid body fitting and condition number cut-off levels. Furthermore, window of tolerance, type of image acquisition and system/scanner details, type of calibration cage, whether fixed or portable x-ray tubes were used, and accuracy levels were often lacking.

Discussion There is a need for more stringent observation and adherence to RSA guidelines. Updating the guidelines and making them clearer for researchers as well as peer review purposes is crucial in ensuring that RSA continues to be the gold standard of migration and wear measurement in the future. We suggest an updated mandatory appendix of minimum requirements that must be published with all clinical RSA studies.

Day: Thursday	Time: 16.00-16.10	Location: Grand Hotel

Post-operative Assessment of Acetabular Cup Alignment Using Radiostereometric Analysis – A Retrospective Analysis

Andreas Burger (Halifax Biomedical Inc, Mabou), Scott Sporer (Mabou), Leanna MacLean (Mabou), Stephane Sogne (Mabou), Kenneth MacKenzie (Mabou), Kayla MacEachern (Mabou), Erik Giphart (Vail)

Proper placement of the acetabular component of a total hip replacement (THR) is crucial for a positive surgical outcome. Misalignment of the cup can result in impingement, increased wear and pre-mature loosening. Post-operative assessment of placement depends on choosing a reliable reference frame; one that corresponds to the pelvic reference frame used to determine placement during surgery. Plain radiographs are the most commonly used technique, but are inaccurate due to inconsistencies in patient positioning and varying pelvic tilt. Radiostereometric analysis (RSA) may have the potential to be a superior alternative for measuring cup orientation. This study investigates the repeatability of using RSA to measure cup orientation.

Two repeat post-operative and one follow-up RSA supine exam were collected retrospectively from 20 THR patients. Patients were asked to relax between double examinations, but were not re-positioned. The exams were analyzed using Model-Based RSA (MBRSA, Leiden, The Netherlands), the global cup orientations were extracted and then used in ProEngineer (PCT, Needham, MA) to compute inclination and anteversion. Cup orientation in MBRSA was determined by four analysts. Repeated-measures one-way ANOVA with post-hoc Bonferroni-corrected paired t-test were used to compare cup alignment measurements.

The means (standard deviations) of the cup orientation for all patients from post-operative exam one, post-operative exam two and follow-up exams were 50.69 (5.15)°, 50.59 (5.12)° and 48.27 (5.02)° for inclination; and 30.06 (10.12)°, 29.77 (10.38)° and 32.89 (9.42)° for anteversion. Significant differences were found between the post-operative exams and the follow-up exam ($p = 0.0018$ and 0.0019 for inclination, $p = 0.0055$ and 0.0084 for anteversion). Precision, calculated as the standard deviation of the difference in cup orientation between the repeat post-op exams, was found to be 0.47° for inclination and 0.71° for anteversion. Inter-analyst assessment demonstrated no significant differences.

Measurement of inclination and anteversion was sensitive to patient alignment with respect to the global coordinate system. As a result, the calculated precision was lower than traditional RSA applications, but may still be considered sufficient for clinical applications. Inter-analyst measurements were repeatable. RSA has the potential to develop into a more accurate tool with the development of bone matching techniques to account for pelvis orientation. RSA provides advantages in that implant migration and alignment can be calculated using a single exam at each follow-up, reducing the patient's radiation exposure and additional analysis requirements. To further validate this method, precision should be re-evaluated with patient's being re-positioned between repeat (double) post-operative examinations.

Day: Thursday	Time: 16.10-16.20	Location: Grand Hotel

Does an interspinous spacer affect the residual range of motion in two adjacent lumbar spine vertebrae – preliminary results

Michael Schwarze (Hanover Medical School, Hannover), Frank Seehaus (Hannover), Christof Hurschler (Hannover), Dorothea Daentzer (Hannover)

Introduction

Lower back pain is one of the endemic diseases of our time. In severe cases surgical intervention is indicated, whether by fusing the affected segment or implementing a disc prosthesis. Both possibilities are demanding and non-reversible interventions, including documented clinical disadvantages [1]. An less invasive alternative is the application of a interspinous spacer, which aims to preserve a certain degree of mobility in the segment while providing offloading of the disc [2]. To date, the actual degree of remaining mobility has not been investigated sufficiently accurately *in-vivo* .

Aim of this study is to investigate residual mobility of a spinal segment after stabilizing treatment with an interspinous spacer .

Method

Ten patients (mean age: 68y) were recruited, whereby the indications for an interspinous spacer were given, and all patients provided informed consent . A spacer (Wallis ®, Zimmer Spine) was implanted in the lumbar spine along with at least four Tantalum markers in each of the adjacent vertebrae. Conventional and RSA radiographs in standardized reclination and inclination (after surgery, 3, 6, 12 and 24 months post-op). Spinal segment motion was calculated using the MBRSA software (Medis specials) and functional intersegment angles were measured manually by an experienced observer.

Preliminary Results

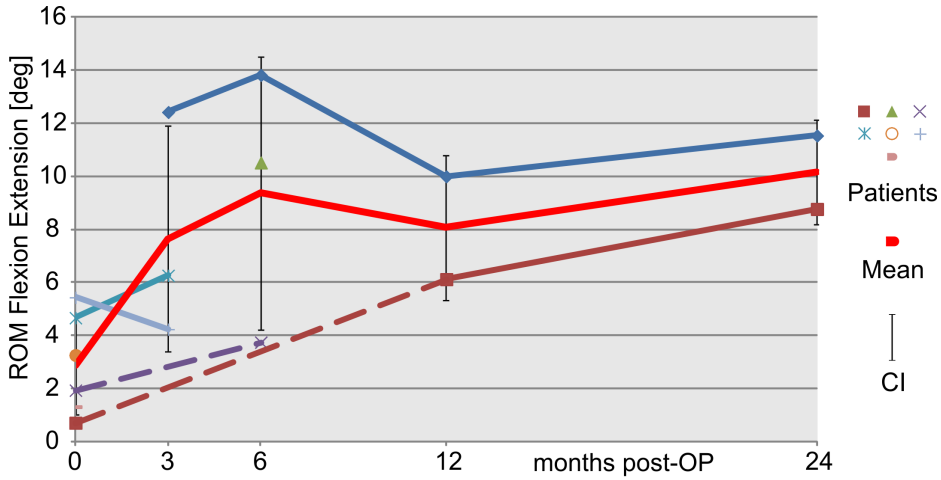


Fig.1: Range of motion (ROM) of the vertebral segment treated with a spinous spacer determined with RSA in individual patients. Loss to follow-up at 3months (n=3) and 6 months (n=1) due to insufficient image quality (n=2) and failure of patients to present (n=2) .

Mean post-operative mobility measured by RSA between the segments treated with the spacer was 2.9±1.9 deg. Mobility increased upon further follow-up in three of four cases (Fig. 1). Comparison of conventional radiograph analysis with RSA shows limited agreement in values of observed differences in intersegment motion ranging from -3.2deg to 8.7deg and a mean absolute difference of 3.4±2.4deg.

Discussion

The aim of this study was to determine the residual mobility of two adjacent vertebrae after treatment with an interspinous spacer. Treated vertebral mobility range in accordance with the expected function of the device was found, *i.e.* slightly less than physiologic. Conventionally observed mobility of the segments post-OP compared to pre-OP was reduced less than reported in the literature to date [3]. Differences between measuring techniques are within the variability of the conventional technique [4]. Although this preliminary study suggests that the investigated implant provides stability while permitting residual motion, the limited number of patients in particular at 24 months follow-up prevents us from drawing further conclusions at this time.

References

[1] Park; Spine 29: 1938-44, 2004
[2] Reith; Orthopäde 39: 580-4, 2010
[3] Sobottke; Eur Spine J (18): 1494-1503, 2009
[4] Vrtovec; Eur Spine J (18): 593-607, 2009

Day: Thursday	Time: 16.20-16.30	Location: Grand Hotel

01. Comparison of Two Humeral Head Resurfacing Implants. 1 year Results of a Randomized Controlled Clinical Trial.

Inger Mechlenburg (Aarhus University Hospital), Thomas Klebe (Regional Hospital Silkeborg), Kaj Døssing (Regional Hospital Viborg), Kjeld Søballe (Aarhus University Hospital), Maiken Stilling (Aarhus, Denmark)

Purpose
Humeral head resurfacing implants (HHRI) is used to preserve bone stock and restore normal anatomy in the osteoarthritic shoulder joint. The aim of this study was to examine implant migration and bone density changes in proximity of two different HHRIs.

Methods
29 patients (12 females) at a mean age of 63 (39-82) years and with shoulder osteoarthritis were randomly allocated to a Copeland (Biomet) (n=12) or Global Cap (Depuy) implant (n=17). 4 patients were lost before 12 months follow-up. Both prostheses were cementless and hydroxyapatite coated but had small design differences. Post-op and at 6, 12, 24 weeks and 12 and 24 months migration of the prosthesis was measured with use of radiostereometry (RSA). Until 6 months follow-up periprosthetic bone mineral density (BMD) was measured with DXA, and Constant Shoulder Score (CSS), Western Ontario Osteoarthritis of the Shoulder Index (WOOS) was recorded.

Results
Two years migration data are currently being analyzed and will be ready for presentation in May. At 1 year total translation (TT) (p=0.69) was 1.52mm (SD 1.6) for the Copeland implant (n=8) and 0.7mm (SD 0.38) for the Global Cap implant (n=12).

At 6 months BMD decreased 28% from 0.59 to 0.42 g/cm ^{2} (p= 0.01) around the Copeland implant (n=10) and 15% from 0.44 to 0.37 g/cm ^{2} (p=0.21) around the Global Cap (n=11). The differences were similar (p=0.21).

15 patients completed CSS and WOOS at 6 months. In the group with a Copeland prosthesis, CSS increased from 55 to 68 (p=0.25) and WOOS improved from 1019 to 535 (p=0.03). For the patients with a Global Cap, CSS improved from 32 to 57 (p= 0.12) and WOSS improved from 1311 to 477 (p= 0.01).

4 revisions, 2 in each group, were related to cuff-problems and pain (suspected overstuffing). Revised implants were found to have good osseointegration.

Conclusion
Early implant fixation, as judged by RSA, was good for both implants. Bone was lost in proximity of both implants. The functional gain on activities of daily living was only modest for all patients.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

02. Radiostereometric and plain radiographic analysis of glenoid and humeral component stability after total shoulder arthroplasty

Audrey Nebergall (Massachusetts General Hospital, Boston), Meridith Greene (Boston), Jonathan Streit (Cleveland), Yousef Shishani (Cleveland), JP Wanner (Cleveland), Charles Bragdon (Boston), Henrik Malchau (Boston), Reuben Gobezie (Cleveland)

Introduction

Failure of total shoulder arthroplasty (TSA) is often due to glenoid component loosening. The presence of radiolucent lines on plain radiographs and pain are the standard indications of potential component loosening. However, the significance of radiolucent lines as an indicator of loosening in TSA has not been determined. Radiostereometric Analysis (RSA) is a radiographic technique that allows for early detection of component motion. The purpose of this prospective clinical study was to monitor humeral and glenoid component stability in primary TSA patients using RSA and plain radiographs.

Methods

Twenty-nine osteoarthritic patients were enrolled into the study. All patients received a press-fit, cobalt-chrome humeral stem and a ultra-high molecular weight polyethylene cemented glenoid component. For monitoring component stability using RSA, up to 8 tantalum beads, 0.8mm in diameter were implanted into the non-articulalar edge of the glenoid component and up to 11 beads, 1mm in diameter, were implanted into the bone of the humerus and glenoid and coracoid processes of the scapula. RSA and plain radiographs were obtained at six months, one year and two years after surgery. The Wilcoxon signed ranks test was used to determine whether migrations were significant over time at $p \leq 0.05$.

Results

17 shoulders were followed at 1 year and 14 at 2 and 3 years. The median± standard error translation of the glenoid component was 0.05±0.06 at 1 year, 0.14±0.07 at 2 years and -0.07±0.09 at 3 years. The median± standard error rotation of the glenoid component was -0.30±0.12 at 1 year, -0.52±0.23 at 2 years and -0.52±0.32 at 3 years. The median± standard error subsidence of the humeral component was -0.03±0.06 at 1 year, -0.04±0.14 at 2 years and -0.05±0.23 at 3 years. The Wilcoxon signed ranks test showed there was no significant difference in migration of either component over time. At 2 years, radiolucencies were detected around the glenoid component in 8 patients and around the humeral component in 4 patients.

Discussion

The RSA data at 3 years demonstrates stable humeral and glenoid components after an initial period of settling. The glenoid component appears to be stable, though small amounts of linear and rotational motion are still evident in the medial/lateral and varus/valgus directions at that time. Longer term follow-up of this cohort will be necessary to determine if the small motion detected in this study represents continued settling or the early stages of component loosening.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

03. Measuring Micromotion of a Pyrocarbon Shoulder Resurfacing Hemiarthroplasty. An experimental study using marker-free radiostereometry.

Kristofer Hallberg (Stockholm), Björn Salomonsson (Stockholm), André Stark (Stockholm), Olof Sköldenberg (Stockholm)

Introduction

Pyrocarbon is a material that is used in hemiarthroplasties involving smaller joints, especially in the hand and elbow (1) . In several studies it has been shown to minimize erosion of the remaining cartilage on the opposing joint surface. Pyrocarbon is semi-radiolucent on plain radiographs and in anticipation of a clinical trial involving a new humeral head resurfacing implant we validated a previously used method for marker-free radiostereometry (RSA) (2) .

Material and methods

Six geometrically identical hemispherical resurfacing prostheses of different sizes (3 x pyrocarbon [PyroTITAN™ HRA] and 3 x CrCo [TITAN ™ both Ascension Orthopaedics, USA]] were marked with tantalum beads and mounted in a sawbone. Standard and marker-free radiostereometry (UmRSA 6.0 computer software, biplanar calibration cage 10, RSA Biomedical AB, Sweden) was then done repeatedly with gradual shifts of position of each prosthesis between each analysis. A marker-free algorithm developed for metal-backed acetabular cups (3) was then compared to standard RSA to determine the accuracy and precision (Figure 1). We defined the precision as ≤ 1.96 SD of the difference between double examinations. We defined the accuracy as ≤ 1.96 RMS ("root mean square", a measure of the magnitude of varying quantity) as the difference in migration of two positions measured with both standard and marker-free RSA.

Results

We found no difference between the accuracy and precision for pyrocarbon and CrCo implants. The accuracy for marker-free radiostereometry ranged between 0.23 - 0.36 mm for translations, 0.11 - 0.69 degrees for rotations and 0.62 for maximum total point motion (MTPM). The precision (reproducibility) was between 0.05 - 0.19 mm for translations, 0.08-0.21 degrees for rotations and 0.27 mm for MTPM.

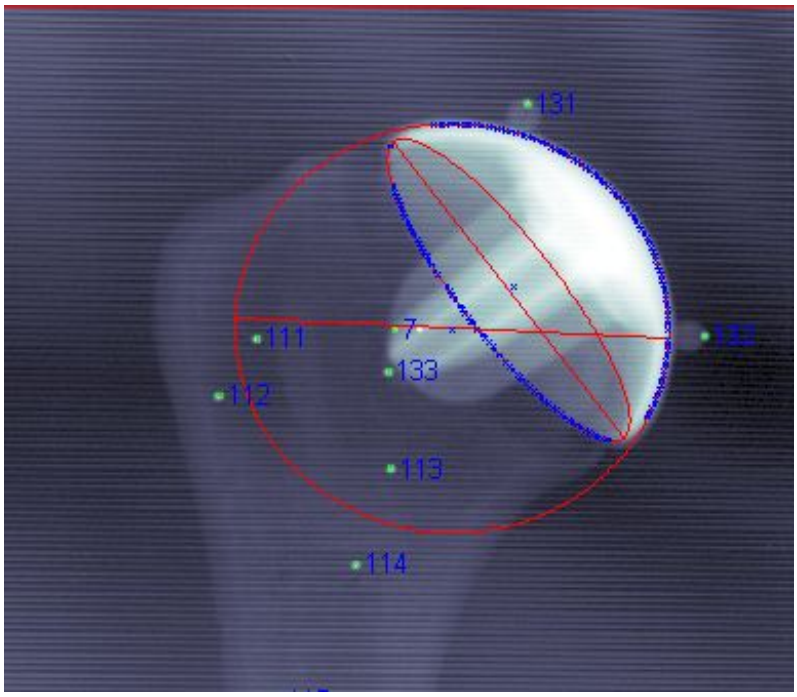
Discussion

Based on our results, marker-free radiostereometry can be used to measure migration of a semi-radiolucent pyrocarbon humeral head resurfacing prostheses. We plan to use this method in future RSA clinical trials on implant fixation and glenoid erosion.

1. Ricon FJ, Sanchez P, Lajara F, Galan A, Lozano JA, Guerado E. Result of a pyrocarbon prosthesis after comminuted and unreconstructable radial head fractures. J Shoulder Elbow Surg. 2012;21(1):82-91. Epub 2011/05/03.

2. Sköldenberg O, Ödquist M. Measurement of migration of a humeral head resurfacing prosthesis using radiostereometry without implant marking: an experimental study. Acta Orthop. 2011;82(2):193-7. Epub 2011/03/25.

3. Borlin N, Rohrl SM, Bragdon CR. RSA wear measurements with or without markers in total hip arthroplasty. J Biomech. 2006;39(9):1641-50. Epub 2005/07/02.



Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

04. The effect of Refobacin and Palacos bone cement on fixation of total hip arthroplasty. Two-year follow-up of a randomized RSA-Study of a form-enclosed stem.

Paul van der Voort (Leiden University Medical Center, Leiden), Danny van Delft (Leiden), Huub van der Heide (Leiden), Bart Kaptein (Leiden), Edward Valstar (Leiden), Rob Nelissen (Leiden)

INTRODUCTION

The mechanical properties of acrylic bone cement influence the long-term survival in cemented total hip arthroplasty (THA). The Boneloc disaster showed that even slight changes in the chemical constitution of cement can have tremendous clinical impact. Therefore, we feel that introduction of a new bone cement with renewed composition should be accompanied by a clinical roentgen stereophotogrammetric analysis (RSA) study.
Palacos bone cement (Heraeus Medical) is a well-established cement that provides excellent clinical results. The more recently introduced Refobacin bone cement (Biomet) contains the same ingredients as Palacos bone cement, however in different proportions.
In this randomized, blinded RSA study we compared Palacos R + gentamycine with Refobacin R + gentamycine bone cement in patients eligible for total hip arthroplasty.

PATIENTS & METHODS

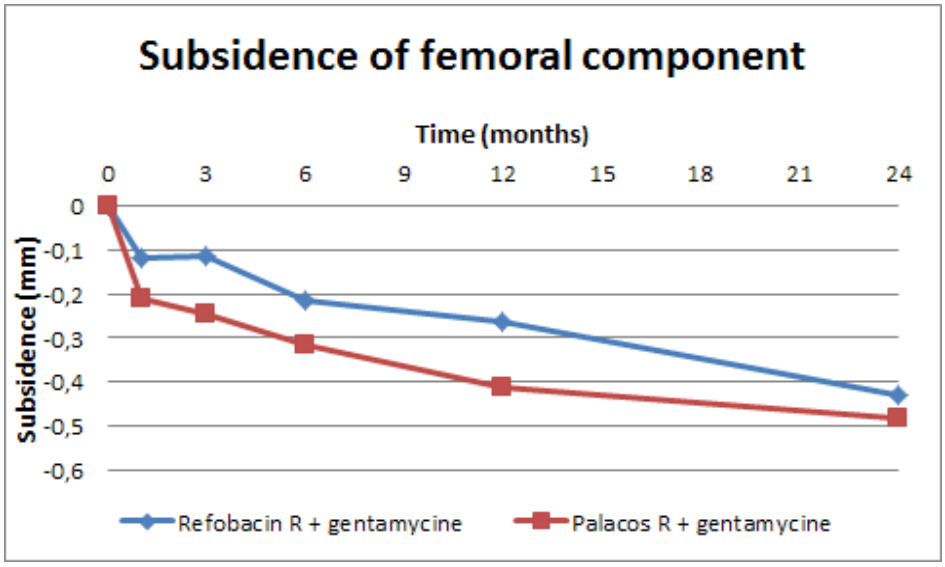
Sixty-two consecutive cemented THAs in 59 patients were randomized into a Palacos cement group and a Refobacin cement group. All patients received a Stanmore THA (Biomet) using third generation cementing technique. Primary outcome was component migration measured using RSA and secondary outcome was the Harris Hip Score (HHS). Twelve hips with an insufficient marker configuration on the first RSA examination were excluded. Three patients died and 1 patient was lost-to-follow-up as a result of a cerebral infarction. This left 44 stems suitable for migration measurement at 2-year follow-up.

RESULTS

At the 2-year follow-up moment no statistical difference existed between the two cement groups, for neither translation nor rotation migration data. The mean subsidence of the stem at 2-year follow-up was 0.5 ± 0.73 mm for Palacos bone cement and 0.4 ± 0.41 for Refobacin bone cement. Both cement groups showed excellent clinical results. The mean HHS at 2-year follow-up was 82 ± 23 points for Palacos bone cement and 82 ± 17 points for Refobacin bone cement.

CONCLUSION

Refobacin bone cement showed similar migration at two-year follow-up as the well-established Palacos bone cement. Based on these results, Refobacin is expected to have similar (excellent) long-term survival as Palacos bone cement.



Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

05. Five-year radiostereometric analysis of the Exeter femoral stem and the X3 acetabular liner

Trevor Gascoyne (Concordia Joint Replacement Group, Winnipeg), Martin Petrak (Winnipeg), Thomas Turgeon (Winnipeg), Eric Bohm (Winnipeg)

The primary goal of this study was to determine if the addition of tobramycin to Simplex P (Stryker) bone cement increases femoral stem subsidence, thereby increasing the risk of long-term aseptic loosening. The secondary goal of this study was to examine the in vivo wear rate of the Trident X3 (Styker) cross-linked polyethylene acetabular liner.

Twenty-six of the 32 patients initially enrolled in this study were followed beyond five years. Sixteen patients received tobramycin-laden Simplex T bone cement and ten patients received ordinary Simplex P. The Exeter (Stryker) femoral stem with pre-attached radiostereometric (RSA) markers was used throughout the study. Tantalum markers were inserted into the femoral bone in all patients. Supine RSA examinations were obtained at six weeks, six months, one, two, three, and >five years post-operatively. The acetabular liner initially used in this study was the Trident (Stryker) gamma-in-inert gas sterilized conventional polyethylene (CPE) bearing. Partway through the study, a switch was made to the Trident X3 (Stryker) cross-linked polyethylene (XLPE) liner. Twenty-one patients with five-year follow-up received 36 mm articulations, of which five received the CPE liner and 16 received the XLPE liner. Polyethylene wear was measured as the linear penetration of the femoral head into the acetabular shell. T-tests with a significance level of 0.05 were used for statistical comparisons.

No significant difference was found between the tobramycin-laden Simplex T and ordinary Simplex P groups ($p=0.28$) at an average of 5.8 years post-operatively. The CPE acetabular liners showed significantly greater total ($p<0.001$) and superior ($p<0.001$) penetration than the X3 liners at an average follow-up of 6.6 and 5.4 years (respectively). The average superior penetration rate of the CPE and XLPE liners was 0.051 mm/yr and 0.006 mm/yr, whereas the average total penetration rate was 0.072 mm/yr and 0.036 mm/yr (respectively).

At mid-term follow-up, there appears to be no difference in stem subsidence between the cement groups which suggests that use of tobramycin-laden bone cement does not increase the risk of long-term implant loosening. Patients with the CPE liners showed significantly greater wear than those with the XLPE liner. The Trident X3 liner shows extremely low wear of 0.036 mm per year with no reported cases of liner fracture. The power of this study is limited as we were only able to compare small patient groups due to loss of follow-up. Also, implantation of the CPE and XLPE liners was not randomized, potentially introducing selection bias.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

06. Design modifications of the uncemented Furlong hip prosthesis results in insignificant early subsidence but does not affect further stability.

Erik Weber (Lund), Martin Sundberg (Lund), Gunnar Flivik (Lund) The aim of this study was to evaluate the migration pattern of the classic, well proven cementless Furlong HAC stem compared to the modified Furlong Active stem in a randomized, controlled trial over two years using radiostereometric analysis (RSA). The Furlong Active stem has several new design features compared to the Furlong HAC stem. The collar has been removed along with the lateral fin; it is shorter and has more rounded edges both laterally and medially in the proximal part of the prosthesis. Proximally the Active stem is double tapered whereas the Furlong HAC is parallel sided in the coronal plane. 50 patients with primary osteoarthritis were randomized to receive either the HAC stem or the Active stem. The patients underwent RSA examinations and conventional x-ray examinations immediately post-operatively, and at 3, 12, 24 and 60 months. The collarless Active stem subsided to a greater extent (mean 0.99 mm, CI 0.35 to 1.64) compared to the collar-fitted HAC stem(mean 0.31 mm, CI 0.13 to 0.50), within the first three months (p=0.046). There was, however, no difference in retroversion or any of the other RSA measured motions between the two stems. After three months, both stem types had stabilized and no further migration was seen. In conclusion the Active stem shows no signs of unfavourable migration patterns up to 5 years of follow-up and the results suggest that the osseointegration is not compromised by the new design features. In fact, it has a similar early migration pattern compared to other commonly used, well documented, uncemented, collarless prostheses.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

07. RSA Evaluation of Vitamin E Doped Highly Cross-linked Polyethylene and Acetabular and Femoral Component Stability

Audrey Nebergall (Massachusetts General Hospital, Boston), Meridith Greene (Boston), Nanna Sillesen (Boston), Harry Rubash (Boston), Young-Min Kwon (Boston), Charles Bragdon (Boston), Henrik Malchau (Boston)

INTRODUCTION: *In vitro* research shows that vitamin E doping of highly cross-linked polyethylene (VEPE) has improved wear performance, retention of mechanical properties, and high resistance to oxidation. An acetabular shell with a porous titanium surface for bone ingrowth fixation was also developed. The purpose of this study was to evaluate femoral head penetration into VEPE and implant stability using Radiostereometric Analysis (RSA).

METHODS: 57 patients (61 hips) participated in a 5 year RSA study. Tantalum beads were placed in the pelvis, femur, and VEPE liner. Each patient received a VEPE liner, a porous titanium coated cup, and a stem with a 32mm head. RSA radiographs were scheduled postoperatively (PO), at 6 months, 1, 2, 3, and 5 years. Wilcoxon signed-rank nonparametric tests determined if changes in penetration or migration were significant over time at $p \leq 0.05$.

RESULTS: 48 hips were followed at 1 year, 40 at 2 years, and 27 at 3 years. The median± standard error head penetration was 0.03±0.02mm at 1 year, 0.04±0.01mm at 2 years, and 0.05±0.01mm at 3 years, there were statistically significant differences between 6 months and 3 years (p=0.021), 1 and 2 years (p=0.026) and 2 and 3 years (p=0.008). The acetabular components median migration was 0.12±0.03mm at 1 year, 0.08±0.04mm at 2 years, and 0.04±0.05mm at 3 years, with no significant differences. The median femoral stem distal migration was 0.10±0.20mm at 1 year, 0.06±0.09mm at 2 years, and 0.01±0.36mm at 3 years; there were statistically significant differences between 1 and 3 years (p=0.01) and 2 and 3 years (p=0.01).

DISCUSSION: Early femoral head penetration in VEPE liners is low. This penetration is likely due to creep of the material, which is low compared to non- vitamin E doped polyethylene measured by similar techniques. We are not concerned about the significant differences in the amount of wear over time, as it is still considerably lower than previous generation polyethylene. In other RSA studies, similar trends were seen between years 5 and 7, but disappeared at 10 years. After initial settling, all acetabular components were stable regardless of the presence of lucencies. While most stems were stable, the high standard error at 3 years results from one stem that migrated substantially by 6 months, which remained stable at 1 and 3 years. This is the longest term documentation of *in vivo* wear performance of VEPE. The early stability of cups and femoral components is promising.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

09. A novel method for clinical wear measurement in radio opaque acetabular components.

Dov Goldvasser (MGH, Boston), Anders Troelsen (Copenhagen), Meridith Greene (Boston), Charles Bragdon (Boston), David Ayers (Worcester), Henrik Malchau (Boston)

Abstract : As the use of tantalum acetabular cups becomes more prevalent, it is more important to develop methods to measure polyethylene wear when radio-opaque acetabular cups are used.

Introduction: Radiostereometric analysis (RSA) is the gold standard for assessment of wear in polyethylene liners in total hip replacement (THR). When polyethylene liners are used in conjunction with tantalum cups, conventional RSA analysis is not possible. We propose a novel method for wear analysis for this type of radio-dense acetabular shell. The purpose of this study was to validate this new methodology using RSA images from a randomized RSA study where tantalum and titanium acetabular components were used.

Methods: The study cohort consisted of 43 THR patients. Patients were randomized to receive either titanium or tantalum acetabular cup with a conventional or a highly cross-linked polyethylene liner. Femoral head penetration was assessed by standard RSA (titanium cups) and the novel method (titanium and tantalum cups). The novel "fictive head" method can estimate the center of the femoral head by using the two proximal tantalum beads on the femoral stem and information of the stem/head configuration. We assessed the accuracy and variation of the novel method, and its ability to estimate femoral head penetration.

Results: Femoral head penetration in titanium acetabular cups by the "fictive head" method demonstrated wear results comparable to that of standard RSA in both conventional and highly cross-linked PE liners (see table). The 95% limits of agreement were -0.220 mm to 0.242 mm.

Time Postoperatively (number of patients)	Mean Penetration in mm (standard deviation)	
	Standard RSA	Novel method
6 months (n=10)	0.085 (0.066)	0.039 (0.089)
1 year (n=11)	0.169 (0.074)	0.106 (0.146)
2 year (n=10)	0.241 (0.071)	0.200 (0.135)
3 year (n=5)	0.328 (0.122)	0.327 (0.138)
4 year (n=8)	0.362 (0.148)	0.426 (0.225)
5 year (n=7)	0.363 (0.137)	0.385 (0.214)

Discussion: The novel "fictive head" method offers accurate assessment and can be a viable solution for assessment of femoral head penetration in prospective studies on conventional and highly cross-linked PE liners, in which the implantation of tantalum cups would otherwise make wear assessment impossible.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

10. A radiostereometric study comparing wear measured by markers in the polyethylene with markers in the periacetabular bone

Einar Lindalen (Lovisenberg Deaconal Hospital, Oslo), Lars Nordsletten (Oslo), Stephan Röhrl (Oslo)

Background:
Radiostereometric analysis (RSA) is documented to be both precise and accurate to measure the polyethylene wear after total hip replacements. Traditionally the point motion of the head center in relation to a segment of at least 3 tantalum markers in the polyethylene has been used to estimate the wear. Increasing head sizes and new cup materials may diminish visibility of markers. This may lead to study drop-outs because of too few markers in the reference segment to perform RSA. Markers in the periacetabular bone are easier to detect making this segment more predictable. The aim of the study was to compare wear using tantalum markers in the cup, the periacetabular bone and a calculated wear estimation including cup migration.

Methods:
31 patients from a randomized trial had tantalum markers in the polyethylene and in the peri-acetabular bone. We could therefore measure the wear according to both methods and also calculate the cup migration. We used a uniplanar radiostereometric technique. The Wilcoxon signed rank test for related samples was used to test for differences between the methods. P-values below 0.05 were interpreted as being significant.

Results:
Proximal wear was 0.34 mm (95% CI: 0.29-0.38) when we used the polyethylene as the reference segment and 0.52 mm (95% CI: 0.38-0.65) using the periacetabular bone as reference segment. Wear was therefore overestimated by 53 % when using the periacetabular bone as reference segment. Mean cup migration in the y-axis was 0.14 mm (95% CI: 0.02-0.26). The mean total 3D migration of the cup was 0.36 mm (95% CI: 0.23-0.50). Subtracting the individual vertical migration of the cup in each case we estimated the wear to be 0.38 mm (95% CI: 0.31-0.44 and P = 0.021 compared to wear with markers in the polyethylene). Therefore, correcting for the vertical movement of the cup, wear was still overestimated but only by 0.04 mm. The cup migration seemed to influence the wear calculations leading to an overestimation of the wear when markers in the periacetabular bone were used as a reference segment.

Interpretation:
Wear measured with periacatebular bone markers are influenced by cup migration leading to an overestimation of the wear measurements. Wear measurements using markers in the peri-acetabular bone are therefore not reliable and should not be used as the reference segment.

The current study has been published in: Clinical Biomechanics 27 (2012) 511-514

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

11. Early implant migration and subjective outcomes of shape match versus conventional computer navigated total knee arthroplasty in a Canadian centre.

Elise Laende (Dalhousie University & QEII Health Sciences Centre, Halifax, Nova Scotia), Glen Richardson (Halifax, Nova Scotia), Michael Biddulph (Halifax, Nova Scotia), Allan Hennigar (Halifax, Nova Scotia), Michael Dunbar (Halifax, Nova Scotia)

Purpose Surgical techniques for implant alignment in total knee arthroplasty is a burgeoning field as many manufacturers introduce patient-specific cutting blocks derived from 3D reconstructions of pre-operative imaging, commonly MRI or CT. The OtisMed system uses a detailed MRI scan of the knee for 3D reconstruction plus a full leg scan to estimate the kinematic axis, dictating the cutting planes in the custom-fit cutting blocks that are machined for each patient. The resulting planned alignment can vary greatly from a neutral mechanical axis. The purpose of this study was to evaluate the early fixation of components in subjects randomized to receive shape match derived kinematic alignment or conventional alignment using computer navigation.

Methods Forty-two patients were randomized to receive a cruciate retaining cemented total knee replacement (Triathalon, Stryker) using computer navigation aiming for nuetral mechanical axis (standard of care) or custom cutting blocks (OtisMed custom-fit blocks, Stryker). Pre-operatively, all subjects had MRI scans for custom cutting block construction to maintain blinding. RSA exams and health outcome questionnaires were performed post-operatively at follow-ups 6 week, 3 month, and 6 month follow-ups.

Results Five MRI scans for surgical planning were not useable due to motion artifacts. Of these, 2 rescans were successful, 1 subject chose to not undergo a rescan, and 2 subjects had unsuccessful rescans. The OtisMed-planned overall alignments ranged from 4 degrees valgus to 9 degrees varus. Ligament releases were performed in 62% of navigation cases and 32% of OtisMed cases. One OtisMed case was revised for failure of the cruciate ligament, resulting in a polyethylene liner exchange for a thicker, cruciate substituting insert. Implant migration at 6 months was 0.28±0.13 mm for the OtisMed group and 0.25±0.17 mm for the navigation group (maximum total point motions; 95% confidence interval from double exams = 0.14 mm). EQ-5D scores, Oxford Knee scores, satisfaction, pain, and range of motion were not different between groups at any follow-up to 6 months, including the polyethylene liner exchange case.

Conclusions

Implant migration was not different between groups at 6 months despite differences in planned implant alignment. Subject function and satisfaction were also not different between groups, despite significantly fewer ligament releases in the OtisMed group. It should also be acknowledged that this method may not be possible for all patients due to the MRI scanning requirements. Continued evaluation with RSA to 2 years will be performed to monitor these subjects over the longer term.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

12. Implant migration of computer navigated unicondylar knee replacements to one year

Elise Laende (Dalhousie University & QEII Health Sciences Centre, Halifax, Nova Scotia), Michael Dunbar (Halifax, Nova Scotia), Glen Richardson (Halifax, Nova Scotia)

Purpose

Unicondylar knee replacement remains a controversial procedure with the potential to offer appropriate patients a less invasive procedure than total knee replacements (TKR), but with a relatively high number of revisions compared to TKR. It can be argued that the surgery is technically more variable, lending itself well to computer navigated surgery to guide the bony cuts. The objective of this study was to evaluate the fixation of the tibial and femoral components of unicondylar knee replacements performed with computer navigation.

Methods

Twelve subjects were recruited who had elected to undergo unicondylar knee repalcement. All subjects received the cemented Partial Knee Replacement (PKR) Implant (Stryker, Mahwa NJ) inserted by a single surgeon using computer navigation. During surgery, eight tantalum markers, one millimetre in diameter, were inserted into the proximal tibia and distal femur. Using a calibration box, stereo RSA radiographs were taken post-operatively and with follow-ups at 6 weeks, 3, 6, and 12 months. Health status and functional outcome measures were recorded to quantify functional status of subjects before surgery and at each follow-up interval.

Results

Maximum total point motion (MTMP) migrations were 0.55±0.40 mm at 6 months and 0.72±0.61 mm at 12 months for the tibial component, and 0.35±0.22 mm at 6 months and 0.36±0.22 mm at 12 months for the femoral component. One subject was revised after 6 months for pain. At 6 months her migrations were 0.38 mm (tibial component) and 0.29 mm (femoral component) indicating that implant loosening was not a factor. The clinical precision of the MTPM metric from double exams of all patients was 0.78 mm for the tibial component and 0.25 mm for the femoral component (95% confidence intervals), showing the influence of the component geometries on the precision of model-based RSA.

The Oxford Knee Score improved from 38±6 pre-operatively to 19±5 at 12 months (score from best to worst is 12 - 60) and the subjects' satisfaction with their knee improved from 26±21 pre-operatively to 85±20 at 12 months (score from best to worst is 100-0).

Conclusions

Very few studies have previously examined the fixation of unicondylar knee replacements despite the wide range of success with these implants. The data to date from our centre suggests good implant fixation is achieved early, even in individuals who are unsatisfied with the procedure. The subjects in this study will be followed to 2 years to determine if early migrations remain consistent.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

13. All-poly vs metal-backed unicompartmental knee arthroplasty. Preliminary results of a prospectic randomized clinical and RSA study

Paolo Barbadoro (Resident Doctor, Bologna), Andrea Ensini (Bologna), Alberto Leardini (Bologna), Claudio Belvedere (Bologna), Francesco Cenni (Bologna), Michele D'Amato (Bologna), Francesca Fusai (Bologna), Sandro Giannini (Bologna)

Introduction

U nicompartmental knee arthroplasty (UKA) has showed good clinical results, but less satisfactory revision rates than total knee arthroplasty. Proper indications and a correct surgical technique are the key factors to achieve a successful UKA implantation. However, aseptic loosening of the tibial component represents one of the main UKA revision causes, especially in all-polyethylene designs. This can be accurately investigated by using RadioStereometric Analysis (RSA).

We want therefore to investigate in UKA about the claimed superiority in terms of tibial component fixation and clinical outcomes of the metal-backed with respect to all-polyethylene tibial component designs.

Methods

The present prospective study was designed for 40 patients undergoing UKA surgery. The patients were randomized in 2 groups: 20 were implanted with an all-polyethylene (group A) and 20 with metal-backed (group B) tibial components; both groups had the same femoral component (UNI-Journey, S&N).

Clinical and RSA evaluations at 3, 6, 12 and 24 months were performed . Particularly, relevant translations and rotations along and about the medio-lateral, longitudinal and antero-posterior axes, and maximum total point motion (MTPM) of the tibial component were calculated. So far, only 12 patients were analyzed, i.e. 6 metal-backed and 6 all-poly, at 6 months follow-up.

Results

On average, IKS -Knee and -Function clinical scores at 6-months follow-up were 84±6 and 92±13 in the group A, and 89±8 and 97±5 in the group B , respectively. The maximum absolute mean value of the tibial component translation and rotation in group A occurred along the medio-lateral axis (0.09±0.07 mm) and about antero-posterior axis (0.5±0.5 degrees), whereas in group B along and about antero-posterior axes (0.19±0.20 mm and 0.8±0.8 degrees). The MTPM was 0.28±0.13 and 0.49±0.30 mm in group A and B , respectively. Neither clinical nor migration significant differences were found between groups.

In one patient (group B), migration as large as 0.5 mm posterior translation, 2.5° internal and 2.2° varus rotations, and 1.0 mm MTPM was observed at 6 months follow-up.

Discussion

Our preliminary results show similar performances of the two groups analyzed in terms of clinical scores and tibial component mobilization . In one metal-backed UKA , a large migration was

found . T he limited number of patients and the early follow-up do not enable yet to draw definitive conclusions, but the modern all-polyethylene tibial components in UKA do not appear to be inferior to the metal-backed one according to a similar previous RSA analysis.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

14. Initial migration in uncemented Monoblock and Modular trabecular metal total knee replacements.

Elise Laende (Dalhousie University & QEII Health Sciences Centre, Halifax, Nova Scotia), Allan Hennigar (Halifax, Nova Scotia), Glen Richardson (Halifax, Nova Scotia), David Amirault (Halifax, Nova Scotia), Gerald Reardon (Halifax, Nova Scotia), Michael Dunbar (Halifax, Nova Scotia)

The trabecular metal Monoblock TKR is comprised of a porous tantalum base plate with the polyethelyne liner embedded directly in the porous metal. An alternative design, the trabecular metal Modular TKR, allows polyethylene liner insertion into the locking base plate after base plate implantation, but this removes the low modulus of elasticity that was inherent in the Monoblock design. The purpose of this study was to compare the fixation of the Monoblock and Modular trabeucular metal base plates in a randomized controlled trial.

Methods

Thirty-one subjects were randomly assigned to receive the uncemented trabecular metal Monoblock or uncemented trabecular metal Modular knee replacement (Zimmer, Warsaw IN). A standard procedure of tantalum marker insertion in the proximal tibial and polyethylene liner was followed with uniplanar RSA examinations immediately post-operatively and at 6 week, 3 month, and 6 month follow-ups.

Results

The clinical precision of the maximum total point motion (MTPM) values was 0.13 mm (95% confidence interval of double exams). Twenty-one subjects had RSA results at 6 months (14 Monoblock). Implant migration at 6 months had a median value of 0.65 mm (range 0.35 - 2.75 mm) for the Monoblock group and a median value of 0.90 mm (range 0.09 - 2.90 mm) for the Modular group (MTPM). A previous study of the Monoblock trabecular metal implant had identified two subgroups of high and low migration (MTPM above and below 1 mm respectively). The current study contains 4 subjects in the Monoblock group with migration above 1mm MTPM and 3 in the Modular group.

Conclusions

Initial migration of the Monoblock and Modular trabecular metal tibial base plates is in keeping with the results of a previous study of the Monoblock implant and is not different between groups. These groups will be followed for 2 years to determine if the pattern of migration stabilizes. It remains to be seen if the novel behavior of the Monoblock implant (high initial migration but stable longer term fixation) translates to the Modular implant design with its stiffer base plate.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

15. Two year migration results of hydroxyapatite-coated uncemented tibial components in a multi-center RSA study.

Elise Laende (Dalhousie University & QEII Health Sciences Centre, Halifax, Nova Scotia), Glen Richardson (Halifax, Nova Scotia), Allan Hennigar (Halifax, Nova Scotia), Dermot Collopy (Perth, Australia), Michael Dunbar (Halifax, Nova Scotia)

Purpose

Uncemented total knee replacements have been purported to provide better long-term fixation in younger patients. Surface coatings on tibial components are often employed with the aim to enhance fixation, but require *in vivo* testing for evaluation. This multi-center study uses RSA to evaluate the fixation of uncemented tibial components with an hydroxyapatite surface coating.

Methods

Thirty-one patients were recruited in a consecutive sample survey of patients undergoing total knee arthroplasty in Halifax, Canada (n=16) and Perth, Australia (n=15) using the same inclusion/exclusion criteria and receiving the same uncemented implants with the same surgical approach. Calibrated stereo RSA radiographs were taken post-operatively and again at six weeks and three, six, 12 and 24 months following surgery. Health status and functional outcome measures were recorded before surgery and at each follow-up interval.

Results

The patients recruited at the two centers were of the same age (66±6.2 years) and weight (88±15 kg), but differed in height (Halifax: 168±9.2 cm, Perth: 178±8.3 cm; p value = 0.004), BMI (Halifax: 31±4.7 kg/ m^2 , Perth: 27±2.9 kg/m^2 ; p value = 0.005), and tibial component size (Halifax: mean size 4, Perth: mean size 6). The Oxford Knee functional score differed for the two centers pre-operatively (Halifax: 41±7.7, Perth: 31±7.6; p value = 0.003).

The migration results, calculated as maximum total point motion (MTPM), were at 1 year 1.21±1.02mm for Halifax and 0.46±0.12 mm for Perth and at 2 years 1.32±1.22 for Halifax and 0.52±0.12 mm for Perth. The migration between 1 and 2 years were 0.30±0.13 for Halifax and 0.26±0.13 for Perth (p value 0.096). The clinical precision of the MTPM metric from double exams of all patients was 0.18 mm (95% confidence interval).

The MTPM migration data were examined for the influence of age, sex, BMI, and tibial component size. Tibial component size was found to be the only variable with a trend towards different migration patterns, independent of the mass of the subject.

Conclusions

While the magnitudes of implant migration were different between locations, both Halifax and Perth subjects showed stabilization between 1 and 2 years, with no significant difference. The trend for smaller tibial components to have higher migration, independent of subject mass, requires further investigation. Multi-center recruitment is valuable for obtaining a diverse patient population and ensuring the success of an implant design across a more representative global group.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

16. Validation of the in vivo volumetric wear measurement for total knee prostheses in model-based RSA

Emiel van IJsseldijk (Leiden), Benoit Lebel (Division), Berend Stoel (Leiden), Edward Valstar (Leiden), Solene Gouzy (Valence), Claude Vielpeau (Caen), Bart Kaptein (Leiden)

Implant failure related to polyethylene wear remains an important issue in total knee arthroplasty. Polyethylene wear is usually assessed by measuring the remaining insert thickness on X-ray images of the knee. To reflect the amount of wear debris more accurately, a 3-dimensional overlap measurement has been suggested, which is based on implant component models that are matched on calibrated stereo X-ray images using model based roentgen stereogrammatic analysis. The goal of this study was to determine the influence of pose estimation errors, insert thickness deviation and variation in the femoral contact location on the accuracy and precision of the measurement using simulations and a phantom experiment.

In the simulation experiments we found that the pose estimation was the largest source of variation. The 95% prediction interval varied between 111 to 283 mm ^{3}, which is approximately 100% to 200% of the detected volumetric wear. Insert thickness variation resulted in prediction intervals of 74 to 174 mm ^{3}. In the phantom experiment the detection rates were determined for an insert with a true wear pool of 230mm ^{3} based on 15 RSA images acquired at different flexion angles (0°, 30° and 60°). Large differences in the detected wear volume were found for different flexion angles. At most 56% of the true wear volume was detected (129 of 230mm ^{3}, 30° of flexion). The prediction interval due to femoral contact location was 40mm ^{3}.

In summary, both the accuracy and precision of the volumetric wear measurement were low. The prediction interval of the volumetric wear measurement is at least as large as the measurement outcome itself. This is an important limitation to the applicability of the volumetric wear measurement in clinical practice and further clinical validation is required.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

17. From fixation to kinematics: 25 years of experience at Rizzoli Orthopaedic Institute from static to dynamic

Danilo Bruni (Rizzoli Orthopaedic Institute, Bologna), Laura Bragonzoni (Bologna), Marco Bontempi (Bologna), Silvio Patella (Bologna), Michele Gagliardi (Bologna), Maurilio Marcacci (Bologna)

The Rizzoli Orthopaedic Institute has been involved in RSA since 1998.
During last 25 years, several investigations have been carried on to evaluate both implant fixation and poliethylene deformation in unicompartmental and total knee replacements.
RSA evaluation has demonstrated that in a particular TKR implant, with mobile half-bearings, the threshold for loosening was 1.3° for rotation about the longitudinal axis and 0.5 mm for medio-lateral translation. Moreover, RSA has revealed cold flow to be concentrated in the posterior region of the medial half-bearing. This has lead to further improvement in polyethilene and implant design.
RSA has also demonstrated that in all-poly tibial UKR, poliwear does not impair tibial component fixation and that deformation of the all-poly tibial component is strictly correlated to implant loosening. Moreover, RSA has been used to investigate stress-inducible displacement of the tibial component in all-poly UKRs. It has been demonstrated that rotations around the transverse axis of the knee joint are the most common form of stress-inducible displacement, while stress-induced translations are negligible. Moreover, stress-inducible translational displacement has reached significantly higher values for those patients with unexplained painful UKR, despite no sign of loosening on conventional radiographic and standard supine RSA evaluations.

Further application of RSA has focused on the kinematic evaluation of poliethilene motion pattern modifications throughout a 3 years follow-up period after a mobile-bearing TKR. Patients have been investigated in weight-bearing conditions and results demonstrated that longitudinal rotations and medio-lateral translations tended to increase at last follow-up, while sagittal translations dod not show any significant modification over time.

At present, a new device has been installed at the Istituto Ortopedico Rizzoli. It was specifically designed and made for RSA, static and fluoroscopic. This device can work both in mono- and bi-planar configuration as required by the RSA protocols. Moreover it is able to acquire image stacks in order to study the in-vivo and real time kinematics of a joint. he theoretical biomechanical resolution of a static RSA followup tests is 0.2mm for translation and 0.3° for rotation. In fluoroscopic configuration the theoretical resolution is 1mm for translation and 1° for rotations, depending on the used frame rate and on the joint movement speed. A kinematic comparison of different prosthetic designs is currently ongoing, to evaluate different motion patterns under dynamic weight-bearing conditions and to compare them with passive kinematics acquired intra-operatively using a navigation system.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

18. Knee prosthesis and roentgen stereophotogrammetric analysis: Outcomes and correlations at minimum 12 years follow up

Laura Bragonzoni (Rizzoli Orthopaedic Institute , Bologna), Danilo Bruni (Bologna), Silvio Patella (Bologna), Marco Bontempi (Bologna), Michele Gagliardi (Bologna), Ibrahim Akkawi (Bologna), Maurilio Marcacci (Bologna)

Over the last years research has focused on attempts to achieve better fixation in knee prosthesis by improving cementing techniques and prosthetic designs; thus prosthetic fixation is critical while loosening at the bone-cement interface is still an important matter for the orthopaedic surgeon.

In the present study, we evaluated in vivo displacement of both total and unicompartimental knee prosthesis implanted on 73 patients by collecting data from roentgen stereophotogrammetric analysis associated to the conventional X-rays and clinical follow-ups; we were able to reach only 18 patients (2 males and 16 females) for the actual follow up because of death or other diseases occurred on the other patients over the years (mean age at the time of surgery 68, range 27-83).

Micromotion of the prosthetic components and its correlation with the clinical outcome, also in terms of loosening prediction factors, has been assessed at mean 13 years follow-up (range 12-16 years).

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19. Conventional RSA: Accuracy and Application

Xunhua Yuan (University of Western Ontario, London, Ontario),

Recent clinical RSA studies require more and more high accurate detection which comes up to the limitation of RSA technique itself. This requirement demands flawless performance of RSA. Understanding each steps of RSA procedures and its function would help to meet this demand, further would assist in the development of new RSA approaches.

Conventional RSA technique is a revise simulation of clinical X-ray examination towards the subject with tantalum markers implanted while the examination is properly calibrated. The simulation involves landmark measurement, 3D landmark reconstruction based on stereo-photogrammetric technique, and motion calculation followed by classical rigid body theory. All these steps contribute and control the overall final RSA accuracy.

X-ray image is different with optical photo at that it records the number of photon passing through the object while optical photo is a hard copy of the object, like the shadow of an object. The number of photon passing through the object is proportional to the passing length; therefore, the image intensity of a spherical tantalum marker has point symmetric feature with orientation independent in 3D space. These special features enable the detection of marker center at sub-pixel level and the detection would not affected by the surrounding background intensity. These are fundamental advantages for using spherical tantalum marker which would produce high accuracy measurement, and for distinguishing conventional RSA from the other edge detection approaches.

Besides the measurement, the accuracies of 3D landmark reconstruction and motion calculation could be estimated by either analytical or numerical solutions in advance. These estimations are specifically important when designing a new RSA study.

Although high accuracy could be retained in most clinical RSA application, some challenges were existed, such as false knee cage placement, hip examination in standing position for over-weight subject, under/over dose exposure, lack of marker number due to view blocked, and non-standard RSA setting etc. Special approaches should be applied to these situations in order to salvage the application, but the accuracy of these application would be sacrificed, in most cases it would be lower than the normal situation.

The future of clinical RSA will be enormous by the benefit of the development of medical imaging technology. From RSA methodology point of view, real time RSA system with cassette based DR imaging detectors would be the optimal system for static analysis, while dynamic RSA using digital flat panel imaging modality would expend RSA application to the real dynamic environments.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

20. The potential role of RSA in understanding the pathology of pelvic ring disruptions

Stuart Callary (University of Adelaide, Adelaide, Australia), Lucian Solomon (Adelaide), Anthony Pohl (Adelaide)

Introduction

The in vivo stability of the pelvic ring after fracture stabilisation remains unknown. Plain radiographs have a low accuracy in diagnosing loss of fracture reduction over time. RSA has been previously shown to be an accurate technique to examine the healing of other fractures. This pilot study investigated the potential role of RSA in pelvic trauma.

Methods

This study included five patients with a similar type C pelvic ring disruption who were all operated on using the same surgical technique and had RSA markers inserted at the time of surgery. All five patients had a unilateral comminuted sacral fracture lateral to the sacral foramina, treated with posterior plating, and pubic rami fractures stabilised by external fixation for six weeks. All patients were mobilised partial weight bearing after regaining leg control. RSA examinations at 2, 4, 12 and 26 weeks included three radiographic pairs taken in supine, standing and supine positions. Two additional exams were performed the day prior and post pin removal at 6 weeks.

Results

At latest follow-up, there were no complications. All patients ambulated before the 2 week follow-up and progressed uneventfully with no loss of reduction identifiable on plain radiographs over time. Minimal displacements (translations less than 0.3mm and rotations less than 0.5°) were recorded between the supine exams pre and post standing at 2 weeks. Hence, the supine examination was found to be a reliable position to measure the migration of the sacrum over time. The movement recorded under standing load was elastic at each time point. At 26 weeks, in contrast to plain radiographic results, RSA measurements revealed that one patient had a fracture migration greater than 4mm. Comparative RSA examinations pre and post external fixator removal demonstrated movement greater than 2mm in three patients.

Conclusion

RSA allows identification of displacements of pelvic fractures which are difficult, if not impossible, to identify and quantify with any other imaging techniques. As a consequence, RSA has the capacity to promote a better understanding of pelvic ring injuries and importantly, to optimise the treatment of these injuries.

Day: Thursday	Time: 16.30-17.30	Location: Grand Hotel

Strain and forces in arthrodiastasis

Harald Steen (Oslo University Hospital, Oslo), Ragnhild Gunderson (Oslo), Leif Pål Kristiansen (Oslo), Joachim Horn (Oslo), Per Ludvigsen (Oslo)

In the present study we wanted to measure forces, strain and amount of reduced load across the ankle joint during the arthrodiatasis procedure. By use of radiostereometry (RSA) the change in height of the joint space associated with this surgical method could be measured. With integrated force transducers mounted in the external frame across the ankle and implanted tantalum spheres in the bone on each side of the joint, the frame's distraction force and load-share, and the relative intersegmental movement and change in joint gap size were measured. Examinations were performed in 7 patients directly postoperatively, with 3 weeks increments until the external fixator was removed after 3 months, and at later follow-ups. External distraction of 5-13 (median 8.8) mm resulted in an expanded median joint space of 4.1 (range 3.1-5.5) mm during treatment. High tension forces (maximum 439 N) developed in the frame which unloaded the joint by 50% or more in all tested patients. During weight bearing (median 51% of body weight) the joint gap was reduced with less than 1 mm in all patients except for one (1.2 mm). Postoperatively after 1.2 (1.0-2.8) years the change in distance between tibia and talus compared to the preoperative condition showed a median increase of 0.7 (-2.3-2.1) mm which is interpreted as a corresponding change in the height of the articular cartilage. Our measurements indicate that a frame with standard configuration is efficient in unloading the joint and that the tension in general can be reduced. A diastasis of about 2-3 millimeters joint space is sufficient to unload the joint and avoid contact between the articular surfaces during weight bearing.

Day: Friday	Time: 08.30-08.40	Location: Grand Hotel

RSA of the Immediate Anatomical Changes Following Medial Opening Wedge HTO

Matthew Teeter (London Health Sciences Centre, London), Kristyn Leitch (London), Xunhua Yuan (London), Trevor Birmingham (London), Robert Giffin (London)

Introduction: High tibial osteotomy (HTO) is an established surgical treatment for osteoarthritis of the medial compartment of the knee. Medial opening wedge HTO relies on adequate fixation of the osteotomy site during bony healing. The objective of this study was to evaluate the immediate anatomical changes that occur during the first six weeks following a medial opening wedge HTO.

Methods: Ten patients were recruited for the study under an IRB approved protocol. The patients included nine males and one female, with a mean age of 49.0 ± 5.5 years and mean BMI of 28.4 ± 3.8 kg/m2. The patients underwent HTO using an opening wedge osteotomy system and a nonlocking plate. Cancellous allograft bone was used in osteotomies >7.5 mm. To enable RSA examination, marker beads were inserted into bone sites before the osteotomy was performed, in the tibia both proximal to the opening wedge, and distal to the opening wedge, as well as in the femur and patella. RSA exams were first obtained immediately prior to the osteotomy, and subsequently at one, two, four, and six weeks post-operatively. Two patients were also available for examination at seven years post-operatively.

Results: All patients demonstrated 6 to 14 degrees of valgus rotation pre- to post-osteotomy about the anterior-posterior axis, consistent with an opening wedge. Eight of the ten patients demonstrated 2 to 5 degrees of internal rotation about the vertical axis pre- to post-osteotomy, with the other two patients demonstrating 0.5 to 2 degrees of external rotation. Translations in the tibia in all planes were stable post-osteotomy, with sub-millimeter displacement between two weeks and six weeks for all patients, and at seven years for the two patients with long-term follow-up. All patients demonstrated immediate distal translation of the patella by 2 to 4 mm relative to the femur, followed by proximal translation of the patella over the six weeks, partially or completely returning to its original pre-osteotomy location.

Discussion: The magnitude and direction of the initial rotations and translations pre- to post-osteotomy varied depending upon the surgeon-determined correction goal for the HTO. In some patients, up to an additional degree of rotation was seen at the second week, either further increasing the post-osteotomy changes or returning towards the pre-osteotomy state. All patients stabilized rotations after two weeks, and also maintained consistent translational stability after two weeks, with sub-degree and sub-millimeter changes up to six weeks post-osteotomy.

Day: Friday	Time: 08.40-08.50	Location: Grand Hotel

A Randomized controlled Radiostereometric study comparing a novel porous titanium construct to a porous coated surface in cementless total knee arthroplasty

Nikolaj Winther (Hillerød, Denmark), Claus Lindkær Jensen (Copenhagen), Thomas Lind (Hillerød), Claus Munk Jensen (Gentofte), Henrik Schrøder (Copenhagen), Gunnar Flivik (Lund), Michael Mørk Petersen (Copenhagen)

Aseptic loosening of the tibial component in total knee arthroplasty (TKA) remains a leading cause of revision surgery, and newer techniques are currently developed to meet the patientsÂ´ demands for increased durability of the implants.Regenerex is a novel porous titanium construct. It has biomechanical characteristics (e.g. compressive strength and elastic modulus) very close to that of normal trabecular bone. It is believed that these characteristics will facilitate bone ingrowth and secure a better fixation to the host bone, thus increasing the implant survival.

OBJECTIVES: In a prospective randomised study a novel porous titanium construct used for total knee arthroplasty (TKA) is evaluated. It is compared to a porous coated surface. Both tibial component coatings are designed to provide excellent conditions for bone ingrowth.

METHODS: 60 patients scheduled for a TKA were included in the study and block randomized to receive a posterior cruciate ligament retaining, modular tibial component coated with a new porous titanium construct (Regenerex) or a porous coated component(Vanguard) .The measurements of migration were performed according to standard RSA protocol guidelines (cut-off levels: conditions number of 150 and mean error of 0.350) using 6.0 UmRSA software (RSA Biomedical, UmeÃ¥) at SkÃ¥ne University Hospital , Lund , Sweden .

RESULTS: Knee and function scores as well as the WOMAC score improved significantly from preoperatively to 1 year follow-up. Two patients were lost to follow-up. The remaining 58 patient were accessible for analyses. Both types of tibial components displayed almost all the migration within the initial 3 months. Average MTPM in the porous titanium construct coated group between 6 and 12 month was 0.15mm (0.09-0.70) with a total migration of 1.64mm (0.3-4.49) versus in the in porous coated group it was 0.16mm (0.03-0.98) and total migration 1.41mm (0.2-4.43).No statistically significant differences between MTPM or any of the other parameters (segment motion) between the two groups were found.

CONCLUSION: Both groups showed stable migration pattern with low migration rates from 3 month to 12 month. We found no differences between the tibial component coated with the new porous titanium construct and the porous coated component regarding rotation or translatation about X-,Y- and, Z-axes. There was a tendency towards a slight higher migration within the first 3 month in the Regenerex group compared to the porous group and a tendency towards less total migration between 3 month and 12 month in the Regenerex group. The dominating modes of migration in both groups were subsidence and posterior tilt.

Day: Friday	Time: 08.50-09.00	Location: Grand Hotel

Screws do not enhance fixation. A randomized controlled trial of uncemented tibial base plates with or without screw fixation measured by RSA.

Elise Laende (Dalhousie University & QEII Health Sciences Centre, Halifax, Nova Scotia), Allan Hennigar (Halifax, Nova Scotia), David Amirault (Halifax, Nova Scotia), Gerald Reardon (Halifax, Nova Scotia), Michael Dunbar (Halifax, Nova Scotia)

Purpose

The option of screw fixation for the uncemented BioFoam total knee tibial components is available to surgeons, but it is unclear if this augmentation is necessary to achieve stable fixation. The foam metal backed tibial components utilize a porous titanium coating on the underside of the tibial baseplate, intended to promote bone in-growth and provide a more robust bone-implant interface without cement. The addition of up to four titanium screws is also possible. The purpose of this study was to employ radiostereometric analysis (RSA) to compare implant migration in a randomized controlled trial of this implant design with or without screw fixation over two years.

Methods

Fifty-one patients were randomized to receive an Advance BioFoam total knee replacement (Wright Medical) with or without screw fixation. During surgery, eight tantalum markers, one millimetre in diameter, were inserted into the proximal tibia and five into the polyethylene liner. RSA radiographs were taken post-operatively and at six weeks and three, six, 12 and 24 months following surgery using dual x-ray heads and a uniplanar calibration box. Health status and functional outcome measures were recorded to quantify functional status of subjects before surgery and at each follow-up interval.

Results

The migration results, calculated as maximum total point motion (MTPM) were 0.75 mm median (range 0.28-3.54 mm) at 1 year and 0.75 mm median (range 0.28-3.47 mm) at 2 years for screw fixation and 0.95 mm median (range 0.19-5.33 mm) at 1 year and 0.87 mm median (range 0.20-5.08 mm) at 2 years without screw fixation. The change in migration from 1 to 2 years was not significantly different between groups (median MTPM values of 0.19 mm and 0.17 mm for screw fixation and without screw fixation respectively, p value = 0.364). The clinical precision of the MTPM metric is 0.36 mm (95% confidence interval) from double exams of all patients.

Conclusions

The migration results at two years indicate that although the group without screw fixation had a tendency to greater overall motion, both groups achieve stable fixation with minimal increase in MTPM between 1 and 2 years. Although higher than the migration seen with cemented tibial components, the amount of migration is comparable to other uncemented designs. The addition of screw fixation was not found to be necessary to achieve stable fixation.

Day: Friday	Time: 09.00-09.10	Location: Grand Hotel

CR and PS monoblock Trabecular Metal tibial components vs cemented NexGen implants in TKA. A 5-year RSA study

Kjell G Nilsson (Umeå University, Umeå), Anders Henricson (Falun)

Introduction: This is a study comparing the quality of fixation of uncemented cruciate retaining (CR) and posterior stabilized (PS) monoblock trabecular metal tibial (TMT) components with conventional cemented modular tibial components in NexGen total knee arthroplasty during 5 years using RSA.

Material: 26 knees were operated with CR TMT, 49 knees were operated with PS TMT and 21 knees were operated with cemented CR NexGen Tibia by 2 surgeons. All patients had primary OA or OA secondary to trauma such as ACL rupture or meniscal tear. All patients were followed clinically and with RSA for 5 years postoperatively.

Results: Compared to cemented implants the TMT implants migrated significantly more during the initial 6 weeks to 3 months. Thereafter the all TMT implants stabilized up to 5 years. Most of this initial migration occurred within the first 6 weeks (or perhaps even earlier, however no RSA radiographs were done between postop. and 6 weeks). Somewhat surprisingly, the PS TMT implants displayed slightly smaller migration than the CR TMT implants. When omitting the initial 3 months migration in all groups and comparing the migration between 3 months and 5 years no significant differences could be found between on the one hand the CR and PS TMT implants and, on the other hand the cemented implants.

Discussion: The RSA literature shows, that all uncemented implants display initial early migration, i.e. settles. If this occurs early and if the implant then stabilizes a good long-term prognosis as regards fixation can be anticipated, as is evident from this study. It seems as if this early migration is due to initial settling and analogue to the "bedding in" which is found in analysis of polyethylene wear. If one excludes this initial settling period and calculate the migration from 3 months and onwards one can see that the TMT implants migrates as little as the cemented implants. Somewhat surprisingly did the PS implants display slightly smaller migration than the CR TMT implants. One would have assumed that the inherent larger conformity of the PS implants would have led to larger forces to the interface and hence a larger migration.

Day: Friday	Time: 09.10-09.20	Location: Grand Hotel

Fixation of high-flexion Total Knee Arthroplasty - 5-year follow-up results of a 4-arm randomized controlled clinical and Roentgen Stereophotogrammetric Analysis (RSA) Study

Marc Nieuwenhuijse (Leiden University Medical Center, Leiden, The Netherlands), Paul van der Voort (Leiden), Bart Kaptein (Leiden), Henrica van der Linden - van der Zwaag (Leiden), Edward Valstar (Leiden), Rob Nelissen (Leiden)

Background. High-flexion Total Knee Arthroplasty (TKA) was introduced to meet demands of increased flexion. However, concerns have been raised regarding the fixation of high-flexion TKA designs and increased rates of loosening have been reported. Thus far, migration, and thus fixation, of high-flexion TKAs has not been analyzed and the preferential bearing type (mobile or fixed) in this respect is unknown.

Methods. Seventy-eight of 86 consecutive knees scheduled for TKA were randomized to one of four NexGen Legacy Posterior Stabilized (LPS) TKA designs: 1) LPS-Flex mobile, 2) LPS-Flex fixed, 3) LPS mobile and 4) LPS fixed. Primary outcome was component migration measured using roentgen stereophotogrammetric analysis, secondary outcomes were postoperative flexion, extension and Knee Society Score (KSS). Patients were evaluated postoperatively at 6, 12, 26 and 52 weeks and annually thereafter. At 5-year follow-up, 8 patients had died and 2 patients were lost-to-follow-up. Seventy-seven tibial and 42 femoral components were suitable for migration measurements.

Results. Overall 5-year migration of the 77 tibial components was not significantly different between the 4 TKA designs (p =0.373) and migration was comparable at the 2 and 5-year follow-up moments (p =0.565 and p =0.604). Migration stabilized in all but three components (2 LPS-Flex mobile, 1 LPS fixed); one of these components has already been revised and was confirmed to be (aseptically) loose. Overall 5-year migration of the 42 femoral components was comparable between the 4 designs (p =0.949) and similar at 2 and 5 years postoperatively (p =0.971 and p =0.443). One femoral component migrated excessively (LPS-Flex mobile). In patients who had I) mean postoperative flexion >125 â or II) maximum flexion >135 â during the 1 to 5 year follow-up period, migration of high-flexion components was comparable to conventional components (p >0.05) and indicative of appropriate fixation. Postoperative flexion, extension, KSS and KSS-function were comparable during the 5-year follow-up period and at the 2 and 5-year follow-up moments (p >0.05).

Conclusion. The LPS-Flex TKA with either a mobile or fixed bearing has comparable migration to its conventional counterpart and is expected to have similar (excellent) long-term survival. This high-flexion TKA may safely be used in patients expected to benefit from a high-flexion potential.

Day: Friday	Time: 09.20-09.30	Location: Grand Hotel

Bone Cement with Initial Slow-Curing Increases Stability of Tibial Trays in TKR

Maiken Stilling (Aarhus University Hospital, Aarhus, Denmark), Frank Madsen (Aarhus), Claus Fink Jepsen (Aarhus), Kjeld Søballe (Aarhus), Anders Odgaard (Aarhus)

Background
Viscosity of Refobacin Plus Bone Cement (RP) is slightly reduced during the initial working-phase, as compared with Refobacin Bone Cement R (RR), which may reduce porosity of the cement during vacuum mixing and enhance durability and life-time of cemented prostheses.

Purpose
to compare fixation of tibial trays fixed with two different curing bone cements.

Methods
54 patients (21 men) at a mean age of 67 years (range 44-83) with knee osteoarthritis (but no osteoporosis) were operated with the Vanguard® Complete Knee System (Biomet Inc) and were randomly allocated to implant fixation with either RP or RR. Both cements contained gentamycin and were mixed with the closed Optipac® mixing system. At 3 and 6 months, 1 and 2 years we e valuated implant migration, periprostheric bone mineral density (BMD) in 3 regions, and clinical outcomes (AKSS and OKS).

Results
At 2 years follow-up Maximum Total Point Motion was lower (p=0.04) for tibial trays fixed with RP (0.76 mm, SD 0.65, n=27) compared to fixation with RR (0.97 mm, SD 0.51, n=27). The periprosthetic BMD loss up to 2 years was similar between the groups in 3 regions and in total on AP (p>0.70) and LA DXA scans (p>0.30). The bone loss was 3.5% (SD 13%) medial to the stem, 2% (SD 9%) lateral to the stem, 4% (SD 19%) anterior to the stem, 7% (SD 19%) posterior to the stem and 2% (SD 6%) below the stem. Mean knee-score (88, SD 10), function-score (84, SD 13), OKS (39, SD 5) and improvement (pre-op to 2 years) was similar (p>0.18). Mean flexion was 117° (range 85-145). Satisfaction was high.

Conclusion
Fixation of tibial trays inserted with the initial slow-curing Refobacin Plus Bone Cement is superior to fixation with standard-curing Refobacin Bone Cement R at 2 years follow-up. Loss of periprosthetic BMD was small and functional results were good.

Day: Friday	Time: 09.30-09.40	Location: Grand Hotel

Measurement of Migration of a Focal Knee Resurfacing Implant Using Radiostereometry. An experimental study.

Olof Sköldenberg (Danderyds sjukhus, Ortopeden, Stockholm), Leif Ryd (Stockholm)

Introduction

Articular resurfacing metal implants have been developed to treat full thickness localized articular cartilage defects (1) . Standard radiostereometry (RSA) of prosthetic migration requires that tantalum beads are inserted into the implant but because of itÂ´s size this is not possible for articular resurfacing components. In this study we therefore modified the tip of an articular knee implant and used it as a marker for RSA and validated the method.

Material and methods

The manufacturer of a articular resurfacing prostheses (Episurf Medical AB, Sweden) modified the tip of an implant into a 3 mm hemisphere (Figure 1). We also marked the implant with 3 tantalum beads (2 diametrically opposite under the hat and one on top of the distal hemisphere) and mounted it into a sawbone. 8 tantalum beads were inserted into the sawbone in order to provide a reference segment. Point motion RSA of the "hemisphere bead" using standard automated RSA (UmRSA 6.0 computer software, biplanar calibration cage 10, RSA Biomedical AB, Sweden) as gold standard was compared to the tip hemisphere where raw coordinates were measured manually and fed into the RSA soft-ware. 6 repeated stereograms with gradual shifts of position of the specimen between each double exposure were used for the analysis. The tip motion was compared to the point motion of the hemisphere bead to determine the accuracy and precision.

Results

The accuracy for point motion RSA of the hemisphere was 0.11-0.34 mm for translations. The precision (reproducibility) was 0.09-0.21 for translations.

Interpretation

The accuracy and precision for translations is acceptable when using a 3 mm hemisphere at the tip of an articular knee resurfacing implant instead of tantalum marker beads. Rotations of the implant can, of course, not be evaluated. The method is accurate and precise enough to detect relevant migration and will be used for future clinical trials of the new implant.

1. Manda K, L, Eriksson A. Finite element simulations of a focal knee Ryd resurfacing implant applied to localized cartilage defects in a sheep model. J Biomech. 2011;44(5):794-801. Epub 2011/02/09.

Day: Friday	Time: 09.40-09.50	Location: Grand Hotel

The Oxford® Cementless Partial Knee Tibial Trays Subside Initially but Stabilize at 6 Months: A Randomized Clinical RSA Study

Maiken Stilling (Aarhus University Hospital, Aarhus, Denmark), Frank Madsen (Aarhus), Claus Fink Jepsen (Aarhus), Lone Rømer (Aarhus), Kjeld Søballe (Aarhus), Per Wagner Kristensen (Aarhus), Anders Odgaard (Aarhus)

Background
The meniscal bearing Oxford® Cementless Partial Knee Replacement for anteromedial osteoarthritis was introduced to r educe the incidence of radiolucent lines observed on screened radiographs under cemented Tibial Trays.

Purpose
To compare implant fixation of cementless and cemented Oxford® Partial Knee Tibial Trays up to 1 years follow-up.

Methods
79 patients (48 men) were randomly allocated to surgery with cementless hydroxyapatite-coated or cemented Oxford® Partial Knee Tibial Trays (Biomet Inc) at 2 hospital sites. Femoral components were either single-pegged or double-pegged in the cemented group and double-pegged in the cementless group. Refobacin bone cement (Biomet Inc) was used. E valuation of implant migration, radiolucent lines (RLL), and clinical outcomes (AKSS and OKS) was performed at 6 weeks, 3 and 6 months, and 1 year.

Results
The cementless Tibial Trays (n=25) migrated more than the cemented Tibial Trays (n=55) at all follow-ups ($p<0.01$). Significant segment motion of the cementless Tibial Trays occurred mainly in the first 6 weeks with subsidence of 0.3mm (SD 0.06mm), posterior tilt of 0.61° (SD 0.55°) and medial tilt of 0.77° (SD 0.84°), however migration stabilized between 6 months and 1 year. Between 6 months and 1 year 20% of cemented Tibial Trays while 0% of cementless Tibial Trays ($p=0.02$) migrated more than 0.2mm (total translation). Analysis of radiolucent lines is ongoing. At 1 year clinical scores was similar between groups ($p>0.17$) with similar improvement ($p>0.40$). Satisfaction was high.

Conclusion
The cementless Oxford® Partial Knee Tibial Tray migrate initially but stabilize at 6 months probably because of achieved bony anchorage. Cementless fixation is even better than cemented fixation between 6 months and 1 year. At 1 year functional results were similar between the groups.

Day: Friday	Time: 09.50-10.00	Location: Grand Hotel

No difference in implant migration and clinical outcome between cemented versus press-fit placed stems in revision total knee replacement: a randomized controlled trial

Petra Heesterbeek (Nijmegen), Ate B Wymenga (Nijmegen), Gijs van Hellemondt (Nijmegen)

OBJECTIVES
The number of revisions of total knee replacements (TKR) increases annually. Because of reduced bone stock, stable fixation of the implant is important. The femoral and tibial components are usually cemented. The stems can be placed either by cementing or press-fit. To date, there is no consensus on the preferred stem fixation technique. The primary goal of this study was to assess the stability of cemented versus press-fit placed stems. Secondarily, the clinical results were compared between the groups.

METHODS
In this prospective randomized controlled trial 32 patients needing revision TKR were included; allocation into the cemented or press-fit stem groups occurred by randomization during surgery. During the first 5 postoperative days the baseline RSA radiograph was obtained. Patients were followed at 6 weeks, 3, 6, 12, and 24 months. Migration of the femoral and tibial implants (translation or rotation > 1mm or °) was measured with model-based radiostereometric analysis (MB-RSA). At 6 weeks, double RSA radiographs were obtained in order to assess the precision of the measurement method. Clinical results were evaluated using the Knee Society Score, the KOOS, active flexion, and VAS pain and satisfaction. Migration and clinical outcome was compared between cemented and press-fit using Mann-Whitney and Chi-square tests.

RESULTS
Reproducibility of the MB-RSA method was good: precision of translation and rotation of the femur and tibia components were well below 1 mm / °. At 24 months, no difference in median migration or the number of migrating components (MTPM>1mm) was found between the cemented and press-fit placed stems. However, the cemented tibia component showed more migration at 12 months (p=0.048). In both groups, approximately one third of the components showed MTPM>1mm. None of the clinical scores differed between the groups.

CONCLUSIONS
Cemented and press-fit placed stems were equally stable at 24 months of follow-up. Unexpectedly, both groups showed migrating implants, whereas there were no clinical or radiological signs of loosening. MTPM was quite high for almost all patients, theoretically indicating a possible increased risk for loosening. The migration mechanism of this specific group of implants needs to be unraveled.
Conclusion: to date there is no difference in stability and clinical outcome between cemented and press-fit placed stems.

Day: Friday	Time: 10.30-10.40	Location: Grand Hotel

Inducible displacement for evaluation of symptomatic total knee replacements

Elise Laende (Dalhousie University & QEII Health Sciences Centre, Halifax, Nova Scotia), Michael Dunbar (Halifax, Nova Scotia)

Purpose

A challenge with symptomatic knee replacements is adequate diagnostic tools to evaluate mechanical causes of pain. Conventional metrics, such as plain radiographs, lack resolution and dimensionality. While implant migration measured with RSA may offer a long-term measure of loss of fixation, inducible displacement (measurement of relative motion of the implant before and after an applied load) may provide a more timely assessment of mechanical reasons for painful knee replacements. The purpose of this pilot study was to evaluate inducible displacement assessments of symptomatic total knee replacements.

Methods

Six subjects were assessed with inducible displacement after they reported significant pain. Four subjects had cemented revision replacements and two had uncemented primary replacements (1 hydroxyapatite coated, 1 trabecular metal). For inducible displacement exams, subjects stood weight-bearing on the affected limb. Subjects also resisted inward and outward torques of 10 Nm applied to a rotating platform on which they stood. All loaded exams were compared to a supine reference exam at the same visit.

Results

Inducible displacement results showed a range of implant motions in response to the loaded exams (Table 1).

Table 1. Maximum implant motion for standing or standing + torque test

implant	maximum translation (mm)	maximum rotation (degrees)	classification	follow-up care
revision	0.66	n/a	poor fixation	re-cemented
revision	0.97	7.01 (posterior tilt)	poor fixation	revised
revision	0.50	0.44 (external rotation)	borderline fixation	pending
revision	0.24	0.40 (external rotation)	stable fixation	pain management
primary HA-coated	1.21	2.02 (medial tilt)	poor fixation	revised
primary trabecular metal	0.64	0.59 (anterior tilt)	poor fixation	pending

One subject underwent re-cementation of the revision component through a tibial cortical window, using a cement gun to inject a new layer of cement following removal of the existing cement and fibrous tissue. An inducible displacement exam on this subject following the re-cementation procedure found maximum total point motion was reduced to 0.08 mm from 0.66 mm prior to the procedure and the subject reported pain relief.

Conclusions

Inducible displacement examination of symptomatic total knee replacements has the potential to provide

additional diagnostic information to surgeons. Performing different types of inducible displacement exams may be helpful in determining the mechanism of failure by isolating the direction of implant motion. Additionally, inducible displacements may prove to be an effective means of evaluating potential novel salvage procedures, such as cement injection, as well as new products that may be developed for such applications.

Day: Friday	Time: 10.50-11.00	Location: Grand Hotel

Do we need weight bearing radiographs for the assessment of polyethylene wear in total knee replacements?

Emiel van IJsseldijk (Leiden), Edward Valstar (Leiden), Berend Stoel (Leiden), Rob Nelissen (Leiden), Bart Kaptein (Leiden)

INTRODUCTION
RSA studies could provide valuable data to evaluate wear progression of new designs for total knee replacements. However, most RSA images are acquired in supine view, while it is generally postulated that weight bearing views are required to detect linear penetration. However, this hypothesis has never been validated and the aim of this study is therefore to compare the outcome of in vivo measurements of linear penetration for total knee prosthesis between weight bearing and non weight bearing views.

METHOD
We randomly selected 31 patients with a NexGen total knee prosthesis from a clinical study for which subsequently a weight bearing standard radiograph and non weight bearing RSA image pair was acquired at two years follow up. We measured the linear penetration in both images and compared the results. In addition, the mediolateral stability of the prosthesis was scored and the difference in flexion angles between the weight bearing and non weight bearing images were measured.

RESULTS
The linear penetration for the non weight bearing radiographs was 0.37mm larger on average than for the non weight bearing RSA images. The difference had a standard deviation of 0.73mm and was statistically significant. No correlation was found between this difference and the difference in flexion angle, or the mediolateral stability.

CONCLUSION
The results show that non weight bearing views are less sensitive for measuring linear penetration and should not be used for wear assessments. The difference of 0.37mm is clinically relevant, as wear rates in practice are as small as 0.1mm. Other explanations such as differences in flexion angles or mediolateral stability were investigated and could not have caused this difference.

Day: Friday	Time: 11.00-11.10	Location: Grand Hotel

The effect of patient positioning on the precision of model-based radiostereometric analysis

Trevor Gascoyne (Concordia Joint Replacement Group, Winnipeg), Thomas Turgeon (Winnipeg), Jason Morrison (Winnipeg)

Model-based radiostereometric analysis (MBRSA) is accurate enough to measure *in vivo* wear of a total knee replacement; however, there are a number of important factors that must be optimized. The purpose of this research was to determine which patient-radiograph positions and knee flexion angles achieve the greatest precision and accuracy of MBRSA for measurement of wear in a TKR.

The RSA setup consisted of two x-ray sources separated by a 60° angle and exposed two digital radiography plates mounted behind a uni-planar RSA calibration frame. A set of size 3, posterior stabilized, Genesis II TKR components (Smith & Nephew) were reverse engineered and converted for use in mbRSA (RSAcore). The components were mounted onto artificial bones by a trained surgeon (TT) and subsequently mounted to a rigid support frame to serve as an *in vitro* phantom.

MBRSA precision was determined for three flexion angles; standing (0°), flexed (45°), and sitting (90°), as well as four imaging orientations; antero-posterior (AP), 30° offset, 60° offset, and medio-lateral (ML), in a 3x4 factorial experiment with nine replicates. Precision was measured as the standard deviation of separation distance between TKR components on repeated radiographs. Optimal imaging positions were determined through analysis of variance of precision. MBRSA accuracy was determined for the four best imaging positions by inducing small displacements along and about all axes of motion using translation and rotation tables. Accuracy was measured as the mean (bias) and standard deviation of measured versus actual displacement.

Antero-posterior and medio-lateral imaging orientations as well as both standing and sitting flexion of the knee achieved optimal MBRSA precision/accuracy of better than 0.035 mm (in-plane translation) and 0.12° (in-plane rotation).

The precision of MBRSA measured in this study is comparable to, or better than, that reported in previous *in vitro* MBRSA studies; 0.062 mm [1] and 0.023 mm [2] (in-plane translation). Imaging orientation and knee flexion have a significant effect on MBRSA precision. Precision in the ML orientation is equivalent to precision in the AP orientation. Medio-lateral imaging is advantageous over antero-posterior imaging as a more complete range of flexion can be examined during an RSA examination. The techniques and findings of this research will be applied to future clinical studies aimed at developing an effective tool to assess short-term *in vivo* wear in total knee replacements.

Day: Friday	Time: 11.10-11.20	Location: Grand Hotel

Virtual Point Models May Provide More Details of Implant Migration

Maiken Stilling (Aarhus University Hospital, Aarhus, Denmark), Anders Odgaard (Aarhus), Frank Madsen (Aarhus), Kjeld Søballe (Aarhus)

Background
Model-based RSA by use of implant CAD or RE models describe the motion of the central point of the implant. Adding virtual points to the existing model may add essential details of which part if the implant that moves the most.

Purpose
To describe the detailed early migration of cementless Oxford® Partial Knee Tibial Trays.

Methods
25 patients (18 men) at a mean age 65 years (range 38-81) were operated with cementless hydroxyapatite-coated Oxford® Partial Knee Tibial Trays (Biomet Inc) at 2 hospital sites. The patients were a subgroup from a 3-way randomized study. We evaluated implant migration at 6 weeks using CAD implant models. The same RSA scenes were then re-analyzed by exchanging the implant model to the same size CAD implant model with virtual points added at the anterior posterior, medial, and lateral edge.

Results
The cementless Tibial Trays (n=25) migrated a mean Total Translation (TT) of 0.35mm (sd 0.28; range 0.05-1.29) at 6 weeks. The greatest motion was subsidence of 0.28 mm (sd 0.29). Using the 4 virtual points we found 0.74mm (sd 0.59) TT of the posterior point, 0.54mm (sd 0.41) TT of the medial point, 0.45mm (sd 0.33) of the anterior point, and 0.31mm (sd 0.21) of the lateral point. Subsidense was the greatest motion for all points with 0.67mm (sd 0.53) for the posterior point, 0.46mm (sd 0.43) of the medial point, 0.23mm (sd 044) of the anterior point, and 0.06mm (sd 0.23) of the lateral point.

Conclusion
The virtual point model made it clear that the migration pattern for the cementless Oxford® Partial Knee Tibial Tray is largely medially and especially at the posteromedial corner. Virtual points may be added to any part of a CAD model, and point analysis may add knowledge of the migration pattern and help improve the surgical techniques and implant design.

Day: Friday	Time: 11.20-11.30	Location: Grand Hotel

Validation of in vivo RSA wear measurement in total knee replacements: preliminary results

Trevor Gascoyne (Concordia Joint Replacement Group, Winnipeg), Martin Petrak (Winnipeg), Eric Bohm (Winnipeg), Thomas Turgeon (Winnipeg)

Short-term analysis of polyethylene (PE) wear and creep in total knee replacements (TKR) is feasible with model-based RSA (MBRSA); however, previous methods have not been well validated or optimized. The primary objective of this pilot study is to validate MBRSA estimation of TKR wear, and associated creep, by comparison to the measured wear and creep on the retrieved PE inserts.

Five patients were recruited, each requiring revision surgery of their Genesis II TKR (Smith & Nephew) which was *in situ* for a minimum of 2 years. Five, standing, MBRSA examinations of each patient were obtained to facilitate wear (including creep) analysis as well as to determine; MBRSA precision from double examinations, the effect of weight bearing, and the effect of mild (20-35°) and moderate (35-50°) knee flexion on wear measurement. Reverse-engineered models of the TKR components were positioned in Geomagic Studio (Geomagic Inc.) using pose data from mbRSA (RSAcore). Volumetric PE wear was estimated from these models as the overlap between the femoral condyles and an unworn PE insert. The measured PE wear volume was computed as the volumetric difference between the retrieved insert and a matching unworn insert; only the articular surfaces were compared.

The average volumetric wear rate was 99 mm^3/yr (SD: 39 mm^3/yr) based on the measured wear of the PE bearings. The volumetric wear estimated by MBRSA was on average 72% (SD: 27%) of the measured wear on each insert. The precision of wear measurement was 52 mm^3 (SD: 65 mm^3) based on double examinations. Unloading the knee joint resulted in an average of 165 mm^3 (SD: 140 mm^3) less wear measured when compared to a loaded examination. By combining the standing and flexion examinations, the total estimated wear increased by an average of 47 mm^3 (SD: 80 mm^3), resulting in a more accurate estimate of the measured wear.

Wear measurement in TKRs appears feasible with model-based RSA despite the large standard deviations presented in this research. Patient recruitment for this pilot study is ongoing as the authors expect the precision of wear analysis will be improve with a greater number of samples. Additionally, the effect of insert manufacturing tolerances on wear analysis remains to be considered. The data in this study was obtained from poor functioning TKRs revised for aseptic loosening (2), instability (1), and stiffness (2) and are therefore the results of this research may not be representative of healthy, well functioning TKRs.

Day: Friday	Time: 11.30-11.40	Location: Grand Hotel

In Vivo Dynamic Measurement of Polyethylene Wear in Total Knee Replacement: A Phantom Study

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Introduction: Measurement of implant wear in total knee replacement (TKR) from static radiographs has limited accuracy due to changes that occur to joint contact throughout knee flexion, potentially ignoring regions of wear volume. The objective of this study was to validate a TKR wear measurement technique using dynamic single-plane fluoroscopy. By utilizing dynamic imaging, penetration can be measured continually throughout flexion, accounting for changes in implant contact area.

Methods: A robotically controlled anthropomorphic knee phantom, implanted with a TKR implant and marker beads, was used to enable repeated exams. The implant included 13 interchangeable polyethylene inserts with known amounts of wear (measured directly from the insert with micro-computed tomography), from the equivalent of 0 to 12 years implantation. The knee phantom was scanned with CT, and underwent repeated exams for each worn insert using a dynamic single-plane radiography system. Femoro-tibial translations and rotations (generated by the robot to mimic a patient step-up exam) were measured from the radiographs using point-based 3D-to-2D registration. Implant CAD models were co-registered with the tracked motions based on the CT scan, and penetration of the femoral component into the polyethylene insert was measured for each incremental radiograph frame. Wear depth, wear volume, and frequency of intersection were measured. Measured wear from the dynamic imaging was compared to the known amount of wear for each insert.

Results: No difference was found between the measured and true wear volumes ($p = 0.58$), with excellent correlation between the two for increasing amounts of wear ($r2 = 0.97$). The precision of the measurements was ±39.7 mm3 for volume and ±0.126 mm for wear depth.

Discussion: The precision of the wear volume measurements was ±39.7 mm3, suggesting that the system may be able to accurately measure changes in wear volume above this threshold. Translating the results into a wear rate based on the simulated implantation times, the measured wear rate was the equivalent of 46 mm3/year, slightly less than the true wear rate of 50 mm3/year. The precision of the wear depth measurements was ±0.126 mm, comparable to the precision of static linear penetration measurements that have been reported as 0.100 to 0.170 mm. Although further work is required to optimize the technique for routine in vivo use, the method described and studied in this work holds excellent potential for obtaining both kinematic and wear data from patients with a TKR.

Day: Friday	Time: 11.40-11.50	Location: Grand Hotel

Fluoroscopy-based motion analysis of the tibio- and patello- femoral joint kinematics in total knee replacement

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INTRODUCTION

Total knee replacement (TKR) is an effective surgical treatment, but many patients still do not recover completely the normal lower limb joint kinematics and the normal muscle activity in daily living activities. Whereas the replaced tibio-femoral joint (TFJ) has been largely investigated by various kinematic analyses, the patello-femoral joint (PFJ) has not been considered with the necessary care despite it plays a fundamental role in the knee extensor mechanism. However, the biomechanical function at the knee is successfully performed only when also the patellar tracking occurs correctly. This study wants to assess motion after TKR of all three components, including the resurfaced patella, and to possibly correlate between TFJ and PFJ kinematics.

METHODS

Five patients implanted with a posterior stabilized TKR (Scorpio NRG, Stryker Orthopaedics, NJ, USA) were analyzed at 6 months after surgery. FA was performed during flexion (FaG) and extension (EaG) against gravity using a standard fluoroscope (CAT Medical System, Italy) at 10Hz. Reference frames for the prosthesis components were defined onto the corresponding CAD models. Three-dimensional component positions and orientations were obtained from each image by an established technique which allowed achieving the best alignment between the CAD models and the corresponding contours of the silhouette. Relative motion of the tibial and femoral components was calculated. The patella motion was also tracked using three tantalum beads inserted in the polyethylene component at the time of operation and calculated with respect to the femoral component.

RESULTS

In the operated knee during FaG and EaG, the PFJ rotations were 64.4° and 64.4° in the sagittal, i.e. patellar flexion, 6.7° and 6.8° in the frontal, i.e. patellar rotation, 6.3° and 8.5° in the transverse, i.e. patellar tilt, planes, whereas these for the TFJ were 96.0° and 96.5°, 4.2° and 6.8°, 9.0° and 7.8°. In all cases, a linear increase of the PFJ flexion was observed over TFJ flexion. In addition, a larger TFJ adduction and abduction occurred respectively in patients with a larger PFJ lateral and medial rotation.

DISCUSSION

The preliminary results showed first of all the feasibility of in-vivo patellar tracking after TKR, here reported for the first time. As for the functional assessments, the amount of PFJ rotations and its coupling with TFJ flexion revealed a satisfactory recovering of the normal knee joint kinematics. A larger number of patients and possibly a combined gait analysis with electromyography could reveal more about TKR functions .

Day: Friday	Time: 11.50-12.00	Location: Grand Hotel