IRSA
International Radiostereometry Society

The 8th International RSA Meeting

13 -14 April 2023

Nijmegen, The Netherlands

Program & Abstracts

Leiden University Medical Center

Radboudumc university medical center

Sint Maartenskliniek

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WORD OF WELCOME

A warm welcome to Nijmegen, the oldest city of the Netherlands!

Soon after the excellent digital meeting "live from Oslo", already two years ago, I had a sort of panic attack… What did I do, to opt to organize the next RSA meeting? Fortunately, this feeling soon turned into another state of mind: we can do this! With the organizing team (Lennard, Bart, Dennis and Silvia) we combined our strengths and skills to make this conference a success. We also had a lot of fun, and I was always looking forward to our meetings.

So now it is our turn to organize the bi-annuals RSA meeting as a physical meeting again. In times of digitalization and remote work (forced by the COVID 19 pandemic) it is of extra importance to meet in person. It is easy to view presentations digitally and have online meetings, but we think the advantage of a live conference lies in the social interaction: getting to know each other, have a chat during coffee breaks, exchanging brilliant research plans over lunch, etc. This is where collaboration is born! To help you interact socially and start your new collaborations, you can participate in our Social Challenge game, with the icon on your badge. Please see our website, https://meeting2023.radiostereometry.org/, for more information and instructions on how to win the prize!

To manage your expectations: we cannot and will not surpass the dance moves of Stephan's team... What to expect: a nice social activity on Wednesday in the city center, long breaks during the program where we can meet, industry partners to visit during breaks, a conference diner at a special historic site (come by bike, if you can!), and of course a very strong and interesting scientific program with 42 oral presentations and 14 e-posters, and 4 excellent keynote speakers. Watch out for the rapid fire sessions, where delegates promote their e-posters during very short presentations.

Because a live conference is less sustainable than an online meeting, we have made sustainability choices. There is no conference bag, no paper flyers and the program book can be downloaded on your mobile phone or laptop. We hand over your conference present during registration, and you can already use it during the conference. We chose local, fresh, products during breaks and reduced the meat consumption. Last but not least, we organized the meeting, so for us no travel expenses, no jetlag, no pollution, no panic catching flights, etc. So not a bad choice organizing this 8th International RSA meeting after all!

I hope you will enjoy the program, renew old friendships, make new friends, get new ideas, and most of all, have a good time.

On behalf of the organizing committee,

Petra Heesterbeek

GENERAL INFORMATION

Social Challenge
To help you interact socially and start your new collaborations, we challenge you to participate in our Social Challenge competition. You will find a "Nijmegen-icon" on your badge. Find other delegates with the same icon (or a complete team match) and perform as many activities together as you can. Send the proof (pictures please!) to Petra. Take care that your matching icons are on the picture. If you need inspiration, you can find a list of activities on this page, but feel free to think of new activities! You can earn points (originality, number of activities) for the leaderboard and the participant with the most points will win a prize, which will be awarded during the award session. Perhaps you also want to dine together with your new friends at the conference diner?

- Make a selfie with your icon buddies
- Drink a coffee or tea together
- Have lunch together
- Get a snack for your buddy
- Share your main research theme by a drawing
- Play hints and act out your hobby
- Check out and discuss the e-posters together
- Cycle together
- Share your activities on Twitter or LinkedIn with #irsa23
- Link on LinkedIn

WiFi, hashtag
Network = SMK gast
Wificode = verderinbeweging
#irsa23

Drinks at the conference
At the registration desk you are handed a beautiful cup for your coffee, tea and other drinks. Read all about this cup below.

BE O Cup made from plants!
The BE O cup is made from plants. It's made from used vegetable oils that are entirely waste and residues in origin. This material is renewable and saves CO2. Designed & made in The Netherlands, with head office located in Nijmegen. The cups are assembled and packed by people with a distance to the labour force.

- The BE O cup is designed for a long lifetime.
- EU certified
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- No plastic taste or smell
- Dishwasher proof
- Suitable for coffee (or tea, or else)
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You are welcome to use your cup during the conference and help us to decrease the footprint of the RSA meeting! And please take the cup home with you and we hope you enjoy using it for a long time.

Contact
In case of any urgent questions, please contact Petra Heesterbeek at +31 (0)6 83 516 519.

PROGRAM THURSDAY, APRIL 13, 2023

09.00-09.10 **Welcome**
Petra Heesterbeek

09.10-09.30 **Opening lecture - The future of sharing data**
Mark Van Houdenhoven

Moderators: Stephan Röhrl & Nienke de Laat

09.30-10.30 **Session 1: CT vs RSA**

O1 **CT-RSA is a novel tool to evaluate implant migration with good measurement precision. Harmonization in image acquisition might improve precision**
Olof Sandberg

O2 **Volumetric matching micro motion analysis to measure cup migration in CT-data: A clinical validation experiment**
Bart Kaptein
Nominated for Best Presentation Award:

O3 **CT-based migration analysis is more precise than radiostereometric analysis in total knee arthroplasty – a phantom study and first clinical results**
Lars Harald William Engseth
Nominated for Best Presentation Award:

O4 **Volumetric matching micromotion analysis to measure migration of tibial components in CT images: A clinical validation study of 24 patients**
Nienke de Laat

O5 **Comparison of marker-based RSA and CT-RSA in analysis of micromotions after correction osteotomy of the distal radius: A retrospective study of 24 patients up to 1 year**
Olof Sandberg

10.30-11.00 **Break**

Moderators: Gijs van Hellemondt & Amanda Klaassen

11.00-12.30 **Session 2: Migration - Hip**

O6 **Radiostereometric analysis of a novel reverse total hip system**
Trevor Gascoyne

O7 **The relation between cup and stem migration over five-year follow-up in press-fit total hip arthroplasty (THA), an explorative analysis using radiostereometric analysis (RSA)**
Amanda Klaassen

O8 **A randomized controlled trial evaluating a short, proximally coated, triple-taper blade femoral stem versus a self-locking stem with reinforced proximal body: A 2-year radiostereometric analysis**
Andreas Fontalis

O9 **Migration patterns of acetabular cups: A systematic review and meta-analysis of RSA studies**
Chan Hee Cho

O10 **The migration patterns of two reduced length total hip arthroplasty stems**
Glen Richardson

O11 **Fixation and migration of the G7 BiSpherical acetabular system combined with the GTS stem for total hip arthroplasty - an RSA study**
Ian Blom

O12 **Similar results after 5 years with use of the Fitmore or the CLS stem. Randomized study of 35 patients simultaneously operated with bilateral total hip arthroplasty**
Johan Kärrholm

O13 **Migration and stabilization of a shortened hip stem is comparable to a standard length hip stem in cementless total hip arthroplasty. Results of a randomized controlled trial with 2 year follow-up**
Bart Kaptein

O14 **Highly porous tantalum acetabular components without ancillary screws have similar migration at five years when compared with titanium components with ancillary screw fixation: A randomized controlled trial**
Stuart Callary

PROGRAM THURSDAY, APRIL 13, 2023

12.30-12.45 **Rapid fire session 1**

E1 **Mid-term migration patterns and patient reported hip function five years after primary uncemented total hip arthroplasty**
Nienke Willigenburg

E2 **Comparison of Zimmer acetabular system to the Allofit Cup with roentgen stereophotogrammetric analysis (RSA) in total hip arthroplasty**
Ian Blom

E3 **Mid-term performance of a bicruciate-retaining TKA, a radiostereometric analysis**
Kelly Mills

E4 **Radiostereometric analysis of hydroxyapatite and porous tritanium coated acetabular components in a randomized controlled trial shows comparable migration five years after uncemented THA**
Lennard Koster

E5 **Two year migration results of a neck preserving short stem – is HA coating not beneficial anymore?**
Michael Schwarze

E6 **A randomized controlled trial comparing two-year postoperative femoral and tibial migration of a new and an established cementless rotating platform total knee arthroplasty**
Lennard Koster

E7 **Length changes of the medial patellofemoral ligament during in vivo knee motion: A dynamic evaluation using computed tomography**
Miriam Boot

12.45-13.45 **Lunch**

13.45-14.15 **Keynote 1 - No more toys for the boys or pearls for the girls: Future challenges & opportunities in surgical innovations**
Maroeska Rovers

Moderators: Simon van Laarhoven & Jordan Broberg

14.15-15.45 **Session 3: Migration - Knee**

O15 **Construct stability of revision total knee arthroplasty with tibial cones: Preliminary results of a radiostereometric analysis (RSA)**
Petra Heesterbeek

O16 **Increasing medial conformity of a tibial insert from intermediate to ball-in-socket does not increase tibial baseplate migration**
Abby Niesen

O17 **Inducible micromotion during step-up test evaluated in stabile and continuous migrating medial unicompartmental knee arthroplasties. A dynamic and static RSA study with minimum 5 years follow-up**
Jonathan Jürgens-Lahnstein

O18 **Inducible displacement of a cementless total knee replacement at one year post-operation**
Jordan Broberg
Nominated for Best Presentation Award:

O19 **Topical Zoledronate decreases migration of cementless total knee arthroplasty by suppression of bone resorption: A randomized, double-blinded RSA study of 55 patients with 5 years follow-up**
Karina Linde

O20 **Early migration of total knee replacements; an updated systematic review, meta-analysis, and database study**
Raymond Puijk

O21 **Micromotion of a cemented hinged-type knee revision system, measured with model-based RSA**
Simon van Laarhoven

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O22 **Comparing long-term migration of the same TKA design used in different RSA studies. 10-year follow-up of 5 randomized controlled trials using radiostereometric analysis**
Thies van der Lelij

O23 **Randomized controlled trial comparing traditional versus enhanced-fixation designs of a novel cemented total knee replacement tibial component**
Trevor Gascoyne

15.45-16.15 **Break**

16.15-17.15 **Tour around the clinic**

18.30 **Conference dinner**

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Moderators: Rob Nelissen & Thies van der Lelij

9.30-10.30 **Session 4: Methods**

O24 **Differences in globally-aligned versus local baseplate coordinate systems when computing migration using model-based radiostereometric analysis**
Abby Niesen

O25 **Influence of marker-selection method on mean tibial baseplate migration and individual migration patterns in TKA using marker-based RSA. A re-analysis of an RCT with 5 year follow-up**
Thies van der Lelij

Nominated for Best Presentation Award:

O26 **Measurement error versus repeated measurements: Two methods for computing bias and precision of migration measurements from double examinations using radiostereometric analysis**
Abby Niesen

O27 **The Influence of bead size on migration parameters of model-based roentgenstereometric analysis in small joints: A comparison of 0.5 mm and 1.0 mm beads in the proximal interphalangeal joint, a phantom study**
Rianne Oomen

O28 **Corroboration of coupled musculoskeletal model and finite element predictions with in-vivo RSA migration of an uncemented acetabular component**
Stuart Callary

O29 **Radiostereometry of a novel ceramic hip resurfacing – comparison of clinical precision for uniplanar and biplanar techniques**
Martin Downing

10.30-10.45 **Rapid fire session 2**

E8 **3D virtual planning to assist intra-operative articular reduction and implant choice for patients with tibial plateau fractures**
Nynke van der Gaast

E9 **Randomized controlled trial comparing tibial baseplate stability between anatomic (Femur-First) and mechanical alignment techniques using radiostereometric analysis**
Trevor Gascoyne

E10 **Mid-term migration of the stemless simpliciti shoulder system in total shoulder arthroplasty: A radiostereometric and clinical study with five years follow-up**
Rianne Oomen

E11 **Randomized controlled trial comparison of two hydroxy-apatite coated hip stems using radiostereometric analysis**
Trevor Gascoyne

E12 **Objectively measured knee instability during Pivot-shift test - an experimental dynamic RSA study**
Tobias Vind

E13 **Can virtual three-dimensional planning for proximal humerus fractures reduce intra-articular screw penetration?**
Stijn Mennes

E14 **Ten years of the Canadian RSA Network: Progress, lessons, and prospects for RSA in Canada**
Trevor Gascoyne

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10.45-11.15 **Break**

11.15-11.45 **Keynote 2 - Machine Learning in Orthopaedics**
Eric Garling

Moderators: Emil Toft Petersen & Kelly Mills

11.45-12.45 **Session 5: Kinematics**
Nominated for Best Presentation Award:

O30 **Medial congruent polyethylene design show different tibiofemoral kinematics and enhanced congruency compared to a standard symmetrical cruciate retaining design for total knee arthroplasty-an in vivo randomized controlled study of gait using dynamic radiostereometry**
Emil Toft Petersen

O31 **Tibiofemoral and patellofemoral kinematics are both affected in patients with patellar maltracking disorders; a dynamic CT study**
Dennis Janssen

O32 **Impact of radial head arthroplasty diameter on elbow joint kinematics evaluated by dynamic radiostereometric analysis**
Johanne Frost Teilmann

O33 **Evaluation of glenohumeral kinematics following a simulated bony Bankart lesion. A dynamic radiosteometric cadaver study**
Josephine Olsen Kipp

O34 **Differences in tibiofemoral contact locations between bicruciate-retaining and posterior cruciate-retaining TKA**
Kelly Mills

O35 **Precision of CT-based radiostereomatric analysis compared to marker-based radiostereometry in midfoot kinematics**
Magnus Poulsen

O36 **In-vivo kinematics evaluation of total ankle replacement through dynamic radiostereometric analysis: A prospective study**
Raffaele Zinno

12.45-13.45 **Lunch**

13.45-14.15 **Keynote 3 - A T. rex walks into the x-ray department…**
Anne Schulp

Moderators: Nico Verdonschot & Nina Mathijssen

14.15-15.15 **Session 6: Bearing surfaces and wear**

O37 **No difference in wear between 32 and 36 mm metal femoral heads in uncemented cups with highly cross-linked polyethylene. An RSA study with up to 10 years follow-up**
Gunnar Flivik

O38 **Comparison of 5-year cup and stem migration between a ceramic and polyethylene liner in press-fit total hip arthroplasty (THA), a randomized controlled trial using radiostereometric analysis (RSA)**
Amanda Klaassen

O39 **Polyethylene wear in mobile- and fixed-bearing unicompartmental knee arthroplasty; a randomized controlled RSA study with 5 years follow-up**
Daan Koppens

O40 **Cemented versus cementless dual mobility cup show similar fixation, low polyethylene wear, and low serum cobalt-chromium in elderly patients: A randomized radiostereometry study with 6 years follow-up**
Peter Bo Jørgensen

O41 **Wear in total hip arthroplasty with the Regenerex cup: A radiostereometric study with 5 years of follow up**
Nina Mathijssen

PROGRAM FRIDAY, APRIL 14, 2023

O42 **Polyethylene liner motion in dual mobility hip prostheses measured with static and dynamic RSA one year after operation**
Peter Bo Jørgensen

15.15-15.45 **Break**

15.45-16.05 **Award Session**

16.05-16.30 **Wrap-up & Closure**

ABSTRACTS

Session 1

CT vs RSA

O1 **CT-RSA is a novel tool to evaluate implant migration with good measurement precision. Harmonization in image acquisition might improve precision**
Olof Sandberg

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Olof Sandberg

Session 1

O1

CT-RSA IS A NOVEL TOOL TO EVALUATE IMPLANT MIGRATION WITH GOOD MEASUREMENT PRECISION. HARMONIZATION IN IMAGE ACQUISITION MIGHT IMPROVE PRECISION

Sandberg, O[1], Stjernholm, C[2], Schilcher, J[3,4], Sköldenberg, O[5]
[1] Sectra, Orthopaedics, Linköping, Sweden
[2] Danderyd Hospital, Dep. Of Radiology, Stockholm, Sweden
[3]Department of Orthopedics, Department of Clinical and Experimental Medicine, Linköping University, Linköping, Sweden.
[4]Wallenberg Centre for Molecular Medicine, Linköping University, Linköping, Sweden
[5]Karolinska Institutet, Department of clinical sciences at Danderyd hospital, unit of Orthopaedics, Stockholm, Sweden

Introduction
CT-RSA is a novel alternative to conventional RSA for measuring implant migration. Different settings regarding image reconstruction affect image quality and therefore might affect measurement precision in CT-RSA. In addition, a follow-up CT could be formatted with settings differing from those of the postoperative CT (baseline).
We aimed to investigate the effects of CT settings on measurement precision and the effect of performing a CT-RSA analysis when mixing two CTs made with different settings.

Methods
Postoperative double examinations were acquired in ten patients undergoing uncemented revision THA. All studies were performed on a SOMATOM Drive scanner (Siemens Healthineers, Erlangen, Germany) with a low dose protocol using Sn100 kV (tin filtration) and a quality reference mAs of 128. The estimated average effective dose for each scan was 0.3 mSv. Reconstruction series with variations of the following parameters were obtained for each scan; metal artifact reduction (no or yes), kernel/convolution algorithm (soft, Br32, or sharp, Br59), and field of view (unilateral, 200 mm, or bilateral, individualized).
Analysis was performed in CTMA (version 23.1, Sectra, Sweden) by one experienced examiner. For statistics 95% precision estimates with T-distribution was used. The outcome measure was the precision for total rotation, i.e. the sum of the rotations around all three axes of the cup relative to the pelvis. The femoral component was not analyzed.

Results
Figure presents the upper 95% confidence interval for measurement precision with the various settings, and when mixing different settings. Differences in measurement precision ranged from 0.3 to 0.4 degrees. Two of the mixed analyses showed increased precision estimates.

Discussion and Conclusion
Differences in CT settings had small effects on CT-RSA measurement precision in uncemented revision cups. Out of the three variations, a mix of soft and sharp kernel resulted in the largest loss in precision. A mix of settings regarding metal artifact reduction or field of view had no effect. When several factors were varied simultaneously a more pronounced negative effect was seen.
CT-RSA appears a promising alternative to conventional RSA and robust in handling variations in image acquisition. However, harmonization of scan settings, especially kernel type, appears beneficial.

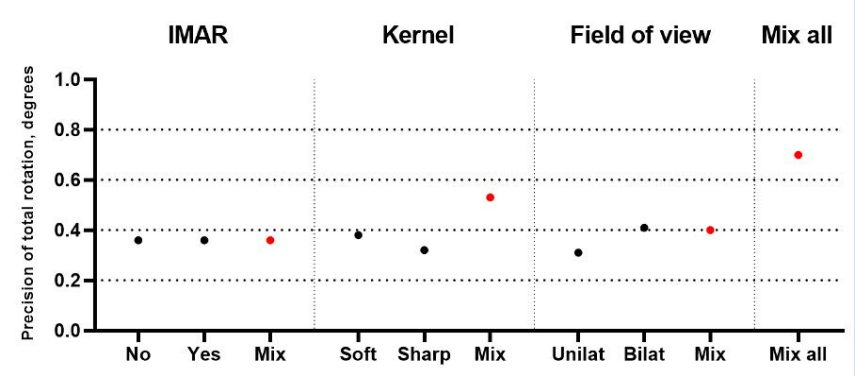


Figure. upper 95% CI for measurement precision of total rotation for various settings.

Session 1

O2

VOLUMETRIC MATCHING MICRO MOTION ANALYSIS TO MEASURE CUP MIGRATION IN CT-DATA: A CLINICAL VALIDATION EXPERIMENT

Bart Kaptein[1], Thomas Robertson2[3], Stuart Callary[2,3]
[1]Department of Orthopaedics, Leiden University Medical Centre, Leiden, Netherlands
[2]Centre for Orthopaedic and Trauma Research, Faculty of Health and Medical Sciences, The University of Adelaide, Adelaide, SA, Australia
[3]Department of Orthopaedics and Trauma Royal Adelaide Hospital, Adelaide, SA, Australia

Introduction
Implant migration analysis from Computed-Tomography (CT) data is an alternative for the well-established radiostereometric analysis (RSA) method. We developed a VoluMetric Matching Micromotion Analysis (V3MA) method based on matching CT image voxel intensities of prosthesis and bone in follow-up CT images. The difference between the calculated transformations defines prosthesis migration. The V3MA method has shown promising results in phantom- and clinical validation experiments of a knee prosthesis, but needs further validation when measuring hip implant migration. The study goal was to validate V3MA measurements of cup migration against traditional RSA.

Methods
CT images at 7 and 10 years post-operatively were analyzed in V3MA from an ongoing clinical RSA randomized controlled trial comparing the migration of uncemented tantalum cup (TM) with a titanium cup (Trilogy)[1]. 17 of the first 39 patients (8 TM and 9 Trilogy) had repeat CTs. Mimics (Materialise) was used to indicate the CT volume of bone and cup in the reference CT and V3MA software powered by Elastix was used for image matching and cup migration calculations. Calculated translations of the cup-sphere center were compared with RSA calculated translations using UmRSA v7.0 software.

Results
Mean differences [95% Limits-of-agreement] for the Medial-Lateral, Proximal-Distal, and Anterior-Posterior translations (mm) were -0.10 [-0.56,0.36], -0.01 [-0.46,0.45], -0.01 [-0.73,0.71] respectively [Figure].

Discussion/Conclusion
Even though compared to RSA, V3MA migration results show small differences in cup translation in all directions, Bland-Altman analysis clearly shows a relation between Ty-difference and CT-slice-spacing. This suggest that accurate V3MA analysis requires high resolution CTs. Interpretation of these clinical validation results is difficult as the expected result may not always be zero. As double RSA examinations show good precision[1], validation in a phantom model are necessary to further understand the error of both V3MA and RSA measurements.

[1] Howie DW, et all. J Arthroplasty. 2020;35(10):2931-7.

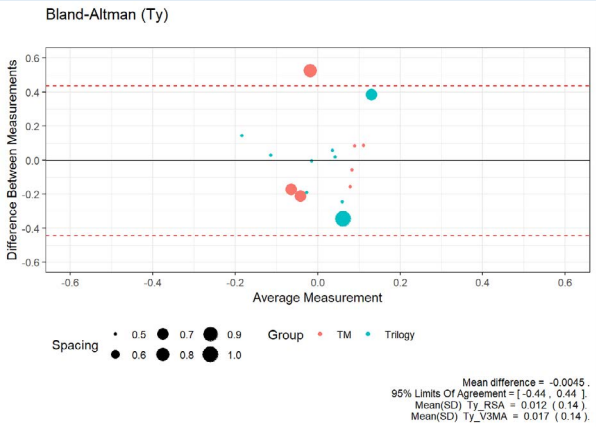


Figure: Bland-Altman analysis of the Proximal-Distal translation (Ty). The CT-slice-spacing is represented by the size of the dots.

Session 1

O3

CT-BASED MIGRATION ANALYSIS IS MORE PRECISE THAN RADIOSTEREOMETRIC ANALYSIS IN TOTAL KNEE ARTHROPLASTY – A PHANTOM STUDY AND FIRST CLINICAL RESULTS

Lars H. W. Engseth[1,5], Anselm Schulz[2], Are H. Pripp[3], Frank-David Øhrn[4] and Stephan M. H. Rörhl[1]
[1] Division of Orthopaedic Surgery, Oslo University Hospital Ullevål, Oslo, Norway,
[2] Department of Radiology and Nuclear Medicine, Oslo University Hospital Ullevål, Oslo, Norway, [3] Oslo Centre for Biostatistics and Epidemiology, Oslo University Hospital, [4] Orthopaedic Department, Kristiansund Hospital, Møre and Romsdal Hospital Trust, Kristiansund, Norway, [5] University of Oslo, Oslo, Norway
Correspondence: lars.engseth@gmail.com, phone: +47 41254136, ORCID 0000-0001-8254-5765

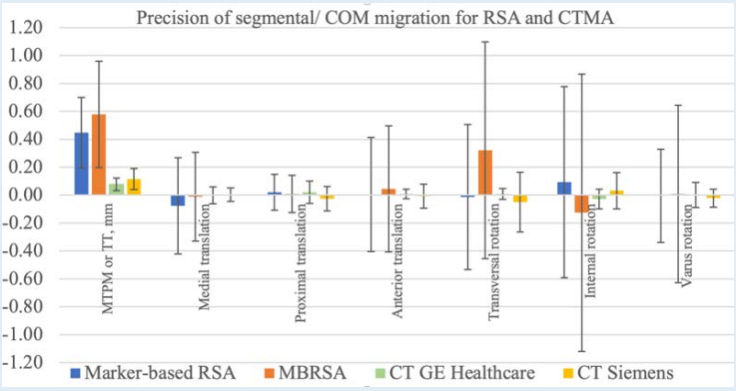
Introduction
Radiostereometric analysis (RSA) is the gold standard for migration analysis, but methods based on computed tomography (CT) has shown comparable results in the shoulder and hip. We attempted to validate a commercially available CT based migration analysis method (CTRSA) by comparison with RSA in total knee arthroplasty (TKA), both in a phantom and in the clinical setting.

Methods
For the phantom, precision analyses were performed through 21 double examinations for model-based RSA, marker-based RSA and CTRSA with two different CT vendors, on a porcine knee with a cemented TKA. In clinical patients, double examinations with RSA and CTRSA were performed on 21 and 30 patients, respectively. Images were analyzed using RSAcore software and CT-based Micromotion analysis (CTMA) software (Sectra AB).

Results
For the phantom, precision data (95% CI) for maximum total point motion (MTPM) using marker-based RSA was 0.19-0.70 and 0.20-0.96 using model-based RSA (MBRSA). Precision data for the point with the highest total translation (TT) for CTMA using the GE scanner was 0.03-0.12 and 0.04-0.19 for the Siemens scanner. There was no difference between marker-based RSA and MBRSA (p=0.07); but CTRSA from both vendors were more precise than both RSA methods (p<0.001); and the CTRSA from the GE scanner was more precise than Siemens (p=0.03). The same pattern was seen for other migrations. Mean effective radiation doses were 0.005 mSv (RSA) and 0.08 mSv (CT) (p<0.001). Intra- and interrater reliability were 0.79 and 0.77, respectively.
In the clinical setting, precision data (95% CI) for MTPM using marker-based RSA was 0.16-0.59 and 0.08-0.63 using MBRSA. Precision data for TT was -0.05-0.38.

Discussion
For the phantom, CTMA was more precise than RSA in TKA migration analysis and had overall good intra- and interrater reliability. Effective doses for CT were higher than for RSA. Clinical measurements strengthen these findings and will be discussed in detail at the meeting.

Conclusion
The studies show that CTMA can be used in migration analysis of TKA, with higher precision than RSA, and with good intra- and interrater reliability. This will revolutionize the opportunity for clinicians everywhere to perform migrations analysis of poor performing TKAs.



O4

VOLUMETRIC MATCHING MICROMOTION ANALYSIS TO MEASURE MIGRATION OF TIBIAL COMPONENTS IN CT IMAGES: A CLINICAL VALIDATION STUDY OF 24 PATIENTS

N.N. de Laat, L.A. Koster, B.L. Kaptein and R.G.H.H. Nelissen
LUMC, Dept. of Orthopedic Surgery, Leiden, The Netherlands

Introduction

Increasing interest has been shown in CT-based migration analysis (CTBMA) as an alternative to radiostereometric analysis (RSA). CTBMA is truly 3D and requires no special hardware. Previous studies have validated CTBMA methods for hip and shoulder implants, but not for knee implants. We developed a VoluMetric Matching Micromotion Analysis (V3MA) method to assess implant migration using CT images and performed a clinical validation study for tibial components in total knee arthroplasty (TKA). The aim of this study was to assess the agreement between V3MA and RSA.

Methods

In a prospective RSA RCT comparing 2 TKA designs, tibial component migration was measured between one year and five years postoperative with V3MA and model-based RSA. For V3MA, the tibial bone and tibial component were segmented in the baseline CT image. Voxel intensities of these volumes were matched on the follow-up CT image using automated image registration. Migration was expressed as three translation and three rotation parameters. Total translations (TT) and total rotations (TR) were calculated with 3D Pythagorean Theorem. V3MA and RSA were compared on TT, TR, and all six migration parameters by assessing the mean differences and limits of agreement (mean ± 1.96*SD) using Bland-Altman analysis.

Results

Twenty-four patients were included for comparison of V3MA and RSA. The mean difference (limits of agreement) was -0.07 mm (-0.43 mm to 0.3 mm) and -0.15° (-0.85° to 0.55°) for TT and TR, respectively. The limits of agreement for translations did not exceed ±0.5 mm. For rotations the limits of agreement were: medial (-0.88° to 0.96°), proximal (-1.38° to 0.98°), and anterior (-0.68° to 0.56°).

Discussion and Conclusion

We showed that V3MA is feasible for tibial components in TKA and migration is comparable to RSA in clinical practice. The majority of the measured migration was small since most migration occurs in the first six months postoperatively. We are conducting phantom studies to assess agreement for larger migration values and to determine the accuracy and precision of V3MA. Overall, V3MA seems a promising alternative to RSA for analysis of tibial component migration in TKA.

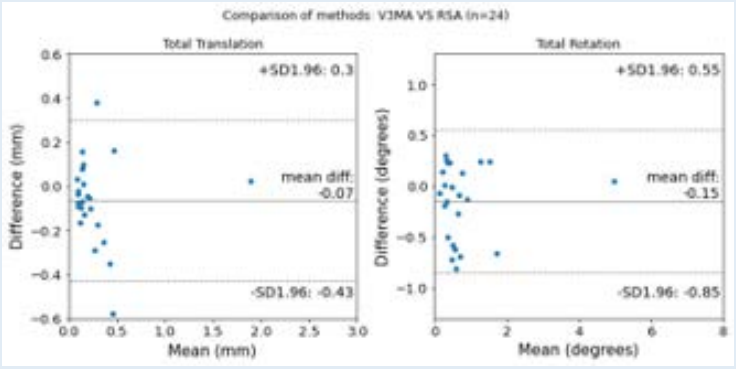


*Figure: Bland-Altman plots of total translations (left) and total rotations (right) of 24 patients comparing V3MA and RSA. Solid lines represent the mean difference between the two methods. Dashed lines represent the limits of agreement (mean ± 1.96*SD).*

Session 1

O5

COMPARISON OF MARKER-BASED RSA AND CT-RSA IN ANALYSIS OF MICROMOTIONS AFTER CORRECTION OSTEOTOMY OF THE DISTAL RADIUS: A RETROSPECTIVE STUDY OF 24 PATIENTS UP TO 1 YEAR

Vasileios Angelomenos[1,2,3], Olof Sandberg[4], Bita Shareghi [1,3], Michael Ullman [1,3]
[1]Department Of Orthopedics, Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
[2]Department of Hand Surgery and Microsurgery, Sahlgrenska University Hospital, Gothenburg, Sweden.
[3]Department Of Orthopedics, Sahlgrenska University Hospital, Gothenburg, Sweden.
[4]Sectra, Linköping, Sweden.

Introduction
Marker-based Radiostereometric Analysis (RSA) has been considered the most accurate clinical method for determining early micromotions of orthopedic implants. Computed Tomography Radiostereometric Analysis (CT-RSA) is a tool that can be used to determine implant and bone micro-movements using low-dose CT scans. The purpose of this study was to evaluate the reliability of the CT-RSA method versus standard marker-based RSA of the wrist in patients who have undergone a correction osteotomy due to a malunited distal radius fracture.

Methods
24 patients with a malunion of the distal radius, planed for correction osteotomy, were included, initially part of a larger study at Sahlgrenska University Hospital, Gothenburg, Sweden. All patients were operated with a radiolucent plate with embedded tantalum markers. Tantalum markers were inserted in the bone segments to enable RSA analysis. RSA and CT examinations were obtained directly post-operatively as well as up to 1 year post-op. Double RSA examinations were performed to establish the precision of the RSA setup. The CT scans were analyzed with the CT-RSA analysis tool. Thereafter, the measurements of the CT-RSA analysis were compared to that of marker-based RSA.

Results
The Bland-Altman analysis showed an adequate level of agreement, considering clinically relevant thresholds, between marker-based RSA and CT-RSA, regarding migration and rotation measurements of the distal radius segment relative to the proximal segment after a correction osteotomy.

Discussion
In the current study the mean values of the difference in translation and rotation and the values of LoA, as well as the corresponding 95% CI were below the values that in our consideration and experience are clinically significant. 95% of the data points in the corresponding graphs were within the LoA. Our data indicate, thus, that the discrepancies of measurements between the two methods are not clinically significant.

Conclusions
Our data indicate that CT-RSA displays comparable measurements to those of RSA and could, thus, be considered as an alternative method in studying micromotion after distal radius osteotomy.

ABSTRACTS

Session 2

Migration - Hip

O6 **Radiostereometric analysis of a novel reverse total hip system**
Trevor Gascoyne

O7 **The relation between cup and stem migration over five-year follow-up in press-fit total hip arthroplasty (THA), an explorative analysis using radiostereometric analysis (RSA)**
Amanda Klaassen

O8 **A randomized controlled trial evaluating a short, proximally coated, triple-taper blade femoral stem versus a self-locking stem with reinforced proximal body: A 2-year radiostereometric analysis**
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Session 2

O6

RADIOSTEREOMETRIC ANALYSIS OF A NOVEL REVERSE TOTAL HIP SYSTEM

Thomas Turgeon[1,2,3], Trevor Gascoyne[3], Colin Burnell[1,2], David Hedden[1,2,3], Eric Bohm[1,2,3]
[1]Concordia Joint Replacement Group
[2]University of Manitoba
[3]Orthopaedic Innovation Centre

Introduction
The concept of phased innovation utilizes high precision metrics to assess early safety and efficacy of a new device in a small number of patients prior to widespread release. A novel reverse total hip has been developed to address hip instability, with a femoral cup and acetabular ball which creates mechanical stability at the extremes of hip joint movement. This study was developed to assess the clinical safety and efficacy of this novel implant design following the principles of phased innovation.

Methods
Twenty-two patients with end-stage osteoarthritis were enrolled in a prospective cohort at a single center. Implant fixation and linear head penetration (joint wear) was evaluated using radiostereometric analysis (RSA). Patient function was assessed using HOOS, Oxford-12, HHS, SF-36 and WOMAC scores at all follow-ups. All patients received at least one acetabular screw to aid initial cup stability. RSA markers were applied in the acetabulum and proximal femur with imaging assessments at 1.5 (baseline), 6, 12, 24, and 60 months.

Results
The cohort consisted of 11 females and 11 males with mean age of 70.8 years and body mass index of 31.3 kg/m2. One patient was revised due to infection. Mean femoral subsidence from baseline at 6, 12 and 24 months was 0.01±0.12mm, -0.01±0.20mm and 0.03±0.16mm. Mean acetabular subsidence from baseline was 0.08±0.11mm, 0.10±0.11mm and 0.09±0.15mm at the same time points. Joint wear from baseline was 0.08±0.04mm, 0.09±0.04mm and 0.07±0.03mm at the same time points. There was significant improvement in clinical outcomes at 24 months with good to excellent results and as collected by PROMs. Patient evaluation at 60 months is still on-going but early data indicates continued strong results for migration, wear, and function.

Conclusions
This ongoing prospective study demonstrates the clinical safety and efficacy of a novel reverse total hip system with excellent fixation and indiscernible wear at 2 years. This study is an ideal example of utilizing RSA in a phased approach to new device assessment and careful clinical release that prioritizes the patient.

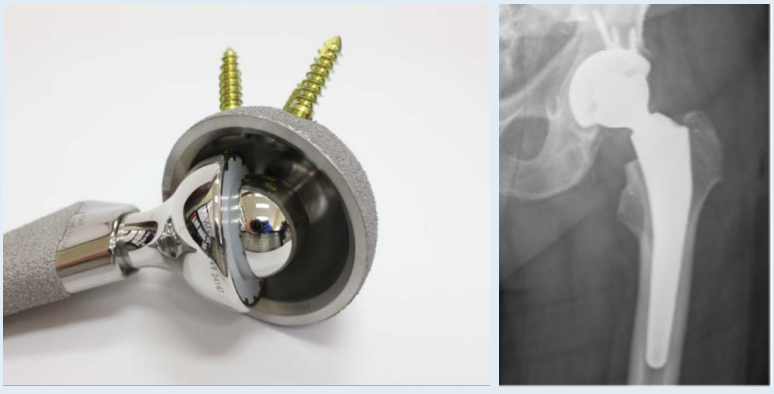


Figure: HIT reverse hip implant and example patient radiograph.

Session 2

O7

THE RELATION BETWEEN CUP AND STEM MIGRATION OVER FIVE-YEAR FOLLOW-UP IN PRESS-FIT TOTAL HIP ARTHROPLASTY (THA), AN EXPLORATIVE ANALYSIS USING RADIOSTEREOMETRIC ANALYSIS (RSA)

Willigenburg N.W.[1], Klaassen A.D.[1], van Loon J. [1,2,3], Koster L.A. [4], Kaptein B.L. [4], Scholtes V.A.B. [1], van der Hulst V.P.M. [5], Haverkamp D. [3], Moojen D.J.F. [1], Poolman R.W. [1,4]
[1] OLVG, Dept. of Orthopedics, Amsterdam, The Netherlands; [2] Amsterdam Movement Sciences, Amsterdam UMC, Academic Medical Centre, University of Amsterdam, Dept. of Orthopaedics, Amsterdam, The Netherlands; [3] Xpert Clinics Orthopedie Amsterdam, Amsterdam, The Netherlands; [4] LUMC, Dept. of Orthopedics, Leiden, The Netherlands; 5 OLVG, Dept. of Radiology, Amsterdam, The Netherlands.

Introduction
The aim of this study was to explore if increased migration in either a press-fit cup or stem is correlated to increased migration in the other component in patients after total hip arthroplasty. We hypothesize that micromotion in the cup and stem are related, especially with a stiff bearing.

Methods
In a randomized controlled trial patients were allocated to a polyethylene (n=25) or ceramic (n=28) liner before primary THA, using a press-fit Delta-TT cup and H-MAX S stem (LimaCorporate). Model-based RSA was used to calculate migrations of the cup and stem. Pearsons Correlation coefficient was used to assess the relation between proximal cup translation and stem subsidence and between cup and stem total translation (√((translation X-axis)2 + (translation Y-axis)2 +(translation Z-axis)2)) at all follow-up moments (1.5, 3, 6, 12, 24 and 60 months).

Results
After initial migration, cups stabilized in approximately 6 months and stems in 6 weeks. For Y-axis translation, all correlation coefficients were negative indicating that proximal migration of the cup coincided with distal migration of the stem. Pearson correlation coefficients ranged from -0.21 (12 months) to -0.29 (1.5 months) in the polyethylene (PE) group and from -0.32 (12 months) to -0.41 (60 months) in the ceramic (CE) group. For total translation, all correlation coefficients were positive, indicating more migration of the cup coincided with more migration of the stem. Pearson correlation coefficients ranged from 0.31 (60 months) to 0.78 (1.5 months) in the PE group and from 0.23 (12 months) to 0.41 (1.5 months) in the CE group. Figure 1 presents the strongest correlation coefficients at 1.5 months after surgery.

Discussion and Conclusion
To our knowledge this is the first study to investigate the relation between cup and stem migration. Further research in combination with bone mineral density (BMD) measurements could help to investigate a potential relation between cup- and stem migration and the influence of bearing. Up to five years after total hip arthroplasty, we observed correlations between cup and stem translation in press-fit components, both with PE and CE liners.

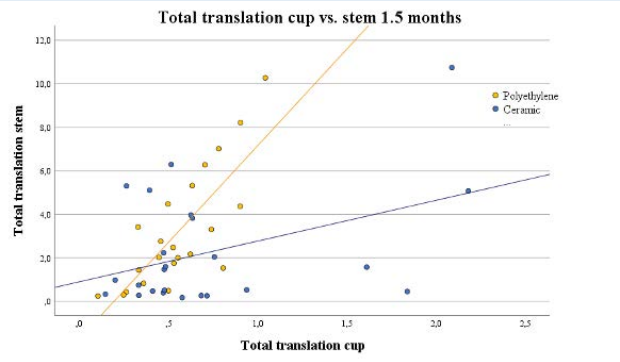


Figure: Illustrating a positive correlation at 1.5 months postoperatively between total translation of the cup and stem, which is strongest in the PE group.

Session 2

O8

A RANDOMIZED CONTROLLED TRIAL EVALUATING A SHORT, PROXIMALLY COATED, TRIPLE-TAPER BLADE FEMORAL STEM VERSUS A SELF-LOCKING STEM WITH REINFORCED PROXIMAL BODY: A 2-YEAR RADIOSTEREOMETRIC ANALYSIS

Andreas Fontalis[1,2], Babar Kayani[1], Ivor Vanhegan[1], Jenni Tahmassebi[1], Isabella Catrina Haddad[1], Dia Eldean Giebaly[1,2], Vishal Rajput[1], Shanil Hansjee[1], Fares S Haddad[1,2]
[1]Department of Trauma and Orthopaedic Surgery, University College Hospital, London, United Kingdom.
[2]Division of Surgery and Interventional Science, University College London, London, United Kingdom

Introduction
Cementless stem designs with proximal metaphyseal fixation aim to achieve better load distribution, reduce stress shielding and improve primary stability. A well-documented method for gauging implant success and longevity is through the measurement of its stability. The purpose of this prospective, randomised controlled trial was to evaluate the 2-year migration and clinical outcomes of two cementless femoral stems.

Methods
60 participants undergoing primary total hip replacement for any cause were randomly allocated to receiving either a triple-taper, proximally coated, short blade stem, with a reduced lateral shoulder or a triple-taper, self-locking design stem, with reinforced proximal body and proximal grooves perpendicular to load transmission. RSA radiographs were performed post-operatively and at 6 weeks, 6 months, 1- and 2 years. The Harris Hip Score (HHS), Oxford Hip Score (OHS) and EQ-5D were also collected.

Results
At two years the median subsidence of the novel short-blade stem was 0.097 (IQR, 0.76) versus 0.086 (IQR, 0.29,p=0.683); medial translation 0.023 (IQR, 0.20) versus 0.029 (IQR, 0.18,p=0.907); anterior translation 0.035 (IQR, 0.57) versus 0.07 (IQR, 0.21,p=0.268). The median total migration of the short blade stem was 0.29 (IQR, 0.65) versus 0.29 (IQR, 0,28, p=0.567) at 6 weeks; 0.57 (IQR, 0.80) versus 0.21 (IQR, 0.20, p=0.005) at 6 months; 0.61 (IQR, 0.78) versus 0.25 (IQR, 0.27, p=0.010) at 1 year; 0.52 (IQR, 1.08) versus 0.26 (IQR, 0.32, p=0.034) at 2 years(Figure 1). Baseline PROM scores improved significantly at 2-years from pre-operatively and were comparable among groups.

Discussion
Both cementless stems exhibited a predictable migration pattern and achieved initial stability. There was no difference in migration across the three Cartesian axes at any timepoint. The triple-taper stem with grooves perpendicular to load transmission demonstrated less total migration that reached statistical significance at 6 months, 1- and 2-years. Migration was well below the proposed RSA thresholds for both stems. Biological fixation of both implants evidenced by the RSA and excellent PROMs are likely to translate to long-term stability, which would need to be corroborated by longer-term outcome studies.

Session 2

O9

MIGRATION PATTERNS OF ACETABULAR CUPS: A SYSTEMATIC REVIEW AND META-ANALYSIS OF RSA STUDIES

Chan Hee Cho[1], Bart G. Pijls[2], Anne Roerink[2], Raissa Katembwe[1], John Matthew Abrahams[1,3], Andrew Baker[1], Lucian Bogdan Solomon[1,3], Stuart A. Callary[1,3]
[1]Centre for Orthopaedic and Trauma Research, Faculty of Health and Medical Sciences, The University of Adelaide, Adelaide, SA, Australia
[2]Department of Orthopaedics, Leiden University Medical Centre, Leiden, Netherlands
[3]Department of Orthopaedics and Trauma Royal Adelaide Hospital, Adelaide, Australia

Introduction
Radiostereometric analysis (RSA) is the most sensitive method to measure in vivo cup migration. Migration greater than 1mm in the first two years is a validated surrogate assessment method to predict future loosening. As most RSA studies only investigate one implant in a relatively small cohort, comparison of cup migration patterns and investigating the influence of implant factors is difficult. Therefore, a systematic review and meta-analysis of RSA studies was conducted to investigate the early- and long-term migration patterns of acetabular cups and the influence of implant factors on cup migration over time.

Methods
A systematic search of PubMed, Embase and Scopus databases was performed to identify all RSA studies of cup migration following primary total hip replacement (THR). Proximal migration at 3 and 6 months; 1, 2, 5 and 10 years were considered for analysis. Implant factors investigated included fixation type, head size, bearing surface, uncemented coating design and year of implant introduction.

Results
There were 47 studies that reported the proximal migration of 83 cohorts (2338 cups). Majority of early migration occurred within the first 6 months post-operation (pooled-mean 0.11mm; 95CI±0.05, Figure 1). The was no significant increase in the mean pooled proximal migration between 1- and 2-years (0.015mm, 95CI±0.014) or 6-months and 2-years (0.015mm, 95CI±0.015). The mean pooled 2-year proximal migration of cemented cups (0.14; 95CI±0.06) was not significantly different to uncemented cups (0.12; 95CI±0.07). Pooled analysis was unable to be performed after 5-years due to the small number of long-term RSA studies. Notably, of 75 cohorts that reported 2-year proximal migration, 27 cohorts (36%) were considered at-risk (>0.2mm at 2-years). 25 of the at-risk cohorts had measurements at both 1- and 2-years and 22 were found to be above 0.2mm at 1-year.

Discussion/Conclusion
Our meta-analysis provides the first evidence that the majority of cup migration occurs within the first 6 months independent of the implant factors investigated within the first 5 years. Further investigation and comparison against long-term survivorship data is required to determine if 6-month and/or 1-year proximal migration measurements may be used as a predictor of long-term loosening.

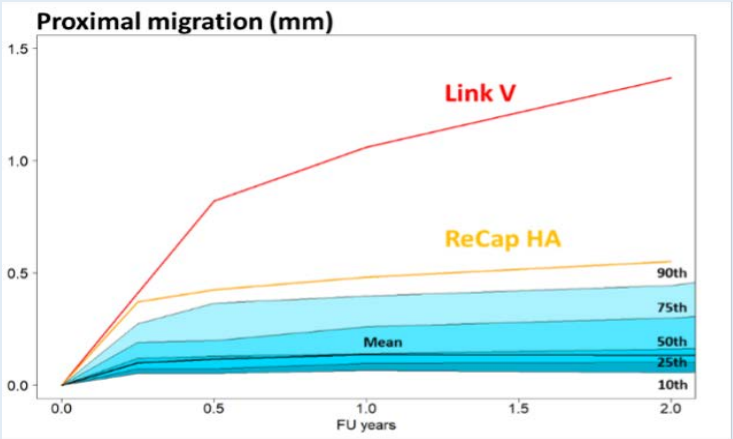


Figure. Early migration in percentiles of 83 study cohorts, 2,328 cups. The migration of two known acetabular cup failures are also plotted as they were outliers: the Link V cup and the ReCap hydroxyapatite coated cup.

Session 2

O10

THE MIGRATION PATTERNS OF TWO REDUCED LENGTH TOTAL HIP ARTHROPLASTY STEMS

Richardson G.[1], Laende E.2, Hurry. J.[3], Dunbar M.[1]
[1]Dalhousie University, Div. of Orthopaedics Surgery. Halifax NS; [2]Mechanical & Materials Engineering, Queen's University, Kingston ON.
[3]IWK NSHealth, Halifax NS

Introduction
The development of shortened femoral hip stems has minimized femoral bone removal and improved the ease of femoral component insertion. Reducing the stem length decreases the implant's resistance to tilting forces by decreasing the effective moment acting at the distal end of the hip stem. The optimum geometry hip stems, specifically the length, shape and surface roughness of cementless stems, are not currently known. The objective of this study was to evaluate the migration patterns of two uncemented shortened stems: the Hydroxyapatite (HA) coated Accolade II stem and the Trilock BPS stem with a highly porous titanium surface.

Methods
This prospective cohort study used model-based RSA to measure subsidence and rotation of the stems. Imaging was completed after surgery, and at 1.5, 3, 6, 12, and 24 months. Inducible displacement was measured at 12 months.

Results
Two-year RSA results were available for 50 patients, 25 each in the Accolade II and TriLock BPS groups. There was no difference in age or sex between the groups, but mean BMI was slightly higher in the Accolade II group at 32 (SD 5) vs. the Trilock BPS group at 28 (SD 4), p=0.01. Overall, mean subsidence at 2 years was not statistically different between groups with 0.08 mm (SD 0.15) for the Accolade II vs. 0.01 mm (SD 0.09) for the Trilock BPS (Figure 1). There was no difference in inducible displacement at one year or with stem rotation at 2 years. There were no implant effects on patient-reported pain, satisfaction or EQ-5D scores.

Discussion
It is possible the increased surface roughness of the Trilock BPS stem allows for greater initial stability as compared to the Accolade II stem with its HA coating. Both stems have mean two-year subsidence below the average two-year migration of 0.66 mm for other successful cementless stems.

Conclusion
The two stem designs did not affect inducible displacement, rotation, or the PROMs. The trend toward greater subsidence with Accolade II stem was not statistically significant in this cohort and both stems demonstrate stable fixation.

Session 2

O11

FIXATION AND MIGRATION OF THE G7 BISPHERICAL ACETABULAR SYSTEM COMBINED WITH THE GTS STEM FOR TOTAL HIP ARTHROPLASTY - AN RSA STUDY

Blom, I.F.[1,2], Vehmeijer, S.B.W.[1], Esch, de, N.[1], Mathijssen, N.M.C.[1]
[1] Reinier Haga Orthopedisch Centrum, Dept. of Orthopedics, Zoetermeer, The Netherlands,
[2]Reinier de Graaf Groep, Dept. of Radiology, Delft, The Netherlands

Introduction
Uncemented total hip arthroplasty (THA) have shown excellent rates of bone ingrowth, longevity and clinical results. However, after failure of a primary THA, a more challenging revision surgery is needed, mainly due to management of the bone stock loss. Therefore, the shorter Global Tissue Sparing (GTS) stem was developed to prevent the loss of bone stock. In this study, we investigated migration and clinical outcomes of this stem in combination with the G7 Acetabular system, designed for optimized intra-operative efficiency (Zimmer Biomet), up to 2 years.

Methods
In this prospective cohort study, 26 patients with primary osteoarthritis (OA) underwent anterior supine intermuscular approach for THA. Radiostereometric analysis (RSA) was performed to investigate migration. Migration was expressed in translations and rotations in x-, y- and z-directions. RSA radiographs were taken directly post-operative and at 6 weeks, 6 months, 1 year and 2 years after surgery. Clinical outcomes were assessed with the Oxford Hip score (OHS), Harris Hip Score and EQ5D.

Results
Both the G7 cup and GTS stem showed significant migration in all directions. At 2 years postoperatively, mean (SD) translation of the G7 cup was 0.78 (1.03), 0.60 (0.59) and -0.41 (1.03) mm along the x-, y-, and z-axis, respectively. Mean (SD) rotation was 1.47 (1.64), -0.74 (1.02) and 1.17 (1.78) degrees around these axes. Mean (SD) translation of the GTS stem was 0.34 (0.43), -1.52 (0.97) and -0.13 (0.46) mm and mean (SD) rotation was -0.49 (0.89), 1.85 (1.85) and 0.05 (0.81) degrees along these axes. For the G7 cup, 2 patients showed continuous migration. The GTS stem showed 4 patients with increased rotation on the x-axis for more than 2 degrees rotation. All clinical outcomes improved after 2 years compared to preoperative outcomes.

Discussion and Conclusion
Migration results of the GTS stem showed high translation on the y-axis and a high rotation value on the Y-axis. These values are comparable to previous studies. (1) Moreover, the GTS stem showed high migration pattern on multiple axis. Long-term follow-up is needed to investigate the relation between early migration and long-term results.

Session 2

O12

SIMILAR RESULTS AFTER 5 YEARS WITH USE OF THE FITMORE OR THE CLS STEM. RANDOMIZED STUDY OF 35 PATIENTS SIMULTANEOUSLY OPERATED WITH BILATERAL TOTAL HIP ARTHROPLASTY

Karin Rilby[1,2], Maziar Mohaddes[1,2] and Johan Kärrholm[1,2,3]
[1]Department of Orthopaedics, Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
[2]Department of Orthopaedic surgery, Sahlgrenska University Hospital, Gothenburg, Sweden
[3]Swedish Arthroplasty Register, Gothenburg, Sweden
Corresponding author: Karin Rilby, Department of Orthopaedic Surgery, Sahlgrenska University Hospital/ Mölndal, Göteborgsvägen 31, 43031 Mölndal. Email: karin.rilby@vgregion.se

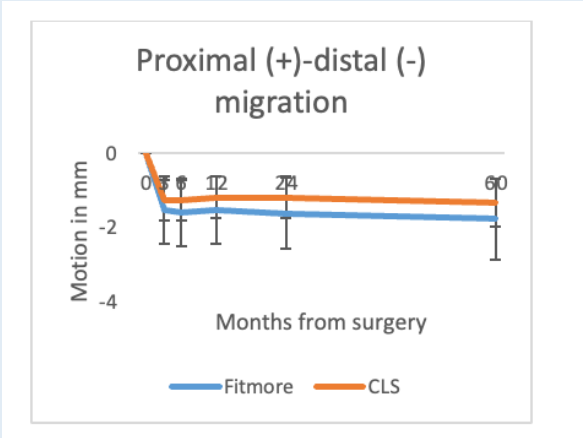
Introduction
Although the Fitmore stem has been on the market for almost 15 years, it is still not well documented in randomized controlled trials.

Methods
In total, 44 patients with bilateral hip osteoarthritis were recruited from the outpatient clinic at Sahlgrenska University Hospital, Mölndal, Sweden. The patients were operated with bilateral one stage total hip arthroplasty. The most painful hip was randomized to either a Fitmore or CLS stem, the second hip was operated with the stem not used on the first side. Patients were evaluated at 3 months, 6 months and at 1, 2 and 5 years with Patient Reported Outcome Measures, RadioStereometric Analysis (RSA), Dual Energy Absorptiometry and conventional radiography. 39 patients had complete follow up at 2 and 35 at 5 years.

Results
At 2 (primary outcome) and 5 years more patients considered the hip with the CLS stem as superior but without statistically significant difference. There were no differences in clinical outcome, magnitude of stem migration or change of bone mineral density at 5 years. At 3 months the Fitmore stems had subsided median -0.71, IQR -1.67 - -0.20 and the CLS stems -0.70, IQR -1.53 - -0.17, mm (p=0.74). In both groups the femoral head center had migrated posteriorly Fitmore: -0.17 IQR -0.98- -0.04 and CLS: -0.23 IQR -0.87 – 0.07, (p= 0.94). After 3 months both stems are stable as groups. There was a tendency to increased loss of bone mineral density during the first two years in the Fitmore group, which seemed to have levelled out at 5 years. At 5 years 1 stem (Fitmore) was revised due to aseptic loosening.

Discussion
Even though the Fitmore stem has been on the market since 2008 there is little evidence that it performs better than a stem of standard length.

Conclusions
Up to 5 years, we found no statistically significant difference in outcomes between the Fitmore and the CLS stem. The slightly worse outcomes including one revised hip because of loosening speaks against the hypotheses that the Fitmore stem should be advantageous to the CLS if more patients had been recruited to this study.



Migration of femoral head center (mm +/- 2 SEM).

Session 2

O13

MIGRATION AND STABILIZATION OF A SHORTENED HIP STEM IS COMPARABLE TO A STANDARD LENGTH HIP STEM IN CEMENTLESS TOTAL HIP ARTHROPLASTY. RESULTS OF A RANDOMIZED CONTROLLED TRIAL WITH 2 YEAR FOLLOW-UP

Lennard A. Koster[1], Bart L. Kaptein[1], E. Goorden[2], Stan A.M.P. Bell[2]
[1]Department of Orthopaedic Surgery, Leiden University Medical Center, Leiden, the Netherlands
[2]Department of Orthopaedic Surgery, Bravis Ziekenhuis, Roosendaal, the Netherlands

Introduction
Short hip stems have been introduced to preserve proximal bone stock, enable minimally invasive techniques and allow more physiological proximal loading reducing the risk of stress shielding. The shortened hip stem in this study, is a broach-only designed enabling minimal invasive techniques. Evidence on clinical performance is limited to mid-term observational data. Early migration measured with radiostereometric analysis (RSA) is a proxy for the risk of long term aseptic loosening. This randomized controlled trial was performed to compare migration and clinical performance of a shortened hip stem and its standard length counterpart.

Methods
Patients eligible for primary cementless total hip arthroplasty (THA) were prospectively randomized to receive a shortened (Microplasty) or a standard length (Reduced Distal) Taperloc Complete hip stem. Both stems had proximal plasma sprayed coating and were combined with an identical cup and liner (all components Zimmer Biomet, USA). Hip stem migration was calculated using Model-based RSA at 1.5, 12 and 24 months after surgery, using a baseline RSA acquisition within 1 week of operation before weightbearing. Clinical performance was scored at the same follow-ups.

Results
Per-protocol analysis of 15 short and 20 long stems, showed that both designs subsided and rotated longitudinally initially, but stabilized from 1.5 months onwards (Figure 1). Mean (95% CI) subsidence and longitudinal rotation were comparable, with -1.50mm (-0.74:-2.26), 2.54deg (3.82:1.26) and -2.31mm (-0.67:-3.95), 1.43deg (2.42:0.44) for short and standard length stems respectively. Clinical performance was not different between designs and all indicated successful THA.

Discussion/conclusion
The short and standard stems in this study performed equally well. The standard length stem is a design with a long and excellent track record. Although no migration threshold have been established, stabilisation appears to be important for a lower long-term risk for aseptic loosening. As such the studied shortened stem is expected to perform well at long-term and could be used as an alternative for the standard length stem in primary cementless THA.

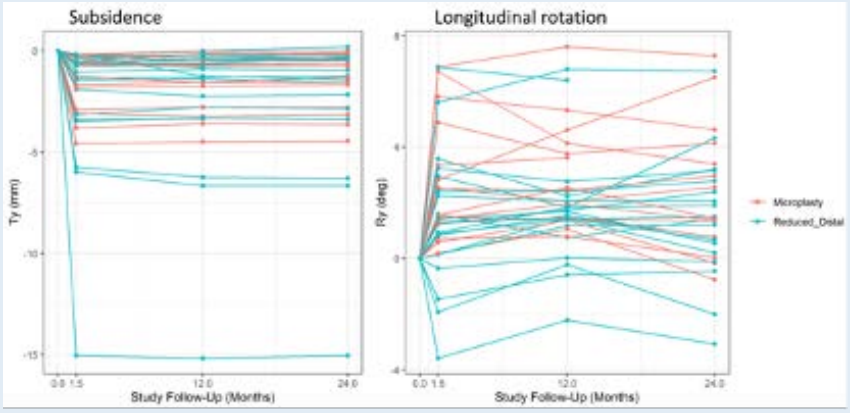


Figure Individual patient subsidence (Left panel) and longitudinal rotation (Right panel) of the shortened (Microplasty) and standard length (Reduced_Distal) hip stems.

Session 2

O14

HIGHLY POROUS TANTALUM ACETABULAR COMPONENTS WITHOUT ANCILLARY SCREWS HAVE SIMILAR MIGRATION AT FIVE YEARS WHEN COMPARED WITH TITANIUM COMPONENTS WITH ANCILLARY SCREW FIXATION: A RANDOMIZED CONTROLLED TRIAL

Robertson T.[1,2], Howie D.W.[1,2], Holubowycz O.[1,2], Solomon L.B.[1,2], Callary S.[1,2]
[1]Centre for Orthopaedics and Trauma Research (COTR), The University of Adelaide, Adelaide, South Australia, Australia;
[2]Department of Orthopaedics and Trauma, Royal Adelaide Hospital, Port Road, Adelaide, South Australia, Australia

Introduction
Highly porous tantalum acetabular components are theorised to provide excellent initial fixation in hip arthroplasty due to their advantageous properties for biological bone ingrowth. Whilst tantalum components have shown to be advantageous in the revision setting, registry studies have identified tantalum components used in primary surgery to be associated with an increased risk of revision. The aim of this randomised study is to compare the mid-term migration of tantalum acetabular components without ancillary screw fixation to titanium components with one ancillary screw fixation.

Methods
66 patients aged 40 to 64 years, with osteoarthritis and Charnley Grade A or B activity grade and who underwent primary THA, were randomized intra-operatively to receive either the tantalum or titanium acetabular component. All patients received the same cemented polished tapered femoral stem, 28-mm cobalt chrome femoral head and highly cross-linked polyethylene liner. Acetabular component migration relative to the surrounding acetabular bone was measured using radiostereometric analysis (RSA) at 4-6 days post-operatively and at 6 weeks, 3 months, 1, 2, 3 and 5 years following THA.

Results
Prior to five years follow-up, (2 tantalum components were revised due to recurrent dislocation and infection. Two additional patients (titanium components) underwent open reduction internal fixation to treat femoral periprosthetic fracture. Harris Hip scores and functional activity scores were similar between groups. At 5 years the mean proximal migration of tantalum components was 0.259mm (95%CI 0.130- 0.387) was not-inferior to titanium components 0.230 (95% CI 0.101 - 0.359) (Figure 1).

Discussion and Conclusion
This trial is the largest of its kind to demonstrate mid-term non-inferiority of tantalum acetabular components without ancillary screw fixation compared to titanium acetabular components. In contrast to previous non-randomised RSA studies, the continued stability provides reassurance to the operative surgeon using tantalum components in the primary setting.

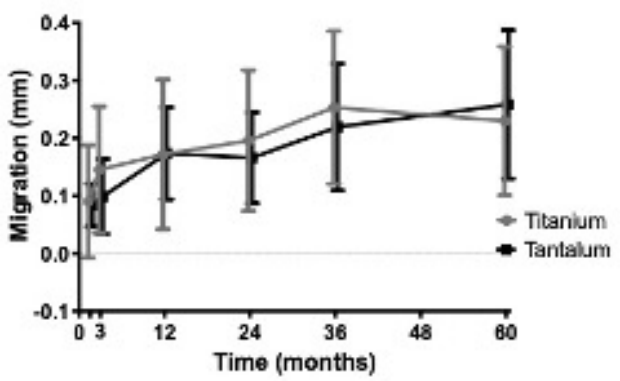


Figure: The mean proximal migration of each cohort at each RSA time interval. Error bars represent 95% confidence interval.

ABSTRACTS

Session 3

Migration - Knee

O15 **Construct stability of revision total knee arthroplasty with tibial cones: Preliminary results of a radiostereometric analysis (RSA)**
Petra Heesterbeek

O16 **Increasing medial conformity of a tibial insert from intermediate to ball-in-socket does not increase tibial baseplate migration**
Abby Niesen

O17 **Inducible micromotion during step-up test evaluated in stabile and continuous migrating medial unicompartmental knee arthroplasties. A dynamic and static RSA study with minimum 5 years follow-up**
Jonathan Jürgens-Lahnstein

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Session 3

O15

CONSTRUCT STABILITY OF REVISION TOTAL KNEE ARTHROPLASTY WITH TIBIAL CONES: PRELIMINARY RESULTS OF A RADIOSTEREOMETRIC ANALYSIS (RSA)

Heesterbeek P.J.C.[1], Belt M.[1], van Hellemondt G.G.[2]
[1]Research Department, Sint Maartenskliniek, Nijmegen, the Netherlands;
[2]Department of Orthopedics, Sint Maartenskliniek, Nijmegen, the Netherlands

Introduction
In (re-)revision total knee arthroplasty (TKA), cones can be used to ensure sufficient fixation of the prothesis in the bone in case of suboptimal metaphyseal bone stock (Fig.). Whether this construct results in stable and safe fixation of the implant, remains to be investigated. We aimed to investigate the stability of the fixation in the bone of the Legion revision TKA with cones until 5 years postoperatively.

Methods
Twenty five patients who underwent a revision TKA with a tibial cone (Smith+Nephew, Memphis (TN), USA) were included in this prospective study. During surgery, tantalum markers were inserted in the tibial bone. The stability was assessed by measuring micromotion (total translation (TT) and total rotation (TR)) of the tibial component with respect to the bone by using model-based RSA analysis (RSAcore, Leiden, the Netherlands). Radiographs were made post-operative, after 6 weeks, 3 months, 6 months, 1 year, 2 years, and 5 years.

Results
Currently, 24 patients were included and of those, 20 patients completed the 6 months follow-up, and 18 the 1-year follow-up. Median age at the time of surgery was 64 years (IQR 60-67 years), and median BMI was 31 (IQR28.2-33.1). The reason for revision was loosening (12/14), instability (1/14) and malalignment (1/14). Median TT at 1 year was 0.48 (IQR0.34-1.35), median TR was 0.93˚ (0.41-1.33). 5 patients showed TT>1mm, 7 patients rotation >1˚. One patient was lost to follow after 1 year due to a repeat revision TKA for loosening.

Discussion and Conclusion
So far, results on group level show a stable fixation, although there are outliers with more micromotion. One patient had a repeat revision TKA for loosening, not evidently related to migration as measured with RSA. At the time of the conference, we expect to share the 1-year migration results of 20/25 patients.

Figure: Cones for tibia and femur (Smith+Nephew), left image, and placement in the tibia bone of a patient with a revision TKA, middle and right images.

Session 3

O16

INCREASING MEDIAL CONFORMITY OF A TIBIAL INSERT FROM INTERMEDIATE TO BALL-IN-SOCKET DOES NOT INCREASE TIBIAL BASEPLATE MIGRATION

Abigail E. Niesen[1], Pranav A. Tirumalai[1], Stephen M. Howell[1], Maury L. Hull1-[3]
Departments of 1 Biomedical Engineering, [2] Mechanical Engineering, [3] Orthopaedic Surgery,
University of California, Davis

Introduction

Increasing medial conformity of a tibial insert from intermediate (I-MC) to ball-in-socket (BS-MC) may increase risk of tibial baseplate loosening and reduce range of motion after unrestricted kinematically aligned (KA) total knee arthroplasty (TKA), which aligns a majority of baseplates in varus. The present study determined whether BS-MC and I-MC inserts had: (1) different maximum total point motion (MTPM), (2) a relationship between MTPM and proximal medial tibial angle (PMTA) and (3) different range of motion (extension and flexion) and clinical outcome scores (Oxford Knee Score (OKS) and Forgotten Joint Score (FJS)) 1 year after unrestricted KA TKA.

Methods

Two cohorts of 35 patients each underwent cemented, unrestricted KA TKA with posterior-cruciate ligament retention and received either the BS-MC or I-MC insert. Biplanar radiographs, acquired on the day of surgery and at four follow-up timepoints (1.5, 3, 6, and 12 months), were processed using model-based RSA to determine MTPM. Two-factor analysis of variance (ANOVA) determined whether MTPM differed for the two insert designs at the follow-up timepoints. Linear regression determined whether there was a relationship between PMTA and MTPM. Kruskal-Wallis tests determined whether maximum extension, maximum flexion, OKS, and FJS differed for the two insert designs at 1 year. Significance was $p < 0.05$.

Results

Preoperative age, body mass index, and OKS were no different between cohorts ($p \geq 0.3469$). There was no difference in mean MTPM for insert design ($p = 0.5598$)(Figure). There was no relationship between PMTA and MTPM at 1 year ($p \geq 0.3276$). There were no significant differences in maximum extension, maximum flexion, OKS, or FJS ($p \geq 0.0810$).

Discussion/Conclusion

Increasing medial conformity did not increase baseplate migration as indicated by mean MTPM. Mean MTPMs for both insert designs were below 0.5 mm at 1 year, a result indicating a low risk of long-term tibial baseplate loosening. Because MTPM was unrelated to PMTA, restricting alignment to ±3° for KA TKA is unjustified. Range of motion and clinical outcomes were comparable for the two insert designs.

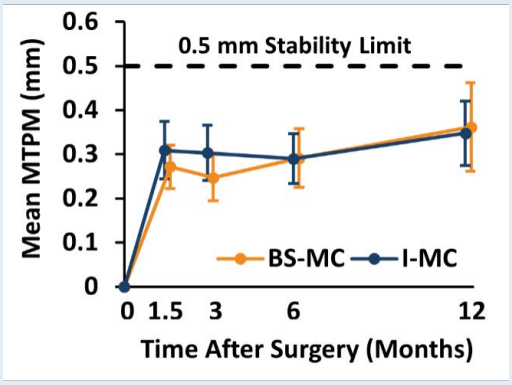


Figure: Mean maximum total point motion (±95% confidence interval using error bars) of tibial baseplates using two insert designs.

Session 3

O17

INDUCIBLE MICROMOTIONS RECORDED WITH DYNAMIC RADIOSTEREOMETRIC ANALYSIS IN 55 UNICOMPARTMENTAL KNEE ARTHROPLASTIES WITH CONTINUES AND NON-CONTINUES MIGRATION

Jonathan Hugo Jürgens-Lahnstein[1,2], Emil Toft Nielsen[1,2], Tobias Dahl Vind[2], Søren Rytter[1,2], Maiken Stilling[1,2]
[1]Aarhus University Hospital
[2]Auto RSA Research Group

Introduction
Static radiostereometric analysis (static RSA) is an established research method to evaluate knee prosthesis stability post-operatively by use of several RSA images obtained over a minimum of 2 years. Based on MTPM migration between 1 and 2 years follow-up knee prostheses can be classified as stable or having continuous migration, the latter predicting a greater risk of revision surgery. Dynamic radiostereometric analysis (dynamic RSA) records the migration pattern (inducible displacement) of a loaded knee prosthesis during a single examination step-up test. The predictive power of inducible displacement on knee prosthesis revision surgery is unknown.

The aim of this study was to investigate the association of inducible displacement (dynamic RSA) and continuous migration (static RSA) of medial unicompartmental knee arthroplasty (UKA).

Methods
55 patients with a medial UKA and static unloaded RSA follow-up to either 2 years or 5 years follow-up (n=8 at 2 years, n=47 at 5 years) were recruited from the AutoRSA database and examined with dynamic RSA during a step-up test in addition to standing Hip-Knee-Ankle radiographs (for the mechanical loading axis). Model-based RSA with a bone-marker reference was used for RSA analysis. Patients with tibial component static RSA migration between 1 and 2 years above 0.2mm MTPM were classified as continuous migrators. For both static and dynamic RSA we recorded translations and rotations along all 3 axis (x, y, z) as well as total translation (TT) and MTPM.

Results
10 patients had UKA tibial components that were classified with continuous migration. In general, the UKA tibial components showed inducible displacement during the step-up test. However, only for mean translation y (stand phase: non continuous: -0.04 mm (95% CI: - 0.06 - -0.01), continues: -0.08 mm (95% CI: -0.16 – 0.00)) and mean total translation (stand phase: non continues: 0.02 mm (95% CI: 0.00 – 0.05), continues: 0.07 mm (95% CI: -0.01 – 0.13)). There was not statistically relevant difference between both groups for the mentioned values. Varus and valgus position of the knee did not influence the inducible tibial component UKA migration pattern (p>0.05).

Discussion/Conclusion
We did not find an association between the migration pattern of tibial components in UKA evaluated as inducible migration during dynamic RSA and as continuous/stable migration with static RSA. The importance of UKA inducible migration for prediction of later revision remains to be investigated in larger studies.

Session 3

O18

INDUCIBLE DISPLACEMENT OF A CEMENTLESS TOTAL KNEE REPLACEMENT AT ONE YEAR POST-OPERATION

Jordan S. Broberg[1-3], J.L. Howard[4], B.A. Lanting[4], and M.G. Teeter[1-4]
[1]Department of Medical Biophysics, Schulich School of Medicine & Dentistry, Western University, London, Canada; [2]Robarts Research Institute, London Canada; [3]Lawson Health Research Institute, London, Canada; [4]Department of Surgery, Schulich School of Medicine & Dentistry, Western University, London, Canada

Introduction
Cementless total knee replacement (TKR) designs are growing in popularity. While multiple studies utilizing radiostereometric analysis (RSA) have shown sufficient fixation of cementless components, few studies have investigated the inducible displacement. The goal of this study was to assess the inducible displacement in tibial baseplates of a modern cementless TKR design.

Methods
Thirty-three patients were included in the analysis. Supine and weightbearing RSA exams were performed at 1-year post-operation. The weightbearing exams consisted of a standing exam (0°), and multiple squat positions with the operated knee at flexion angles of 20°, 40°, and 60°. Inducible displacement between supine and weightbearing exams were reported as maximum total point motion (MTPM) and as 3D translations at different fictive points around the tibial component. Correlations between the flexion angle of the operated knee and inducible displacement were calculated.

Results
The MTPM for the standing (0°) inducible displacement exam was 1.22 ± 0.67 mm. Inducible displacement for the standing (0°) exam was greatest at the medial fictive point (0.92 ± 0.65 mm), followed by the posteromedial (0.83 ± 0.54 mm), anteromedial (0.82 ± 0.47 mm), posterolateral (0.76 ± 0.50 mm), lateral (0.76 ± 0.62 mm), anterolateral (0.72 ± 0.45 mm), and stem tip points (0.54 ± 0.25 mm). An increased operated knee flexion angle correlated with increased inducible displacement (Figure 1). The strongest correlation was at the stem tip fictive point ($r2 = 0.49$, $p < 0.0001$), followed by the anterolateral point ($r2 = 0.20$, $p < 0.0001$), the anteromedial point ($r2 = 0.16$, $p < 0.0001$), and MTPM ($r2 = 0.15$, $p < 0.0001$).

Conclusions
Inducible displacements during a standing position for tibial baseplates of a modern cementless TKR design were greater on the medial side. The MTPM for the standing displacements were, on average, within ranges expected for stable components. The strongest correlation was observed at the stem tip, with both the anterior-posterior translation of the stem tip point and X-axis rotation of the baseplate suggesting a posterior tilt is being induced during the weightbearing exams. An increased knee flexion angle in a weightbearing squat position correlated with greater inducible displacements.

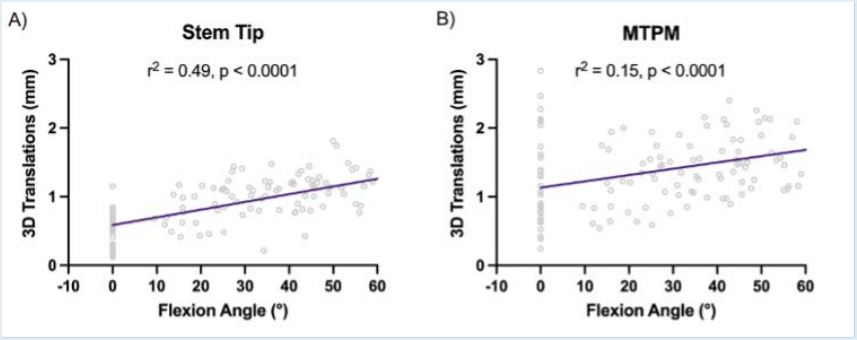


Figure. Plots depicting the correlations between the knee flexion angles during the weightbearing RSA exams and inducible displacements of the tibial baseplate at the A) stem tip fictive point, and for B) the maximum total point motion (MTPM).

Session 3

O19

TOPICAL ZOLEDRONATE DECREASES MIGRATION OF CEMENTLESS TOTAL KNEE ARTHROPLASTY BY SUPPRESSION OF BONE RESORPTION: A RANDOMIZED, DOUBLE-BLINDED RSA STUDY OF 55 PATIENTS WITH 5 YEARS FOLLOW-UP

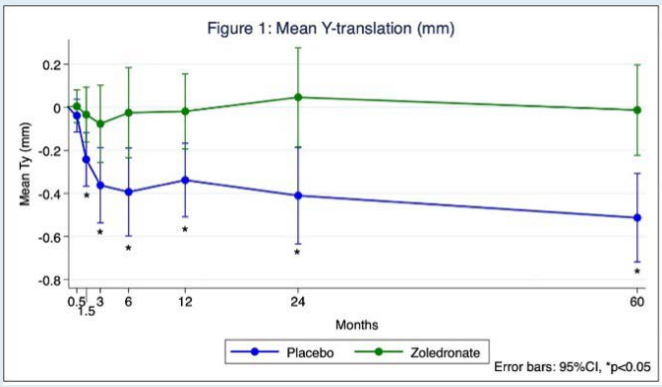
Linde K.N.[1,2], Rytter S.[1], Langdahl B.L. [2,3], Madsen F.1, Stilling M.[1,2]
[1]Department of Orthopaedics, Aarhus University Hospital, Aarhus Denmark
[2]Institute of Clinical Medicine, Aarhus University, Aarhus, Denmark
[3]Department of Endocrinology and Internal Medicine, Aarhus University Hospital, Aarhus Denmark

Introduction
Cementless tibial implants migrate initially until osseointegration. Bisphosphonates inhibit osteoclast activity and reduce bone resorption. We hypothesized that topical zoledronate (ZOL) decreases early migration of cementless tibial implants.

Methods
A prospective, double-blinded, randomized study including 55 patients operated with a total knee arthroplasty using a cementless tibial implant (Regenerex). Patients were randomized to either soaking of the cut off tibia plateau for 60 seconds with 2 ml NaCl (9mg/ml) (placebo group) or ZOL (0.6 ml ZOL (0.8 mg/ml) diluted in 1.4 ml NaCl (ZOL group). We compared migration (subsidence/Y-translation) of the tibial implant using Radiostereometry Analysis (RSA), measured bone turnover markers in blood samples (CTX, P1NP) and periprosthetic Bone Mineral Density (p-BMD) by dual-energy X-ray absorptiometry (DXA). RSA, DXA and blood samples were obtained postoperative and at 2-, 6-, 12- and 24 weeks and at 1-, 2-, and 5-years follow-up.

Results
The ZOL group had statistically significantly less subsidence than the placebo group (figure 1: Mean Y-translation). At 5 years, mean subsidence was -0.01 mm (95% CI: -0.22; 0.20) in the ZOL group and -0.51 mm (95% CI: -0.72; -0.31) in the placebo group (p=0.001). Subsidence from 1- to 5-years follow-up were similar between groups (p>0.08). Bone resorption (CTX) was lower at 2 weeks follow-up in the ZOL group than in the placebo group (p<0.001), bone formation (P1NP) was similar between groups (p>0.05) and p-BMD was higher in ZOL group than in the placebo group after surgery (p=0.031).

Discussion and Conclusion
Most implant migration occurred during the first 6 months after surgery, where the balance between bone formation and resorption plays a major role in implant osseointegration. Topical administration of ZOL during surgery resulted in a net bone gain measured by DXA in addition to a decrease of initial tibial implant migration, which may be explained by suppression of local bone resorption as expressed by bone biomarkers. The migration pattern from 1- to 5-years follow-up was stable and similar in both groups suggesting stable long-term fixation and safety with ZOL treatment.
Topical ZOL may be a clinically significant medical improvement of arthroplasty surgery for survival of cementless tibial implants.



Session 3

O20

EARLY MIGRATION OF TOTAL KNEE REPLACEMENTS; AN UPDATED SYSTEMATIC REVIEW, META-ANALYSIS, AND DATABASE STUDY

Raymond Puijk[1], Rowan H. Puijk[1], José W. M. Plevier[2], Elise K Laende[3, 4], Michael J. Dunbar[4, 5], Peter A. Nolte[1, 6], Bart G.C.W. Pijls[7]
[1]Department of Orthopaedics, Spaarne Gasthuis, Hoofddorp, the Netherlands.
[2]Walaeus Library, Leiden University Medical Center, Leiden, The Netherlands.
[3]Mechanical and Materials Engineering, Queen's University, Kingston, Ontario, Canada
[4]Division of Orthopaedics, Department of Surgery, Dalhousie University and QEII Health Sciences Centre, Nova Scotia Health Authority, Halifax, Nova Scotia, Canada.
[5]School of Biomedical Engineering, Dalhousie University, Halifax, Nova Scotia, Canada
[6]Department of Oral Cell Biology, Academic Centre for Dentistry (ACTA), University of Amsterdam and Vrije Universiteit Amsterdam, Amsterdam, the Netherlands.
[7]Department of Orthopaedics, Leiden University Medical Center, Leiden, The Netherlands.

Introduction
We combined two international databases and updated a systematic review and meta-analysis to evaluate the early and long-term migration of tibial components of Total Knee Replacements (TKR) measured with Radiostereometric Analysis (RSA).

Methods
Data was collected from two international RSA databases (the Netherlands and Canada) and combined with all known studies found through PubMed, Embase, Web-of-Science, the Cochrane Library, and Google Scholar, that reported migration patterns measured with RSA for primary TKR up to May 2022. Study groups were classified according to prosthesis, fixation, and insert (PFI). Migration pattern was defined as Maximal Total Point Motion (MTPM) measured on at least two postoperative RSA follow-up moments.

Results
The databases included 357 TKR records (61 TKRs from the Netherlands and 296 TKRs from Canada). Additionally, the search yielded 1437 new records of which 38 new studies and 66 new study groups were included. Together, 189 study groups with a total of 4574 knees were included for analyses. Most migration occurred in the first 6 months post-operatively (MTPM6m = 0.66mm, based on 109 study groups) followed by a period of little additional migration at 2-year follow-up (MTPM2y =0.61mm based on 181 study groups) and at 5-year follow-up (MTPM5y = 0.68mm based on 44study groups). There were 11 study groups with 10-year migration: MTPM10y = 0.72mm ranging from 0.37mm to 2.25mm. The migration between cemented and uncemented tibial components was different with MTPM1y being 0.44mm [CI 0.39 to 0.48mm] for cemented and 0.99mm [CI 0.85 to 1.12mm] for uncemented. These results remained similar when restricted to studies performed in the last decade (2010 and onwards): MTPM1y = 0.53mm [CI 0.42 to 0.64mm] for cemented and MTPM1y = 0.89mm [CI 0.66 to 1.11mm] for uncemented.

Conclusion
This updated meta-analysis included 4574 TKRs and confirmed our previous findings that most migration occurs in the first 6 months postoperatively. The results also confirmed the difference in migration pattern between the cemented and uncemented tibial components. In particular, pooled migration patterns concerning uncemented prostheses have been updated. This data can be used both as benchmarks and for defining migration thresholds for future evaluation of new TKR.

Session 3

O21

MICROMOTION OF A CEMENTED HINGED-TYPE KNEE REVISION SYSTEM, MEASURED WITH MODEL-BASED RSA

van Laarhoven S.N., te Molder M.E.M., van Hellemondt G.G., Heesterbeek P.J.C.
Department of Orthopaedics, Sint Maartenskliniek, Nijmegen, The Netherlands

Introduction
Hinge knee implants are highly constrained prostheses used in cases in which adequate stability is mandatory. Due to the high constraint nature of the implant, multidirectional stresses are directed through the bone-cement-implant interface, which might explain the relatively high rates of aseptic loosening. The goal of this study was to assess the micromotion of a fully cemented hinged knee implant by the use of radiostereometric analysis (RSA).

Methods
Twenty patients requiring a revision with a fully cemented Legion Hinge Knee System (Smith+Nephew, Memphis, USA) were included. RSA images were taken at baseline, 6 weeks, 3, 6, 12, and 24 months postoperatively. Micromotion of the femoral and tibial components referenced to the markers in the bone was assessed with model-based RSA software, using implant CAD-models (RSAcore, Leiden, The Netherlands). Maximal total point motion (MTPM), total translation (TT) and total rotation (TR) were calculated (median(interquartile range)).

Results
At 2 years, MTPMfemur was 0.87 (0.61-1.63)mm and MTPMtibia was 0.66 (0.57-0.98)mm. TTfemur was 0.36 (0.31-0.83)mm and TRfemur was 0.71 (0.44-1.12)° at 2 years. TTtibia was 0.40 (0.27-0.54)mm and TRtibia was 0.53 (0.39-0.96)° (Fig1). Migration outliers (TT>1mm or TR>1° at 2yrs) were higher in femoral components (7/16) compared to tibial components (2/11). Due to lost to follow-up (3) and insufficient marker visibility micromotion could be assessed in 16 femoral and 11 tibial components at final follow-up.

Discussion
This world-wide-first RSA study on a fully cemented hinged implant in revision TKA showed some degree of early micromotion followed by stabilisation between 6 weeks and 2 years, which was comparable to previous findings in condylar revision TKA. Femoral components showed more micromotion compared to tibial components, which is in contrast to previous clinical and RSA studies on revision TKA and might be caused by the hinge mechanism. So far, none of the implants were revised nor suspected for loosening at 2 years follow-up.

Conclusion
Fixation of this fully cemented hinge-type revision TKA seems adequate in the first 2 years postoperative. Extended follow-up will be needed to ascertain whether the degree of migration will lead to early re-revisions later on.

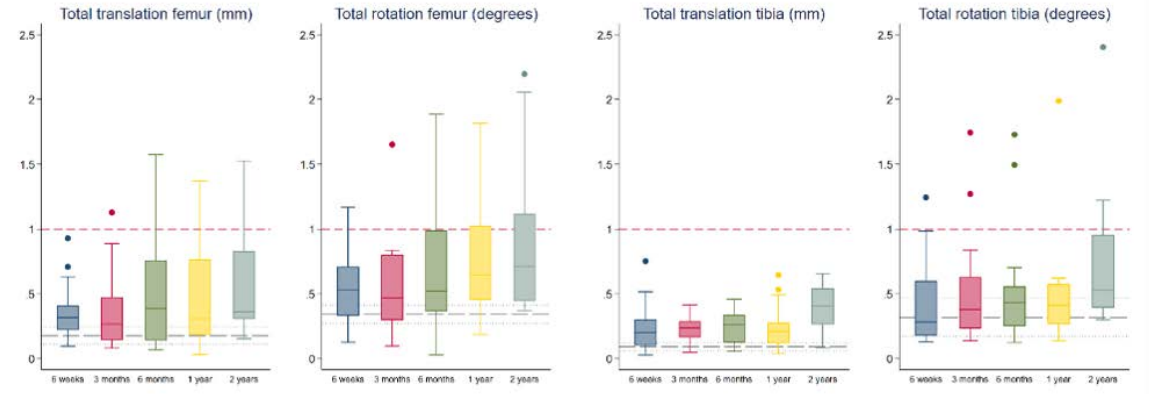


Fig. 1: Total Translation and Total Rotation of the femoral and tibial components at follow-up intervals

Session 3

O22

COMPARING LONG-TERM MIGRATION OF THE SAME TKA DESIGN USED IN DIFFERENT RSA STUDIES - 10-YEAR FOLLOW-UP OF 5 RANDOMIZED CONTROLLED TRIALS USING RADIOSTEREOMETRIC ANALYSIS

T.J.N. van der Lelij, P.J. Marang-van de Mheen, B.L. Kaptein, S. Toksvig-Larsen, R.G.H.H. Nelissen
[1]Dept. of Orthopaedic Surgery, LUMC, Leiden, The Netherlands
[2]Dept. of Biomedical Data Sciences, LUMC, Leiden, The Netherlands
[3]Dept. of Orthopaedic Surgery, Hässleholm Hospital, Hässleholm, Sweden
[4]Dept. of Clinical Sciences, Lund University, Lund, Sweden

Introduction
Radiostereometric analysis (RSA) studies with long-term follow-up on the migration of tibial components in total knee arthroplasty (TKA) are scarce. Moreover, the few studies reporting migration results up to 10 years postoperatively include different TKA designs. Even within cemented and cementless fixation groups, patient characteristics and surgeon-dependent factors like TKA alignment may influence migration. We therefore compared the long-term migration results of the exact same tibial components in TKA but used in different trials.

Methods
5 randomized RSA studies, all performed at the same hospital (Hässleholm, Sweden) included 300 TKAs with 6 distinct TKA implant subtypes (all Stryker, NJ, USA). Tibial component migration (maximum total point motion (MTPM)), was evaluated with RSA at baseline and 3 months, 1, 2, 5, 7, and 10 years postoperatively. A linear mixed-model was used to analyse the repeated measurements.

Results
114 Triathlon cruciate retaining (CR) cemented and 57 Triathlon CR cementless peri-apatite (PA)-coated implants were included from respectively 4 and 2 individual studies. 4 other TKA designs were only included in 1 study. Studies using the same TKA differed in baseline characteristics, including gender ratio, Ahlbäck classification, BMI, and surgeon. There was no significant difference in mean migration over the whole follow-up period between the studies for the Triathlon CR cemented (p=0.81) and Triathlon CR cementless PA-coated TKA (p=0.98) (Figure 1.). After adjusting for the previously stated baseline characteristics, the difference in migration between studies remained non-significant.

Discussion
No difference was found in estimated long-term migration of the same TKA designs used in different RSA studies. The cementless tibial components showed a biphasic migration pattern with high initial migration, while cemented components are initially more stable as the cement provides instant fixation. Interestingly, the cemented TKA did show statistically significant migration beyond 2 years. This warrants further research as individual RSA studies focusing on the between-group comparison of mean MTPM at one follow-up moment may overlook significant change in migration between follow-up moments within one of the groups.

Conclusion
The Triathlon CR cemented and Triathlon CR cementless PA-coated tibial components showed comparable migration when used in different RSA

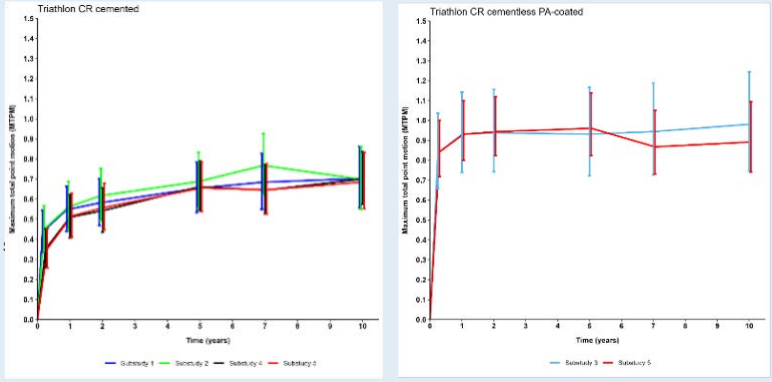


Figure: Mean maximum total point motion during 10-years of follow-up of the Triathlon cruciate retaining (CR) cemented and Triathlon CR cementless peri-apatite (PA) coated implant. The individual lines represent the different RSA studies.

Session 3

O23

RANDOMIZED CONTROLLED TRIAL COMPARING TRADITIONAL VERSUS ENHANCED-FIXATION DESIGNS OF A NOVEL CEMENTED TOTAL KNEE REPLACEMENT TIBIAL COMPONENT

"The Canadian RSA Network" consisting of: Turgeon T.R.[1,2,5], Vasarhelyi E.M.[3], Howard J.[3], Teeter M.G.[3,4], Gascoyne T.C5, Bohm E.R.[1,2,5]
[1]Concordia Joint Replacement Group
[2]University of Manitoba
[3]London Health Sciences Centre
[4]Lawson Health Research Institute
[5]Orthopaedic Innovation Centre

Purpose
The Attune S+ total knee replacement (TKR) is a recently released device featuring a novel backside surface design and surface finish on the tibial baseplate, intended to enhance cement bonding. This study aims to study the effect of the enhanced fixation surface on tibial baseplate stability by comparing the Attune S+ (EF-TKR) to the original Attune (Std-TKR) tibial baseplate using model-based radiostereometric analysis (MBRSA).

Method
Fifty-four patients requiring primary total knee arthroplasty for end-stage osteoarthritis were enrolled at two Canadian centres. Patients were randomized to receive either the EF-TKR or Std-TKR tibial baseplate. Surgical technique was standardized between the two sites. Patients underwent supine RSA imaging at 6 weeks (baseline), 3, 6, 12, and 24 months following surgery, with an additional weight-bearing RSA image obtained at 24 months at one site. The primary study outcome was progression of tibial baseplate subsidence between 12 and 24 months which was compared against a literature threshold of 0.2mm for acceptable migration. Several patient reported outcome measures were also collected throughout the study. Statistical analysis utilized paired and unpaired t-tests with significance set at $p \leq 0.05$.

Results
Forty-four patients (26 females) completed the study to 24 months. Mean patient age was 66±6.7 years and body mass index was 32.3±5.8kg/m2. Tibial baseplate subsidence between 12 and 24 months was not statistically different between Std-TKR (0.000±0.044mm) and EF-TKR (0.018±0.023mm) groups (p=0.128). No patients demonstrated ≥0.2mm of baseplate subsidence between 12 and 24 months. No significant differences in cumulative tibial baseplate subsidence or other directions of motion were found at any follow-up (p>0.100). Weight bearing exams revealed no difference in baseplate subsidence between groups (p=0.935) and virtually no induced displacement. All patients reported significant functional improvement from baseline to 12 and 24 months after surgery.

Conclusion
Our study demonstrates that the Attune and Attune S+ tibial baseplate variants achieve rigid cemented fixation that is maintained to 2 years post-surgery with acceptably low-risk potential for aseptic loosening as well as similar patient-reported health and functional outcomes.

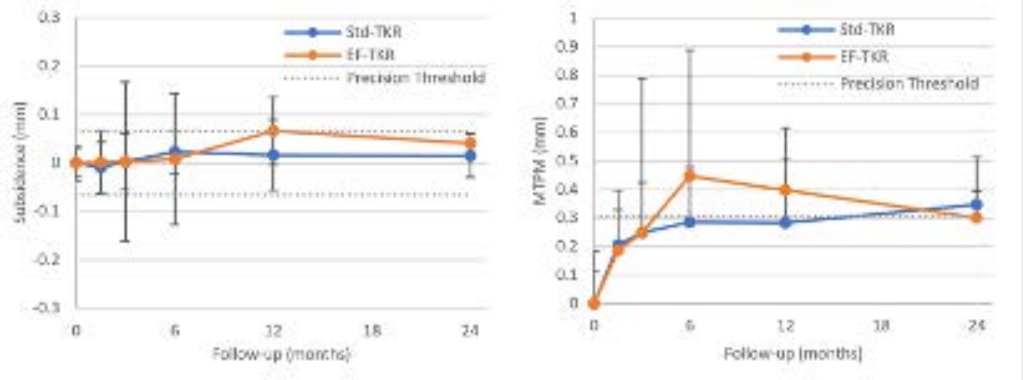


Figure: Tibial baseplate migration over time.

ABSTRACTS

Session 4
Methods

O24 **Differences in globally-aligned versus local baseplate coordinate systems when computing migration using model-based radiostereometric analysis**
Abby Niesen

O25 **Influence of marker-selection method on mean tibial baseplate migration and individual migration patterns in TKA using marker-based RSA. A re-analysis of an RCT with 5 year follow-up**
Thies van der Lelij

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O27 **The Influence of bead size on migration parameters of model-based roentgenstereometric analysis in small joints: A comparison of 0.5 mm and 1.0 mm beads in the proximal interphalangeal joint, a phantom study**
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O28 **Corroboration of coupled musculoskeletal model and finite element predictions with in-vivo RSA migration of an uncemented acetabular component**
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O29 **Radiostereometry of a novel ceramic hip resurfacing – comparison of clinical precision for uniplanar and biplanar techniques**
Martin Downing

O24

DIFFERENCES IN GLOBALLY-ALIGNED VERSUS LOCAL BASEPLATE COORDINATE SYSTEMS WHEN COMPUTING MIGRATION USING MODEL-BASED RADIOSTEREOMETRIC ANALYSIS

Abigail E. Niesen[1], Bart L. Kaptein[4] and Maury L. Hull[1-3]
[1]Department of Biomedical Engineering, University of California, Davis,
[2]Department of Mechanical Engineering, University of California, Davis,
[3]Department of Orthopaedic Surgery, University of California Davis Medical Center
[4]Department of Orthopaedic Surgery, Leiden University Medical Center, Leiden, The Netherlands

Introduction

When using model-based radiostereometric analysis (RSA) to quantify tibial baseplate migration after total knee arthroplasty (TKA), a coordinate system is needed to report migrations in six degrees of freedom. Establishing consistent and clinically relevant migration directions among patients and baseplate designs/sizes is challenging. Deviations in imaging alignment (alignment of the tibia/baseplate during image acquisition) and surgical alignment (alignment of the baseplate on the tibia) will affect migrations when using a globally-aligned baseplate coordinate system (BCS) (defined by the calibration box). Computing migration using a local BCS (defined by the baseplate) may be preferrable. Objectives were to propose a method for defining a local BCS and provide clinical examples to demonstrate differences in the two BCSs for a baseplate with rotational deviations relative to the imaging planes due to imaging and/or surgical alignments.

Methods

Consistent with ISO16087:2013, the local BCS was defined using right-sided anatomic directions: x = medial, y = proximal, and z = anterior. Specifically, +y-axis was perpendicular to the undersurface of the tibial tray pointing proximally, +z-axis was perpendicular to the posterior vertical surface of the tibial tray pointing anteriorly, and +x-axis was the cross product. The globally-aligned BCS placed the origin at the baseplate centroid. The local BCS placed the origin at the point where the tibial tray's lower surface intersected the tibial stem's central axis. Migration values that were previously computed for an example patient using a local BCS were recomputed using a MATLAB simulation to those that would have resulted from using a globally-aligned BCS under three clinically relevant rotational deviations.

Results

In the examples, migration values between the two BCSs differed up to 0.3 mm in translations and 0.4° in rotations (Table). In the imaging alignment example, the direction of y-translation was inconsistent; using the globally-aligned BCS resulted in distal translation (subsidence) and using the local BCS resulted in proximal translation (liftoff).

Discussion/conclusion

Because migrations using a local BCS are independent of imaging and surgical alignments and because local BCSs can be easily implemented using model-based RSA, local BCSs should be used for enhancing consistency in migration directions among patients and baseplate designs.

	Local Baseplate Coordinate System					
	Translations (mm)			Rotations (°)		
	x (+ medial – lateral)	y (+ proximal - distal)	z (+ anterior - posterior)	x (+ flexion - extension)	y (+ internal - external)	z (+ valgus - varus)
	-0.5	0.1	0.6	0.7	-0.6	0.8
Examples of Clinically Relevant Rotational Deviations	Globally-Aligned Baseplate Coordinate System					
	Translations (mm)			Rotations (°)		
	X	Y	Z	X	Y	Z
Imaging Alignment: 20° flexion 10° internal 0° varus	-0.3 (Δ = +0.2)	-0.1 (Δ = -0.2)	0.6 (Δ = 0.0)	0.8 (Δ = +0.1)	-0.8 (Δ = -0.2)	0.4 (Δ = -0.4)
Mechanical Alignment: 5° extension 25° external 0° varus	-0.6 (Δ = -0.1)	0.1 (Δ = 0.0)	0.3 (Δ = -0.3)	0.3 (Δ = -0.4)	-0.5 (Δ = +0.1)	1.0 (Δ = +0.2)
Kinematic Alignment: 8° extension 9° external 9° varus	-0.5 (Δ = 0.0)	0.3 (Δ = +0.2)	0.4 (Δ = -0.2)	0.4 (Δ = -0.3)	-0.6 (Δ = 0.0)	0.9 (Δ = +0.1)

O25

INFLUENCE OF MARKER-SELECTION METHOD ON MEAN TIBIAL BASEPLATE MIGRATION AND INDIVIDUAL MIGRATION PATTERNS IN TKA USING MARKER-BASED RSA. A RE-ANALYSIS OF AN RCT WITH 5 YEAR FOLLOW-UP

T van der Lelij T.J.N.[1]#, Koster L.A.1, Marang-van de Mheen P.J.[2], Toksvig-Larsen S.[3,4], Nelissen R.G.H.H.[1], Kaptein B.L.[1]
[1]Dept. of Orthopaedic Surgery, Leiden University Medical Center, Leiden, The Netherlands.
[2]Dept. of Biomedical Data Sciences, Leiden University Medical Center, Leiden, The Netherlands.
[3]Dept. of Orthopaedic Surgery, Hässleholm Hospital, Hässleholm, Sweden.
[4]Dept. of Clinical Sciences, Lund University, Lund, Sweden.

Introduction
Guidelines on radiostereometric analysis (RSA) studies do not include guidance on the selection of markers that should be used during subsequent RSA examinations to calculate implant migration. Either a consistent set of markers can be used ("consistent-marker method"), or all available markers at each follow-up that can be matched to the reference image ("all-marker method"). If marker-selection method influences migration results, pooling data from RSA studies might be compromised. We therefore assessed the differences between these methods and their effect on estimated migration.

Methods
Data from a clinical trial with 5 year follow-up, in which 72 patients received a cementless or cemented total knee arthroplasty (TKA), were re-analyzed. Tibial implant migration (maximum total point motion (MTPM)) was evaluated using marker-based RSA, with beads inserted in the liner and the tibial bone. RSA examinations at baseline and 3 months, 1, 2, and 5 years postoperatively were analyzed with two marker-selection methods. The number of implants classified as continuously migrating (≥0.1mm increase in MTPM/year after 2 years) was determined with both methods. A linear mixed model was used to compare mean MTPM between TKA groups.

Results
259 follow-up RSA examinations were available. The mean difference in MTPM for individual examinations between marker-selection method was 0.02 [95%CI -0.25 to 0.29]. Differences between TKA groups in mean MTPM at each follow-up were comparable. 5 implants were classified as continuously migrating with the consistent-marker method versus 6 with the all-marker method.

Discussion
Differences in migration results were caused by the use of different prosthesis markers, bone markers, or both (Figure 1). Using different prosthesis markers, the all-marker method MTPM is always equal to or greater than the consistent-marker MTPM. However, the consistent-marker MTPM can be greater than the all-marker MTPM when different bone markers are used.

Conclusion
Different marker-selection methods do not give different results when comparing mean tibial MTPM of two TKA implants. Pooling group-level migration data from RSA studies using different marker-selection methods appears justified. Individual tibial components may or may not be classified as continuously migrating depending on the marker-selection method.

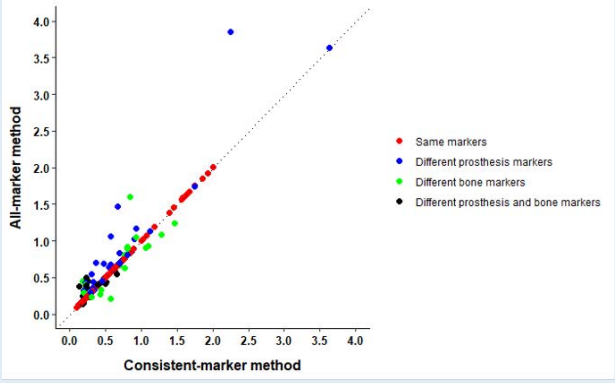


Figure: Scatterplot showing MTPM of all examinations calculated with the consistent- and all-marker method. The line represents the line of equality. The difference in markers used for the migration calculation is specified.

Session 4

O26

MEASUREMENT ERROR VERSUS REPEATED MEASUREMENTS: TWO METHODS FOR COMPUTING BIAS AND PRECISION OF MIGRATION MEASUREMENTS FROM DOUBLE EXAMINATIONS USING RADIOSTEREOMETRIC ANALYSIS

Abigail E. Niesen[1] and Maury L. Hull[1-3]
Departments of [1] Biomedical Engineering, [2] Mechanical Engineering, [3] Orthopaedic Surgery, University of California, Davis

Introduction
When using radiostereometric analysis (RSA), ISO16087:2013 recommends acquiring double examinations (two independent sets of biplanar images on the same day) to compute bias (mean) and precision (standard deviation) of differences in repeated migration measurements (termed repeated measurement statistics). However, repeated measurement statistics do not provide information regarding trueness of the measurements. Double examinations also can be used to compute measurement error statistics (mean and standard deviation of migration measurements relative to trueness) for the condition of no migration. Objectives were to quantify differences in measurement error and repeated measurement statistics in six degrees of freedom (6DOF) and in maximum total point motion (MTPM) using clinical data.

Methods
In a study of tibial baseplate migration, biplanar radiographs were acquired postoperatively on the day of surgery (termed baseline image pair) and double examinations were acquired 3 months postoperatively (termed first image pair and second image pair) for 35 patients. The three pairs of radiographs were processed using model-based RSA; two repeated apparent migrations were computed (baseline image pair to first image pair, baseline image pair to second image pair) and one artifactual migration was computed (first image pair to second image pair). The term artifactual was used because the first and second image pairs were acquired on the same day, hence, true migration is zero and computed migration is an artifact of image processing. Repeated measurement statistics were computed as mean and standard deviation of differences in the two repeated apparent migrations (ΔDx, . . ., ΔΘz, ΔMTPM). Measurement error statistics were computed as mean and standard deviation of artifactual migrations (Dx, . . ., Θz, MTPM).

Results
In 6DOF, measurement error and repeated measurement statistics were nearly identical (Table). For MTPM, measurement error and repeated measurement statistics had different means of 0.21 mm and 0.00 mm, respectively, but similar standard deviations (Table).

Discussion/conclusion
Because measurement error statistics are similar to repeated measurement statistics in 6DOF but provide additional information in the form of bias and precision in MTPM, researchers should report measurement error instead of repeated measurement statistics. Furthermore, ISO16087:2013 should be revised to include measurement error statistics.

Method	Statistics		
	Migration Metric	Mean (mm or °)	Standard Deviation (mm or °)
Measurement Errors (Artifactual Migrations)	*Dx*	0.02	0.09
	Dy	0.02	0.04
	Dz	-0.01	0.05
	Θx	-0.02	0.08
	Θy	-0.03	0.23
	Θz	-0.02	0.10
	MTPM	0.21	0.12
Repeated Measurements (Difference in Two Repeated Apparent Migrations)	*ΔDx*	-0.01	0.08
	ΔDy	-0.01	0.03
	ΔDz	0.01	0.05
	ΔΘx	0.02	0.08
	ΔΘy	0.06	0.23
	ΔΘz	0.01	0.09
	ΔMTPM	0.00	0.13

Table: Summary of clinically-derived measurement error and repeated measurement statistics.

Session 4

O27

THE INFLUENCE OF BEAD SIZE ON MIGRATION PARAMETERS OF MODEL-BASED ROENTGENSTEREOMETRIC ANALYSIS IN SMALL JOINTS: A COMPARISON OF 0.5 MM AND 1.0 MM BEADS IN THE PROXIMAL INTERPHALANGEAL JOINT, A PHANTOM STUDY

R. Oomen[1], I.F. Blom[1,2], G.A. Kraan[1], N.M.C. Mathijssen[1]
[1]Reinier Haga Orthopedisch Centrum, Zoetermeer, The Netherlands
[2]Radiology department of the Reinier de Graaf Gasthuis, Delft, The Netherlands

Introduction
Current literature about model-based radiostereometric analysis (MBRSA) in small joints such as the proximal interphalangeal (PIP) joint is limited. There is no consensus regarding the optimal size of the tantalum beads in smaller joints. It is assumed that smaller beads have an advantage in small joints since the space is limited. However, it is unclear if a smaller bead size affects the MBRSA-parameters of the migration analysis. Therefore, the goal of this study was to determine whether there is a difference in MBRSA-parameters between 0.5 and 1.0mm beads in MBRSA in the PIP-joint.

Methods
A saw bone experiment of the PIP-joint was performed for both 0.5 and 1.0 mm beads. The sawbone was re-positioned in each set of x-rays in an anatomical correct position. Eleven sets of x-rays were made for each bead size. Translations along the x-, y- and z-axis, total translation and conditionnumber (CN) were calculated for the 0.5 and 1.0mm beads. Rotations were not taken into account, since rotations are known to be difficult to measure in small joints

Results
For the distal component the CN for both 0.5 and 1.0mm beads were high, 343.8 (IQR 337.3 – 352.6) and 329.5 (IQR 327.9 – 332.9), respectively. Therefore, accurate analysis for this component was not possible. For the proximal component, total translation was 0.62mm (IQR 0.54 – 1.65) and 0.25mm (IQR 0.17 – 0.36) for the 0.5 and 1.0mm beads, respectively ($p<0.001$), and CN was 129.1 (IQR 128.1 – 131.2) and 125.6 (IQR 124.8 – 125.9) for the 0.5 and 1.0mm size beads, respectively ($p<0.001$). All other parameters were not significantly different.

Discussion and Conclusion
The CN was slightly lower for the 1.0mm beads, but in both sizes below 150, therefore not relevant. Since there was no real migration, a lower total translation is more accurate. There is a significant difference in total translation between both bead sizes, but clinical research is necessary to investigate the clinical relevance. These results suggest that the 1.0mm beads are better for calculating migration in the PIP-joint, however, attention to the spread of the beads is important to avoid high CN, like in the distal component.

Session 4

O28

CORROBORATION OF COUPLED MUSCULOSKELETAL MODEL AND FINITE ELEMENT PREDICTIONS WITH IN-VIVO RSA MIGRATION OF AN UNCEMENTED ACETABULAR COMPONENT

Callary S.[1,2], Fallahnezhad K.[3], O'Rourke D.[3], Bahl J.[1], Thewlis D.[1], Solomon LB.[1,2], Taylor M.[3]
[1]Centre for Orthopaedics and Trauma Research (COTR), The University of Adelaide, Adelaide, South Australia, Australia; [2]Department of Orthopaedics and Trauma, Royal Adelaide Hospital, Port Road, Adelaide, South Australia, Australia; 3Medical Device Research Institute, College of Science and Engineering, Flinders University, Adelaide, South Australia, Australia

Introduction

Finite element (FE) analysis has been extensively used to assess the behaviour of uncemented acetabular cups, for four decades. Although FE studies have been verified against ex vivo data, to date there has been no corroboration between the FE model and in vivo migration data. The aim of this study was to validate FE model predictions against patient-matched in vivo measurements of acetabular component stability using Radiostereometric analysis (RSA).

Methods

Patient specific musculoskeletal and FE models were developed for a cohort of eight individuals who underwent primary total hip replacement and were part of an RSA study. Patient-specific FE models were developed to calculate the mean elastic modulus (MEM) of cancellous bone, composite peak micromotion (CPM), composite peak strain (CPS) and implant contact area during a complete level gait walking cycle. The early RSA implant migration at three months was used to validate and corroborate the FE output metrics.

Results

RSA measurements showed that the 3D migration of the acetabular component for the studied cohort was within the range of 0.11-0.82mm. The mean values of composite peak micromotion CPM and CPS, obtained from the FE model, varied within the ranges of 16.7-16.5μm and 0.0035-0.0152, respectively. Regression analysis indicated a moderate association between the MEM (R2=0.62) and CPS (R2=0.69) with the 3D migration of the acetabular cups. Qualitatively, all the FE precited CPM followed a similar rank order as the in vivo RSA 3D migration data (Figure 1). The two cases with the lowest predicted CPM (<20μm) were confirmed to have the lowest in vivo RSA 3D migration (<0.14mm). The two cases with the largest predicted CPM (>80μm) were confirmed to have the largest in vivo RSA 3D migration (>0.78mm).

Discussion and Conclusion

This study for the first time establishes a direct correspondence between FE predictions of acetabular cup primary stability and in vivo data. While the sample size of this pilot study was low, using prospectively matched CT, gait and RSA examinations may allow further improvements of FE model predictions.

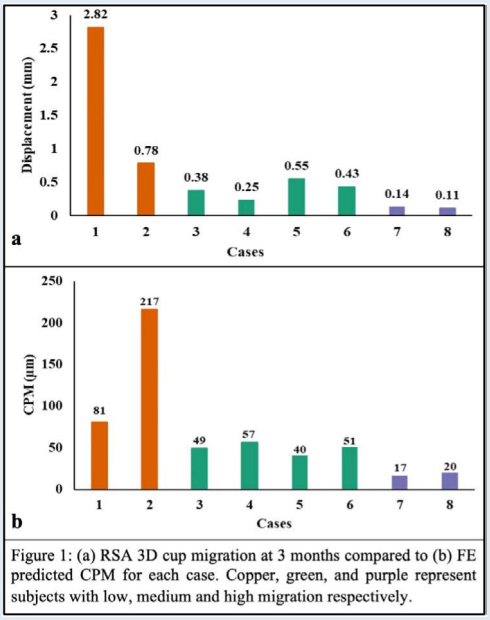


Figure 1: (a) RSA 3D cup migration at 3 months compared to (b) FE predicted CPM for each case. Copper, green, and purple represent subjects with low, medium and high migration respectively.

O29

RADIOSTEREOMETRY OF A NOVEL CERAMIC HIP RESURFACING – COMPARISON OF CLINICAL PRECISION FOR UNIPLANAR AND BIPLANAR TECHNIQUES

Downing M.R.[1,2], Moody C.[3], and Holland J.D.[4]
[1]Dept. Orthopaedics, University of Aberdeen, Aberdeen, UK; 2Downing Imaging Limited, Aberdeen, UK; [3]Radiology, Newcastle Hospitals NHS Trust, Newcastle, UK; [4]Dept. Orthopaedics, Freeman Hospital, Newcastle, UK.

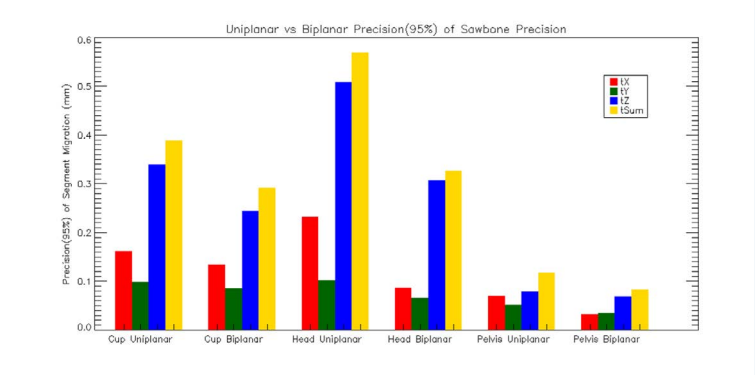
Introduction
Hip resurfacings offer better function for more active younger patients. A clinical radiostereometric study of the ReCerf® Hip Resurfacing Arthroplasty (MatOrtho Ltd., UK) is underway using axial subsidence of the acetabular cup as the primary outcome. This in-vitro study investigates the findings of pre-trial in-vitro assessment of precision at a participating general hospital using static plus mobile x-ray unit.

Method
A Sawbone resurfacing phantom was imaged at the clinical site under typical radiographic repeatability conditions to assess clinical precision. The implants were fixed in the phantom which was imaged centrally and then with movements in the transverse axial and sagittal planes of up to 10 cm and 15 degrees. Acetabular and femoral resurfacing implants were fixed to prepared sawbones secured to a Perspex base plate. Ten markers were placed in the pelvis and femoral segments, with five further markers to make a control segment for marker segment analysis. This method was then repeated using a biplanar setup with the detectors held perpendicular to the x-ray beam beneath the calibration box. A routine digital x-ray room including a mobile x-ray unit setup was used with a Halifax SR calibration box and Carestream DRX Evolution detectors. All images were analysed by a CAD model based RSA method (ABSRA 5.8, Downing Imaging Limited, Aberdeen, UK).

Results
The figure shows transverse, axial, sagittal and total translational precision compared for uniplanar and biplanar for the model based acetabular cup and femoral head, and for a control second marker based segment within the pelvis. Precision for cup migration along the axial axis was 0.098 mm for the standard uniplanar setup and 0.086 mm for the biplanar setup. For the marker based control the improvement of biplanar was more significant.

Discussion
The results suggest there is some small degree of out of plane curvature on the detector plates. This is not unusual for digital detectors. While the biplanar setup was optimal the precision for axial precision was good for both components with both techniques.

Conclusion
Sufficient radiostereometric precision has been demonstrated to perform a pre-market clinical investigation on a much needed new implant technology.



ABSTRACTS

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Kinematics

O30 **Medial congruent polyethylene design show different tibiofemoral kinematics and enhanced congruency compared to a standard symmetrical cruciate retaining design for total knee arthroplasty-an in vivo randomized controlled study of gait using dynamic radiostereometry**
Emil Toft Peterse

O31 **Tibiofemoral and patellofemoral kinematics are both affected in patients with patellar maltracking disorders; a dynamic CT study**
Dennis Janssen

O32 **Impact of radial head arthroplasty diameter on elbow joint kinematics evaluated by dynamic radiostereometric analysis**
Johanne Frost Teilmann

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O34 **Differences in tibiofemoral contact locations between bicruciate-retaining and posterior cruciate-retaining TKA**
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Session 5

O30

MEDIAL CONGRUENT POLYETHYLENE DESIGN SHOW DIFFERENT TIBIOFEMORAL KINEMATICS AND ENHANCED CONGRUENCY COMPARED TO A STANDARD SYMMETRICAL CRUCIATE RETAINING DESIGN FOR TOTAL KNEE ARTHROPLASTY-AN IN VIVO RANDOMIZED CONTROLLED STUDY OF GAIT USING DYNAMIC RADIOSTEREOMETRY

Petersen E.T.[1,2,3] , Rytter S[2,3,4], Koppens D.[1,4] , Dalsgaard J.[1], Hansen T.B.[1,2], Andersen M.S.[5], Stilling M.[2,3,4]
[1]University Clinic for Hand, Hip and Knee Surgery, Holstebro Central Hospital, Holstebro, Denmark
[2]Department of Clinical Medicine, Aarhus University, Aarhus N, Denmark
[3]AutoRSA Research Group, Orthopaedic Research Unit, Aarhus University Hospital, Aarhus N, Denmark
[4]Department of Orthopaedic Surgery, Aarhus University Hospital, Aarhus N, Denmark
[5]Department of Materials and Production, Aalborg University, Aalborg, Denmark.

Purpose
New total knee arthroplasty implant designs attempt to normalize kinematics patterns that may improve functional performance and patient satisfaction. It was hypothesized that a more medial congruent (MC) anatomic bearing design (1) influences the tibiofemoral kinematics and (2) enhances articular congruency compared to a standard symmetrical cruciate retaining (CR) bearing design.

Methods
In this double-blinded randomized study, 66 patients with knee osteoarthritis were randomly included in two groups: MC (n = 31) and CR (n = 33). Clinical characteristics such as knee ligament lesions and knee osteoarthritis scores were graded on preoperative magnetic resonance imaging and radiography. At the 1-year follow-up, dynamic radiostereometric analysis was used to assess tibiofemoral joint kinematics and articulation congruency. Patient-reported outcome measures, Oxford Knee Score, the Forgotten Joint Score, and the Knee Osteoarthritis Outcome Score, were assessed preoperatively and at the 1-year follow-up.

Results
Compared to the CR bearing, the MC bearing displayed an offset with approximately 3 mm greater anterior tibial drawer ($p < 0.001$) during the entire motion, and up to approximately 3.5 degrees more tibial external rotation ($p = 0.004$) from mid-swing to the end of the gait cycle at the 1-year follow-up. Furthermore, the congruency area in the joint articulation was larger during approximately 80% of the gait cycle for the MC bearing compared to the CR. The patient-reported outcome measures improved ($p < 0.001$), but there were no differences between groups. In addition, there were no differences in clinical characteristics and there were no knee revisions or recognized deep infections during follow-up.

Conclusion
The study demonstrates that the MC-bearing design changes tibiofemoral kinematics and increases the area of congruency towards more native knee kinematics than the CR bearing. In perspective this may contribute to a more stabilized knee motion, restoring the patient's confidence in knee function during daily activities.

Session 5

O31

TIBIOFEMORAL AND PATELLOFEMORAL KINEMATICS ARE BOTH AFFECTED IN PATIENTS WITH PATELLAR MALTRACKING DISORDERS; A DYNAMIC CT STUDY

Janssen D.[1], Dunning H.[1], Stan Buckens C.F.[2], Prokop M.[2], Verdonschot N.[1,3], van de Groes S.A.W.[4]
[1]Orthopaedic Research Laboratory, Radboud Institute for Health Sciences, Radboud university medical center, Nijmegen, The Netherlands;
[2]Department of Radiology, Radboud University Medical Center, Nijmegen, The Netherlands;
[3]University of Twente, Laboratory for Biomechanical Engineering, Faculty of Engineering Technology, Enschede, the Netherlands; [4]Department of Orthopaedics, Radboud University Medical Center, Nijmegen, The Netherlands.

Introduction
Patellofemoral pathologies are commonly associated with pathological patellar tracking. Understanding the differences in knee kinematics and patellar tracking between patients and healthy individuals is vital for improving the diagnosis and treatment of these complex knee disorders. The aim of the current study is to use dynamic CT to objectively compare tibiofemoral and patellofemoral kinematics of patients with patellar maltracking diagnosis to that of healthy volunteers.

Methods
One-hundred healthy volunteers and 39 patients were included and underwent a dynamic CT scan. A static high resolution static scan was made in full extension and 41 medium resolution images during an extension-flexion movement. Images were automatically segmented with a deep learning network and static and dynamic images were superimposed with subsequent pointcloud and image registration. Anatomical coordinate systems for the femur, patella and tibia were determined, after which tibiofemoral (TF) IE and VV rotations, and patellofemoral (PF) flexion, tilt and rotation were calculated. Mann Whitney U tests (α=0.05) were performed to demonstrate statistically significant differences between patients and healthy volunteers.

Results
There were no significant differences in age or height. Patients exhibited significantly more external rotation of the tibia from 68° of flexion to full extension during the extension movement, and from full extension to 60° of flexion during the flexion movement (Figure1-left). Patients had significantly less varus than healthy subjects. Lateral rollback was significantly larger in patients compared to healthy volunteers. Patients had a significantly higher lateral patellar tilt throughout the complete motion with a steep increase and decrease around ±20° flexion (Figure1-right). Patients showed a significantly larger patellar lateral translation below 30° of TF flexion, and had a significantly larger variance around 40° of flexion during extension and flexion movement.

Discussion
Both tibiofemoral and patellofemoral kinematics are altered in patients with patella maltracking disorders. Significantly increased external rotation, lateral rollback and valgus rotation of the tibia was found in patients compared to healthy individuals. Furthermore, increased lateral tilt and mediolateral translation of the patella was observed. This study shows that at a population level there are significant differences in the kinematics of patients and healthy individuals. Understanding these differences is vital for improving diagnosis and treatment of patellofemoral maltracking disorders and to unravel the complex aetiology.

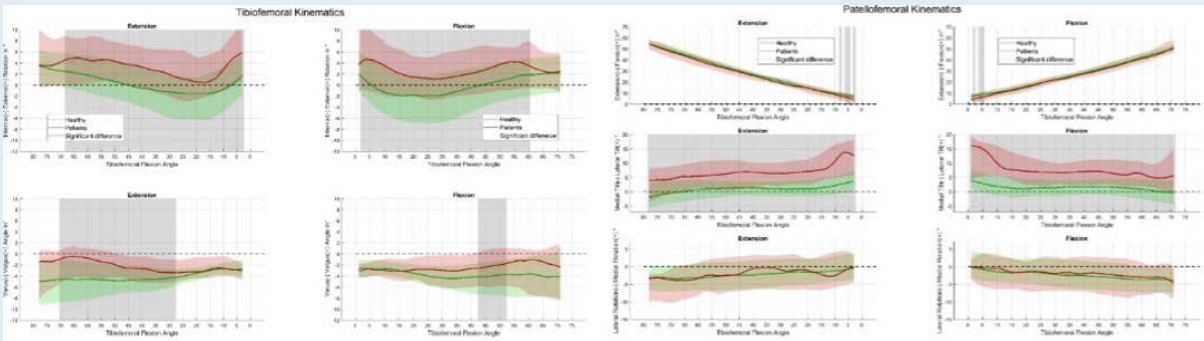

Figure 1: Differences in tibiofemoral (left) and patellofemoral (right) kinematics between patients and healthy subjects.

Session 5

O32

IMPACT OF RADIAL HEAD ARTHROPLASTY DIAMETER ON ELBOW JOINT KINEMATICS EVALUATED BY DYNAMIC RADIOSTEREOMETRIC ANALYSIS

Teilmann J.F.[1,2], Petersen E.T.[1,3], Thillemann T.M.[3], Hemmingsen C.K.[1], Kipp J.K.[1,2], Stilling M.[1,2,3]
[1]AutoRSA Research Group, Orthopedic Research Unit, Aarhus University Hospital, Aarhus, Denmark
[2]Department of Clinical Medicine, Aarhus University, Aarhus, Denmark
[3]Department of Orthopedic Surgery, Aarhus University Hospital, Aarhus, Denmark

Introduction
Radial head arthroplasty (RHA) is a hemiprosthesis used in the treatment of complex elbow dislocation fractures where osteosynthesis is not possible. Improper RHA diameter and length may result in pain, joint stiffness, and osteoarthritis, which is likely caused by unfavorable biomechanical changes. The ideal size of the RHA is unknown and knowledge concerning elbow stability after different head sizes is warranted. The aim of this experimental study was to evaluate the elbow kinematics of different sizes of radial head implants after RHA using dynamic radiostereometric analysis (dRSA).

Methods
Eight human donor arms were examined with dRSA during a motor-controlled elbow flexion-extension movement with the forearm in neutral position, unloaded supinated position, and in supinated position with a 1kg radial load. The elbows were examined before and after RHA with head diameters of anatomical size, +2 mm (oversized), and −2mm (undersized), respectively. The same neutral length anatomical stem was implanted and not changed throughout all tests. The collateral ligaments were kept intact by use of a step-cut humerus osteotomy for repeated RHA exchange. Bone models were obtained from computed tomography scans and AutoRSA software was used to match the bone models with dRSA recordings. To describe elbow kinematics, anatomic coordinate systems were applied to the humerus and radius.

Results
The anatomical sized and undersized RHA diameter did not reveal statistically significant different radio-ulnar and anterior-posterior kinematics in the radiocapitellar joint compared to the native elbow in both forearm positions. With the forearm in a loaded supinated position, an oversized RHA shifted the radial position ulnarly ($p<0.001$). All the RHA sizes showed increased joint distraction ($p<0.05$) in the radiocapitellar joint compared to the native elbow in both forearm positions.

Conclusion
These results suggest that RHA diameter of anatomical size or undersized maintain radiocapitellar kinematics, while an oversized RHA seemed to cause overstuffing. The increased joint distraction suggests that the neutral length anatomical stem overlengthened the radius as compared with the native bone. We caution to avoid overstuffing and overlengthening with use of RSA, as both situations may increase the joint pressure and potentially cause capitellar cartilage wear.

Session 5

O33

EVALUATION OF GLENOHUMERAL KINEMATICS FOLLOWING A SIMULATED BONY BANKART LESION. A DYNAMIC RADIOSTEOMETRIC CADAVER STUDY

Josephine Olsen Kipp[1,3], Emil Toft Petersen[1,2], Theis Muncholm Thillemann[2,3], Thomas Falstie-Jensen[2], Maiken Stilling[1,2,3]
[1] AutoRSA Research Group, Orthopaedic Research Unit, Aarhus University Hospital, Aarhus, Denmark
[2] Department of Orthopedic Surgery, Aarhus University Hospital, Aarhus N, Denmark
[3] Department of Clinical Medicine, Aarhus University, Aarhus, Denmark

Introduction
During anterior shoulder dislocation, the bone rim of the anterior glenoid may be damaged with a combined labral and bone lesion (bony Bankart lesion). This implicates less contact surface in the glenohumeral joint leading to anterior shoulder instability, which typically occurs during active shoulder motion. Dynamic evaluation of glenohumeral joint kinematics during motion has not previously been described.

The aim of this study was to establish an experimental setup to measure the glenohumeral translation before and after a 15% anterior glenoid bone lesion using dynamic radiostereometric analysis.

Methods
Ten human donor arms were rigidly fixed in a motorized custom-made fixture allowing a controlled 90 degrees external rotation of the glenohumeral joint positioned at 60 degrees of abduction. Dynamic radiostereometry recordings were performed before and after inducing a bony Bankart lesion (15% of the glenoid width) during arthroscopy. The stages with intact and bony Bankart lesion were tested with and without a 10N anterior directed load. Bone models from computed tomography scans were registered on dynamic radiostereometry recordings using AutoRSA software. Anatomic coordinate systems were applied to the humerus and scapula bone models to describe glenohumeral joint kinematics.

Results
Without loading, the maximal anterior to posterior translation increased with mean (SD) 0.56 mm (1.68) after the bony Bankart lesion. With a 10N anterior directed load, the maximum anterior to posterior translation increased by 1.32 mm (1.53). After the bony Bankart lesion, the humeral head position was 0.76 mm (1.69) more inferior for the unloaded joint, and 1.15 mm (1.34) more inferior for the loaded joint, as compared with the intact glenoid. After loading, the position of the humerus was more anterior and inferior for the bony Bankart lesion as compared with an intact glenoid.

Conclusion
A 15 % glenoid bone loss changed the humeral head position to a more inferior position and the kinematic pattern with more anterior-posterior translation compared to the intact glenoid throughout the external rotation. However, the 10N anteriorly directed load was insufficient to demonstrate statistical significance of the pathomechanics. More development is needed to establish a useful setup for measuring anterior shoulder instability in human specimens.

O34

DIFFERENCES IN TIBIOFEMORAL CONTACT LOCATIONS BETWEEN BICRUCIATE-RETAINING AND POSTERIOR CRUCIATE-RETAINING TKA

K. Mills[1], B.L. Kaptein2, S.N. van Laarhoven[1], Petra J.C. Heesterbeek[1]
[1]Sint Maartenskliniek, Nijmegen, the Netherlands; [2]Leiden University Medical Center, Leiden, the Netherlands

Introduction
The tibiofemoral contact point (CP) location has been reported to be related to functional and clinical outcome after TKA. In this study we compared the CP of a bicruciate-retaining (BCR) TKA with a posterior cruciate retaining (CR) TKA. The difference between these two implants is the retention of anterior cruciate ligament (ACL) in the BCR-TKA. Thereby the BCR-TKA is designed to allow for the natural soft tissues to control the motion in the knee, which should result in more natural movement and feel of the knee.

Methods
A total of 10 patients with the Journey II CR implant and 10 with the Journey II XR implant (BCR) were included from two simultaneous prospective cohort studies. At three months postoperatively weight-bearing radiostereometric (RSA) images were taken, in extension and in 90° flexion. CP locations were determined from these RSA radiographs using Model-based RSA software and compared between the implants. CP locations are reported as a ratio from 0 to 1, with 0 being the most anterior point of the tibial inserts and 1 the most posterior.

Results
The BCR-TKA shows more lateral rollback from extension to flexion compared to the CR-TKA (p=0.012) with a more posteriorly located CP in flexion for the BCR-TKA (0.67(SD0.05) vs 0.55(SD0.07)) (Figure 1). The variability in CP locations was higher for the BCR-TKA.

Discussion and Conclusion
This preliminary comparison shows more lateral physiological rollback of the BCR-TKA from extension to flexion, indicating that the more flat tibial inserts of this design allows for the ligaments to control the motion as they do in the natural knee. However, in extension the variability in CP locations of the BCR-TKA was higher in both compartments. This could indicate imperfect balancing of the ACL in some patients.

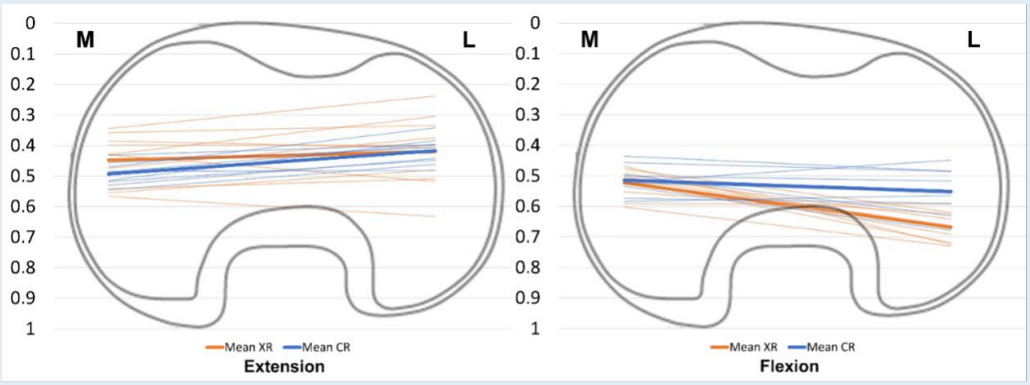

Figure. Contact points (CP) in extension (left) and flexion (right) of CR-TKA (blue) and BCR-TKA (orange), projected on the shape of a CR insert. The lighter lines represent the CP locations for all separate BCR and CR cases.

Session 5

O35

PRECISION OF CT-BASED RADIOSTEREOMATRIC ANALYSIS COMPARED TO MARKER-BASED RADIOSTEREOMETRY IN MIDFOOT KINEMATICS

Magnus Poulsen, Stephan M. Röhrl
Division of Orthopaedic Surgery, Oslo University Hospital, Oslo, Norway.

Introduction
Preliminary arthroplasty studies with Computed Tomography (CT)-based Radiostereometric Analysis (CT-RSA) have shown comparable precision to marker-based Radiostereometry (RSA). If applicable to arthrokinematic studies, CT-RSA signifies a precise, non-invasive method for joint motion assessment and can be performed wherever a CT scanner is available. This is the first study to investigate method agreement between CT-RSA and marker-based RSA for joint motion.

Method
Eight patients with unilateral tantalum markers in 1st cuneiform (C1) and 1st metatarsal (M1) were included. CT and RSA double examinations were obtained under equal conditions. Segmental CT-RSA precision was evaluated with surface registration of both C1-M1 bone, and C1-M1 tantalum markers, while RSA precision was determined with C1-M1 markers only. Additionally, we evaluated the intra-segmental CT-RSA precision by comparing proximal with distal part of M1. All analyses were given as 1.96 x standard deviation.

Results
The segmental CT-RSA precision (both surface anatomy and markers) were in the range of 0.3 – 0.7 mm for translation, and 0.6 – 1.6 ° for rotation. In comparison, the corresponding RSA precision was in the range of 0.4 - 0.9 mm for translation, and 1.0 - 1.6 ° for rotation. Finally, the intra-segmental CT-RSA precision was in the range of 0.1 - 0.2 mm for translation, and 0.4 - 0.5 ° for rotation.

Discussion
The precision of CT-RSA in midfoot kinematics had comparable precision to marker-based RSA. Using registration of surface anatomy or tantalum markers did not influence the CT-RSA precision. CT-RSA offers the possibility of measuring motion in any anatomical region without the need for markers or specialized equipment. However, this is the first CT-RSA study to introduce intra-segmental validation of test precision. Our study indicates that CT-RSA can be used to examine joint motion in a clinical setting.

Conclusion CT-RSA is a valid method to measure foot kinematics when compared to conventional, marker-based RSA.

Session 5

O36

IN-VIVO KINEMATICS EVALUATION OF TOTAL ANKLE REPLACEMENT THROUGH DYNAMIC RADIOSTEREOMETRIC ANALYSIS: A PROSPECTIVE STUDY

R. Zinno [1], S. Caravelli [2], S. Di Paolo [1], A. I. Mirulla[1], E. Vocale [2], S. Massimi [2], M. Mosca [2], L. Bragonzoni [1]
[1]Department for Life Quality studies, University of Bologna, Bologna, Italy,
[2]IRCCS Rizzoli Orthopaedic Institute, Bologna, Italy

Introduction
Nowadays, total ankle replacement (TAR) kinematics has undergone many changes, and critical issues that led to the improvement of prosthetic designs have been highlighted. The dynamic model-based radiostereometric analysis (dMBRSA) allows to study in vivo, under load, and with active muscular action, the biomechanical behavior of the prosthetic components. The study aims to perform clinical and kinematical evaluations of people with TAR.

Methods
A cohort of 18 patients (13 male and 5 female) with a mean age of 61.1±10.1 suffering from ankle osteoarthritis were enrolled in this study. The patients riceved an ankle prosthesis (7 right and 11 left) with a mobile insert (Exactech Vantage) and anterior access. The clinical evaluation was carried out through the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score before the surgery and 9 months after surgery. Kinematical data were obtained in vivo through dMBRSA 9 months after surgery during two motor tasks: from plantar flexion to maximum dorsal flexion (lunge); stand on foot and the rise on tiptoes (rise on toes). For each patient kinematical data were calculated (Grood and Suntay decomposition): Internal-External (IE) rotations, Anterior-Posterior (AP) translations, and Varus-Valgus (VV) rotations of the Tibial component with respect to the Talus component during ankle flexion.

Results
In the kinematical results obtained 9 months after surgery, the "lunge" task showed an anterior translation of the tibia of 11.6 mm, while VV and IE rotations were less than 2 mm during the dorsi-flexion movement. In the "rise on toes" task, the tibial component showed a 14.0° anterior traslation, while VV and IE rotations were similar to the first motor task (Table). Concerning the clinical evaluation, after surgery the AOFAS significantly improved from 33.7±13.7 to 85.9±8.3 ($p<0.001$).

Discussion and Conclusion
The evaluation of joint range of motion with dMBRSA allowed to describe and quantify the movements of tibial component with respect to the talus component, excluding other joints contribution, in people with TAR two common ankle movements. In addition, there was an improvement of clinical outcomes in people after the TAR.

	Lunge			Rise on toes		
	Maximum Peak	Minimum Peak	Range	Maximum Peak	Minimum Peak	Range
Ankle flexion (°)	8.6	-14.0	22.6	6.6	-7.4	14.0
Varus-Valgus (°)	0.7	-1.1	1.7	2.4	0.3	2.1
Internal-External (°)	-2.1	-3.0	1.0	0.7	-0.7	1.3
Anterior-Posterior (mm)	5.1	-6.5	11.6	1.4	-4.4	5.8

Table. Kinematical data of the ankle prosthesis assessed through dMBRSA

ABSTRACTS

Session 6

Bearing surfaces and wear

O37 **No difference in wear between 32 and 36 mm metal femoral heads in uncemented cups with highly cross-linked polyethylene. An RSA study with up to 10 years follow-up**
Gunnar Flivik

O38 **Comparison of 5-year cup and stem migration between a ceramic and polyethylene liner in press-fit total hip arthroplasty (THA), a randomized controlled trial using radiostereometric analysis (RSA)**
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O41 **Wear in total hip arthroplasty with the Regenerex cup: A radiostereometric study with 5 years of follow up**
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Session 6

O37

NO DIFFERENCE IN WEAR BETWEEN 32 AND 36 MM METAL FEMORAL HEADS IN UNCEMENTED CUPS WITH HIGHLY CROSS-LINKED POLYETHYLENE. AN RSA STUDY WITH UP TO 10 YEARS FOLLOW-UP

Halldor Bergvinsson, Vasilis Zampelis, Martin Sundberg, Sverrir Kiernan, Gunnar Flivik
Department of Orthopedics, Skåne University Hospital, Clinical Sciences, Lund University, Lund, Sweden.

Introduction

Large femoral heads have been used to gain more stability in total hip arthroplasty (THA). However, increased head size has been proposed to generate more polyethylene wear and therefore affect the survival of THA. We analyzed the wear of 32 mm and 36 mm femoral heads on modern highly cross-linked polyethylene (HXLPE) in the same type of uncemented cups with radiosterometric analysis (RSA) up to 5 years (32 mm) and 10 years (36 mm).

Patients and Methods

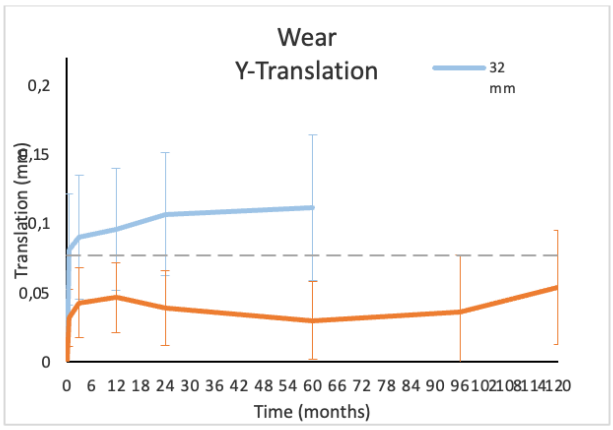
106 patients were recruited from 2 RSA trials, 31 patients received 32 mm and 75 patients 36 mm metal femoral head. All patients got the same HXLPE liner in an uncemented cup. All patients were followed for 5 years using RSA examinations and clinical outcome scores. The patients with 36 mm femoral heads were further followed up to 10 years.

Results

fter 3 months the mean proximal penetration was 0.09 mm (95% confidence interval [CI] 0.05-0.14) for the 32 mm head and 0.04 mm (95% CI 0.03-0.06) for the 36 mm head. At 5 years the mean proximal head penetration was 0.11 mm (95% CI 0.06 – 0.16) for the 32 mm head and 0.02 mm (95% CI 0.0 – 0.05) for the 36 mm head. After 10 years the proximal head penetration was 0.13 mm (95% CI 0.10 – 0.16) for the 36 mm femoral heads. Between 3 months and 5 years, the yearly wear rate was 0.004 mm/year for the 32 mm head, and for the 36 mm head it was 0.001 mm/year measured between 3 months and 10 years. There was no difference between the groups regarding clinical outcome scores.

Conclusion

With HXLPE there is no statistically significant difference in wear up to 5 years between 32 mm and 36 mm femoral heads. The stable, low wear pattern continues for the 36 mm femoral head up to 10 years.



Session 6

O38

COMPARISON OF 5-YEAR CUP AND STEM MIGRATION BETWEEN A CERAMIC AND POLYETHYLENE LINER IN PRESS-FIT TOTAL HIP ARTHROPLASTY (THA), A RANDOMIZED CONTROLLED TRIAL USING RADIOSTEREOMETRIC ANALYSIS (RSA)

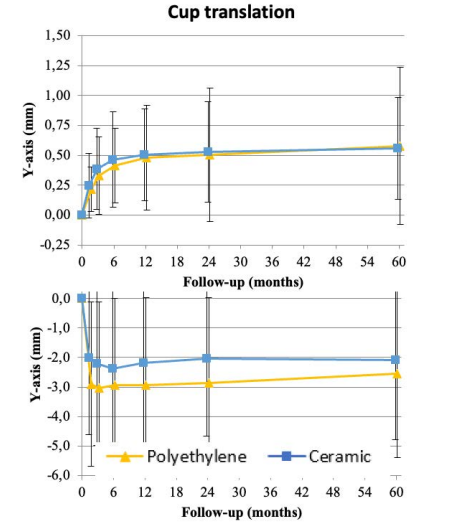
Klaassen A.D.[1#*], van Loon J.[1,2,3*], Willigenburg N.W.1, Koster L.A.[4], Kaptein B.L.[4], Scholtes V.A.B.[1], van der Hulst V.P.M.[5], Haverkamp D.[3], Moojen D.J.F.1, Poolman R.W.[1,4]
*Co-first authors
[1]OLVG, Dept. of Orthopedics, Amsterdam, The Netherlands; [2]Amsterdam Movement Sciences, Amsterdam UMC, Academic Medical Centre, University of Amsterdam, Dept. of Orthopaedics, Amsterdam, The Netherlands; [3]Xpert Clinics Orthopedie Amsterdam, Amsterdam, The Netherlands; [4]LUMC, Dept. of Orthopedics, Leiden, The Netherlands; 5OLVG, Dept. of Radiology, Amsterdam, The Netherlands.

Introduction
The higher stiffness of a ceramic-on-ceramic (CoC) cup-liner construct might affect primary stability and migration of implants. The purpose of this study is to compare 5-year migration patterns of the uncemented Delta-TT cup and H-MAX S stem (LimaCorporate) with either a ceramic (CE) or polyethylene (PE) liner by means of RSA.

Methods
Patients were randomized to a polyethylene (n=25) or ceramic (n=28) liner. RSA X-rays were collected at baseline and 1.5, 3, 6, 12, 24 and 60 months, after primary uncemented THA with a Delta-TT cup, H-MAX S stem with ceramic head. Model-based RSA was used to calculate migrations of the cup and stem, group differences were analysed using mixed modelling. Migration parameters known from literature to be predictive for long-term aseptic loosening were presented.

Results
Regardless of cup-liner construct, cups stabilized within 6 months and stems within 6 weeks after surgery (Figure 1). At 5-year follow-up, Delta-TT cups showed mean proximal migration of 0.56 mm (95%CI 0.37 – 0.74) in the CE group and 0.58 mm (95%CI: 0.25 – 0.90) in the PE group. Mean adduction (decrease of inclination) was 1.05 degrees (95%CI: 0.27 – 1.82) in the CE group and 0.78 degrees (95%CI: -0.16 – 1.71) in the PE group. The H-MAX S stem showed a mean subsidence of 2.09 mm (95%CI: 0.89–3.29) in the CE group and 2.55mm (95%CI: 0.97–4.12) in the PE group at 5 years. None of the differences in rotation and translation between groups, also in the other directions, were significant.

Discussion and Conclusion
These results do not explain the findings of a large registry study reporting higher revision rates with CoC constructs. More research is needed to develop clinically relevant thresholds for migration values in press-fit cups and stems. Liner type does not affect migration of the DELTA-TT cup or the H-MAX S stem. Regardless of liner type the cup stabilises in about 6 months and the stem in 6 weeks after total hip arthroplasty, which is promising for long-term survival.



Session 6

O39

POLYETHYLENE WEAR IN MOBILE- AND FIXED-BEARING UNICOMPARTMENTAL KNEE ARTHROPLASTY; A RANDOMIZED CONTROLLED RSA STUDY WITH 5 YEARS FOLLOW-UP

Koppens D.[1#], Stilling M.[1], Dalsgaard J.[2], Bæk Hansen T.[2], Kaptein B.[3], Rytter S.[1]
[1]Department of Orthopedics, Aarhus University Hospital, Aarhus, Denmark
[2]Department of Orthopedics, University Clinic for hand, hip, and knee surgery, Gødstrup Hospital, Gødstrup, Denmark
[3]Department of Orthopedics, Leiden University Medical Center, Leiden, the Netherlands

Introduction
The main cause of knee revision surgery is aseptic loosening. Polyethylene (PE) wear can result in osteolysis, which can lead to aseptic loosening. Differences in design features between a mobile-bearing (MB) and a fixed-bearing unicompartmental knee arthroplasty (UKA), may influence PE wear.

Aim To compare PE wear of a MB UKA and a FB UKA using RSA with 5 years follow-up.

Methods
A patient-blinded, randomized controlled RSA study with 60 months follow-up was performed. Patients were randomized to either a MB UKA (N = 33) or a FB UKA (N = 32). Weight-bearing stereoradiographs with the knee in extension and in 20° flexion were obtained at 4, 24 (double examination), and 60 months post-operatively. Model-based RSA software was used to analyze the stereoradiographs. Polyethylene thickness (mm) was calculated as the perpendicular distance between the articular surface of the tibial component and the closest point to the femoral component. Linear polyethylene wear was calculated at 12 and 60 months, with the 4 months measurement as reference.

Results
Knee flexion 20 degrees
At 60 months follow-up, mean PE wear in the MB group was 0.35 mm (95% CI 0.29 – 0.42), and 0.25 mm (95% CI 0.18 – 0.32) in the FB group. The wear rate was 0.07 mm/y in the MB group and 0.05 mm/y in the FB group.
Full knee extension
At 60 months follow-up, mean PE wear in the MB group was 0.24 mm (95% CI 0.13 – 0.34), and 0.23 mm (95% CI 0.12 – 0.34) in the FB group. The wear rate was 0.06 mm/y in the MB group and 0.03 mm/y in the FB group.

Discussion and Conclusion
Despite the difference in prosthesis design, the MB UKA and FB UKA showed equal and low polyethylene wear during a period of 5 years in both 20 degrees of knee flexion and in full knee extension.
The mean polyethylene wear rate was 0.05-0.07 mm/y, which is comparable to reported wear rates of UKAs.

Session 6

O40

CEMENTED VERSUS CEMENTLESS DUAL MOBILITY CUP SHOW SIMILAR FIXATION, LOW POLYETHYLENE WEAR, AND LOW SERUM COBALT-CHROMIUM IN ELDERLY PATIENTS: A RANDOMIZED RADIOSTEREOMETRY STUDY WITH 6 YEARS FOLLOW-UP

Peter Bo Jørgensen1[,2], Steffan Tabori-Jensen[3], Inger Mechlenburg[3,4], Morten Humilius[1], Torben Bæk Hansen[1,4], Maiken Stilling[1,2,3,4]
[1]University Clinic for Hand, Hip and Knee Surgery, Department of Orthopaedics, Gødstrup Hospital, Herning, Denmark;
[2]AutoRSA Research Group, Orthopeadic Research Unit, Aarhus University Hospital, Aarhus, Denmark;
[3]Department of Orthopaedic Surgery, Aarhus University Hospital, Aarhus, Denmark;
[4]Department of Clinical Medicine, Aarhus University, Aarhus, Denmark.

Background and Purpose
Dual mobility (DM) articulation total hip arthroplasty (THA) is used increasingly to reduce dislocation risk. We investigated cup fixation, polyethylene (PE) wear, serum chromium and cobalt ions, and their correlation to physical activity in patients with DM implants at 6-year follow-up.

Patients and Methods
In a patient-blinded RCT, 60 patients with hip osteoarthritis at a median age of 74 years (70–82) were randomly allocated to cemented (n = 30) or cementless hydroxyapatite-coated (n = 30) fixation of Avantage DM THA with a highly-crosslinked vitamin-E PE liner. Cup migration and PE wear were measured with radiostereometric analysis (RSA), chromium and cobalt ions were measured in serum, and physical activity was measured with accelerometers.

Results
At 6-year follow-up, proximal cup migration was similar, 0.14 mm (95% CI 0.01–0.28) for cemented cups and 0.21 mm (0.02–0.39) for cementless cups. The PE wear rate from 1- to 6-year follow-up was also similar, 0.06 mm/year (0.04–0.09) for cemented cups and 0.07 mm/year (0.04–0.11) for cementless cups. Serum metal ion levels were undetectable or very low. Physical activity was mainly low intensity and did not correlate to PE wear rate or cup migration.

Conclusion
Cemented and cementless DM implants with highly crosslinked vitamin E infused liners have similar cup migration and PE wear when used for primary THA surgery.

Session 6

O41

WEAR IN TOTAL HIP ARTHROPLASTY WITH THE REGENEREX CUP: A RADIOSTEREOMETRIC STUDY WITH 5 YEARS OF FOLLOW UP

J.H. Pasma[1], I. Blom1[2], N. de Esch[1], S.B.W. Vehmeijer[1], N.M.C. Mathijssen[1]
[1]Reinier Haga Orthopedisch Centrum, Zoetermeer, the Netherlands
[2]Department of Radiology, Reinier de Graaf Gasthuis, Delft, the Netherlands

Introduction
Uncemented acetabular cups in total hip arthroplasty (THA) have shown excellent rates of bone ingrowth, longevity and clinical results. However, wear and migration could result in osteolysis and loosening, respectively, especially in younger and more active patients. The Regenerex Ringloc+ cup (Zimmer Biomet, Warsaw, USA) is a porous-titanium coated cup with a E1-poly liner, which consists of cross-linked polyethylene infused with vitamin E. We assessed the wear using model-based radiostereometric analysis (mRSA) and evaluated the clinical results over a period of 5 years.

Methods
This study is part of a multicenter randomized controlled trial comparing the uncemented GTS and uncemented Taperloc stem (Zimmer Biomet, Warsaw, USA), both combined with an uncemented Regenerex Ringloc+ cup. Patients were included who had primary THA for osteoarthritis or avascular necrosis, aged 18-70 years with a BMI < 35 kg/m2. Radiographs were obtained direct postoperatively, at 3 and 6 months and 1, 2 and 5 years after surgery. Wear is expressed in mm in medial, proximal and anterior direction with respect to the postoperative position. The wear rate is expressed as the wear in proximal direction per year between 0 and 5 years after surgery in mm/year. Clinical outcomes were measured using the Harris Hip Score (HHS), the Hip disability and Osteoarthritis Outcome Score (HOOS) questionnaire and the EQ-5D-3L.

Results
Twenty-five patients were included. Mean age was 61.9 (± 4.7) years, mean BMI 26.1 (± 3.9) kg/m2 and 8 patients (32%) were male. During a period of 5 years the medial wear was -0.001 (± 0.172) mm, the proximal wear 0.08 (± 0.16) mm and the anterior wear -0.09 (± 0.42) mm. The wear rate in proximal direction between 0 and 5 years was 0.017 (± 0.038) mm/year. All clinical outcomes improved after 5 years compared to preoperative clinical outcomes.

Discussion and Conclusion
The results show a low wear after a period of 5 years, which is comparable to previous studies (Li et al. (2021), Wyatt et al. (2019)). The proximal wear rate is lower than the proposed wear threshold of 0.1 mm/year (Dumbleton et al. (2002)). Longer follow-up is needed to relate the wear to future wear-related cup revisions.

O42

POLYETHYLENE LINER MOTION IN DUAL MOBILITY HIP PROSTHESES: STATIC AND DYNAMIC RADIOSTEREOMETRY IN 16 CASES 1 YEAR AFTER OPERATION

Jørgensen P.B.[1], Kaptein B.L.[2], Søballe K.[1,3], Jakobsen S.S.[3] and Stilling M.[1,3]
[1]AutoRSA Research Group, Orthopeadic Research Unit, Aarhus University Hospital, Aarhus, Denmark
[2]Biomechanics and Imaging Group, Department of Orthopaedics, Leiden University Medical Center, Leiden, The Netherlands
[3]Department of Orthopaedic Surgery, Aarhus University Hospital, Aarhus, Denmark

Introduction
Dual mobility hip arthroplasty utilizes a freely rotating polyethylene liner to protect against dislocation. As liner motion has not been confirmed in vivo, we investigated the liner kinematics in vivo using dynamic radiostereometry.

Methods
16 patients with Anatomical Dual Mobility acetabular components were included. Markers were implanted in the liners using a drill guide. Static RSA recordings and patient reported outcome measures were obtained at post-op and 1-year follow-up. Dynamic RSA recordings were obtained at 1-year follow-up during a passive hip movement: abduction/external rotation, adduction/internal rotation (modified FABER-FADIR), to end-range and at 45° hip flexion. Liner- and neck movements were described as anteversion, inclination and rotation.

Results
Liner movement during modified FABER-FADIR was detected in 12 of 16 patients. Median (range) absolute liner movements were: anteversion 10° (5–20), inclination 6° (2–12), and rotation 11° (5–48) relative to the cup. Median absolute changes in the resulting liner/neck angle (small articulation) was 28° (12–46) and liner/cup angle (larger articulation) was 6° (4–21). Static RSA showed changes in median (range) liner anteversion from 7° (-12–23) postoperatively to 10° (-3–16) at 1-year follow-up and inclination from 42 (35–66) postoperatively to 59 (46–80) at 1-year follow-up. Liner/neck contact was associated with high initial liner anteversion (p=0.01).

Discussion and Conclusion
The polyethylene liner moves over time. One year after surgery the liner can move with or without liner/neck contact. The majority of movement is in the smaller articulation between head and liner.

ePOSTERS

Rapid fire session 1

E1 **Mid-term migration patterns and patient reported hip function five years after primary uncemented total hip arthroplasty**
Amanda Klaassen

E2 **Comparison of Zimmer acetabular system to the Allofit Cup with roentgen stereophotogrammetric analysis (RSA) in total hip arthroplasty**
Ian Blom

E3 **Mid-term performance of a bicruciate-retaining TKA, a radiostereometric analysis**
Kelly Mills

E4 **Radiostereometric analysis of hydroxyapatite and porous tritanium coated acetabular components in a randomized controlled trial shows comparable migration five years after uncemented THA**
Lennard Koster

E5 **Two year migration results of a neck preserving short stem – is HA coating not beneficial anymore?**
Michael Schwarze

E6 **A randomized controlled trial comparing two-year postoperative femoral and tibial migration of a new and an established cementless rotating platform total knee arthroplasty**
Lennard Koster

E7 **Length changes of the medial patellofemoral ligament during in vivo knee motion: A dynamic evaluation using computed tomography**
Miriam Boot

Rapid fire session 2

E8 **3D virtual planning to assist intra-operative articular reduction and implant choice for patients with tibial plateau fractures**
Nynke van der Gaast

E9 **Randomized controlled trial comparing tibial baseplate stability between anatomic (Femur-First) and mechanical alignment techniques using radiostereometric analysis**
Trevor Gascoyne

E10 **Mid-term migration of the stemless simpliciti shoulder system in total shoulder arthroplasty: A radiostereometric and clinical study with five years follow-up**
Rianne Oomen

E11 **Randomized controlled trial comparison of two hydroxy-apatite coated hip stems using radiostereometric analysis**
Trevor Gascoyne

E12 **Objectively measured knee instability during Pivot-shift test - an experimental dynamic RSA study**
Tobias Vind

E13 **Can virtual three-dimensional planning for proximal humerus fractures reduce intra-articular screw penetration?**
Reinier Spek

E14 **Ten years of the Canadian RSA Network: Progress, lessons, and prospects for RSA in Canada**
Trevor Gascoyne

E01

MID-TERM MIGRATION PATTERNS AND PATIENT REPORTED HIP FUNCTION FIVE YEARS AFTER PRIMARY UNCEMENTED TOTAL HIP ARTHROPLASTY

Klaassen A.D.[1], Willigenburg N.W.[1], Koster L.A.[2], Kaptein B.L.[2], Scholtes V.A.B.[1], van der Hulst V.P.M.[3], Moojen D.J.F.[1], Poolman R.W.[1,2]
[1]OLVG, Dept. of Orthopedics, Amsterdam, The Netherlands; [2]LUMC, Dept. of Orthopedics, Leiden, The Netherlands; [3]OLVG, Dept. of Radiology, Amsterdam, The Netherlands

Introduction
The risk of aseptic loosening of implants can be predicted by implant migration. This is the first study to evaluate migration and patient reported hip function of the C2 stem and Delta-TT cup (LimaCorporate, Italy), combined with a ceramic liner (CeramTec GmbH, Germany) in uncemented total hip arthoplasty (THA). Previously, the two-year results were presented at the RSA meeting in 2019, therefore in this abstract we focus on the five-year results.

Methods
In a prospective cohort (n=18, age=55±9 years, 13 female) RSA X-rays and Hip disability and Osteoarthritis Outcome Score Physical function Short form (HOOS-PS) scores were obtained at baseline, 6 weeks, 3, 6, 12, 24 and 60 months after THA. Model-based RSA was used to assess migration patterns and HOOS-PS scores were used to evaluate improvement in physical function. Proximal cup translation, change of cup inclination and stem incidence are described in literature as predictors for long-term aseptic loosening and therefore presented.

Results
Delta-TT cups combined with a ceramic liner stabilized within six months and C2 stems within six weeks and remained stable up to five years. At two and five years postoperatively, mean proximal translation at of the Delta-TT cup was 0.48mm (95%CI: 0.25-0.72) and 0.52mm (95%CI: 0.22-0.82) respectively, mean adduction was 1.06°(95%CI: 0.04-2.08)and 1.03°(95%CI: -0.14-2.21). Mean subsidence of the C2 stem was 1mm (95%CI: 0.11-1.91) at two years and 0.93mm (95%CI: -0.09-1.94) at five years.
HOOS-PS scores showed clinically relevant important improvement from 43.5 points (95%CI: 35.7-51.2) pre-surgery to 9.2 points (95%CI: 5.4-13.1) at five-years (p<0.001).

Discussion and Conclusion
Similar migration patterns were observed for Delta-TT cups in this study compared to those in a randomized controlled trial assessing liner type (polyethylene / ceramic) with five-year follow-up (manuscript under review). C2 stems showed initial migration, which is expected due to the settling phase of uncemented components and stabilized afterwards. More research is needed to define more specific migration thresholds for uncemented components. Scores on patient reported hip function were good and improved substantially after THA. These results seem promising for long-term implant survival.

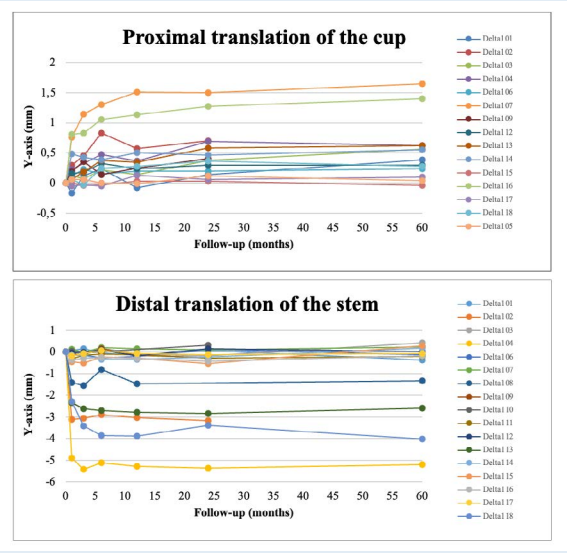


Figure: Individual migration patterns for Y-axis translation of the Delta-TT cup and C2 stem throughout five year follow-up.

ePosters

E02

COMPARISON OF ZIMMER ACETABULAR SYSTEM TO THE ALLOFIT CUP WITH ROENTGEN STEREOPHOTOGRAMMETRIC ANALYSIS (RSA) IN TOTAL HIP ARTHROPLASTY

Ian F. Blom[1,2], Rolf M. Bloem[2], Brechtje Hesseling[2], Nicole de Esch[2], Nina M.C. Mathijssen[2].
[1]Department of Radiology, Reinier de Graaf Groep, Delft, the Netherlands.
[2]Department of Orthopaedic Surgery, Reinier Haga Orthopaedic Center, Zoetermeer, the Netherlands.

Introduction
The Maxera Cup provides a large-head, ceramic-on-ceramic option for younger and active patients. This cup system offers high range of motion and low-wear bearing to better enable the restoration of patient's active lifestyle. To reduce implanting failure, early migration can be tested using radiostereometric analysis (RSA). This results in less suffering for patients and a reduction in healthcare expenses. In this study, we compared migration, clinical and radiographic outcomes of both the Maxera Cup and Allofit Cup up to two years of follow-up and expect comparable outcomes for both cups.

Methods
In this randomized controlled trial, patients with primary osteoarthritis (OA) in the hip joint, were included. Patients were randomized for the Maxera Ceramic cup (n=25) versus the standard uncemented polyethylene Allofit cup (n=25), all combined with the Taper M/L (Zimmer Biomet, Warsaw, Indiana, United States). Migration was measured using RSA radiographs, which were taken at discharge and at 6 weeks, 3 months, 6 months, 1 year and 2 years after surgery. Clinical outcomes were measured using the Oxford Hip score (OHS), Harris Hip Score (HHS) and EQ5D.

Results
At 2 years postoperatively, mean (SD) translation of the Maxera cup was 0.794 (1.5), 0.564 (1.07) and 0.493 (1.77) mm along the x-, y-, and z-axis, respectively. Mean (SD) rotation was 1.256 (4.55), 1.28 (3.57) and 0.171 (2.33) degrees along these axes. Mean (SD) translation for the Allofit cup was -0.791 (1.32), 0.307 (0.58) and 0.094 (0.60) mm along these axes. Mean (SD) rotation was 0.117 (1.26), -0.037 (0.83) and -0.339 (1.85) degrees along these axes.
Total translation respectively for the Maxera and Allofit cup are 1.1905 and 0.1036 mm.
24/25 Allofit cups shows stabilization after 1 year follow up.
The Maxera cup shows translation stabilization after 3 months and rotation stabilization after 1 year of follow-up.
Overtime, the Maxera cup shows higher translation (p=0.040) and rotation (p=0.030) along the x-axis. HHS shows improvement in 40 patients after 2 years of follow-up.

Discussion and Conclusion
Unlike the hypothesis, the Maxera cup shows a higher translation as well as a higher rotation. Clinical relevance is unknown and further research is indicated.

E03

MID-TERM PERFORMANCE OF A BICRUCIATE-RETAINING TKA, A RADIOSTEREOMETRIC ANALYSIS

Mills K., Defoort K.C., van Hellemondt G.G., Heesterbeek P.J.C.
Sint Maartenskliniek, Nijmegen, the Netherlands

Introduction
With a bicruciate-retaining (BCR) total knee arthroplasty (TKA) the horse shoe-shaped implant design and preservation of both cruciate ligaments can affect the fixation of the implant in the bone. Our previous study using radiostereometric analysis (RSA) showed higher micromotion of the tibia component of a BCR-TKA compared to a cruciate-retaining (CR) TKA, until two years postoperative. Therefore, the aim of this study was to investigate the micromotion of this BCR-TKA group at five years postoperatively.

Methods
For all available BCR-TKA patients, at five years postoperatively, RSA radiographs were made and questionnaires were taken: Forgotten Joint Score (FJS), OKS + APQ supplement, KOOS-PS and VAS pain and satisfaction. Micromotion of femur and tibia components was determined and expressed as Total Translation (TT) and Total Rotation (TR) and the change in Maximum Total Point Motion from 2-5 years postoperatively (ΔMTPM2-5yr).

Results
Of the 16 patients who completed two years follow-up, one died, one had a revision and one declined participation. For the remaining 13 patients the median TT of the femoral component at five year postoperatively was 0.47 mm (0.38, 0.63) and femoral TR was 0.52° (0.23, 0.70) (Figure). For the tibia component the median TT was 0.24 mm (0.17, 0.47) and TR was 0.60° (0.46, 1.10) (Figure 1). The median ΔMTPM2-5yr were -0.04 mm (-0.13, 0.09) and -0.01 mm (-0.05, 0.10) for the femoral and tibial components, respectively. Clinical outcomes showed high PROM-scores and high satisfaction (100 (81-100)) and low pain (1 (0-21)) scores. A total of 5 patients reported medial-lateral instability, of which 2 underwent a revision.

Discussion and Conclusion
The BCR-TKA shows stabilization of micromotion from 2-5 years follow-up, except for some outliers. Clinically we saw no signs of implant loosening, high PROM scores and no revisions for loosening, but relatively many cases of unexplained medial-lateral instability.

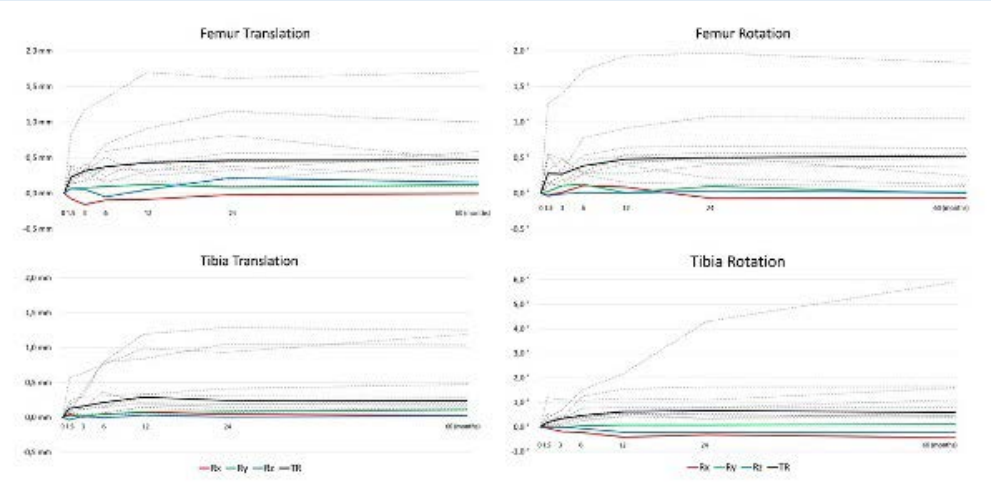


Figure: Femoral (upper) and tibial (lower) translations (left) and rotations (right), the dotted lines present the TT and TR for all individual patients.

E04

RADIOSTEREOMETRIC ANALYSIS OF HYDROXYAPATITE AND POROUS TRITANIUM COATED ACETABULAR COMPONENTS IN A RANDOMIZED CONTROLLED TRIAL SHOWS COMPARABLE MIGRATION FIVE YEARS AFTER UNCEMENTED THA

Lennard A. Koster[1], Sander C. van Eijck[3], Bart L. Kaptein[1], Liesbeth M. Jütten[2], Chris, J. Arts[2], Rene H. ten Broeke[3]
[1]Department of Orthopaedic Surgery, Leiden University Medical Center, Leiden, the Netherlands
[2]Trialbureau Orthopedics, Maastricht University Medical Center, the Netherlands
[3]Department of Orthopedic Surgery, Maastricht University Medical Center, the Netherlands

Introduction

Hydroxyapatite (HA) coatings on acetabular components in uncemented total hip arthroplasty (THA) promoting bone on-growth are frequently used. Porous coating of the component improving in-growth of the bone could possibly result in better fixation. We performed a radiostereometric analysis (RSA) randomized controlled trial with 5 year follow-up comparing migration of a HA coated and a porous tritanium coated acetabular design.

Methods

Patients eligible for primary THA were randomized to receive a porous tritanium coated or a HA coated acetabular component (Trident design, Stryker). Liner and hip stem were identical for both groups. Model-based RSA was used to calculate acetabular component migration at 1, 3, 6, 12, 24 and 60 months postoperative compared to the reference made at the first postoperative day before weightbearing.

Results

Migration results of 17 porous coated and 19 HA coated components showed that not all cups stabilized after 6 months (Figure). At 2 and 5 years postoperative mean (95% CI) proximal migration was 0.48mm (0.30:0.67) and 0.61mm (0.32:0.90) for the porous component and 0.30mm (0.24:0.36) and 0.31mm (0.24:0.38) for the HA component. Mean (95% CI) inclination at 2 and 5 years was 0.47deg (0.19:0.74) and 0.55deg (0.15:0.95) for the porous cups and -0.18deg (-0.54:0.17) and -0.16deg (-0.64:0.32) for the HA.

Discussion and Conclusion

Porous coating potentially enhances bone ingrowth resulting in a better component fixation compared to a HA coated component. However, this study showed that the porous coated component migrated more initially and showed more migration between 2 and 5 years postoperative compared to the HA coated component. In addition, migration of the porous coated component showed larger differences between the patients compared to the HA components. Migration at longer follow-up is warranted to assess if the porous coated components continue to migrate. Based on this study porous coated components do not have a better fixation than HA coated components.

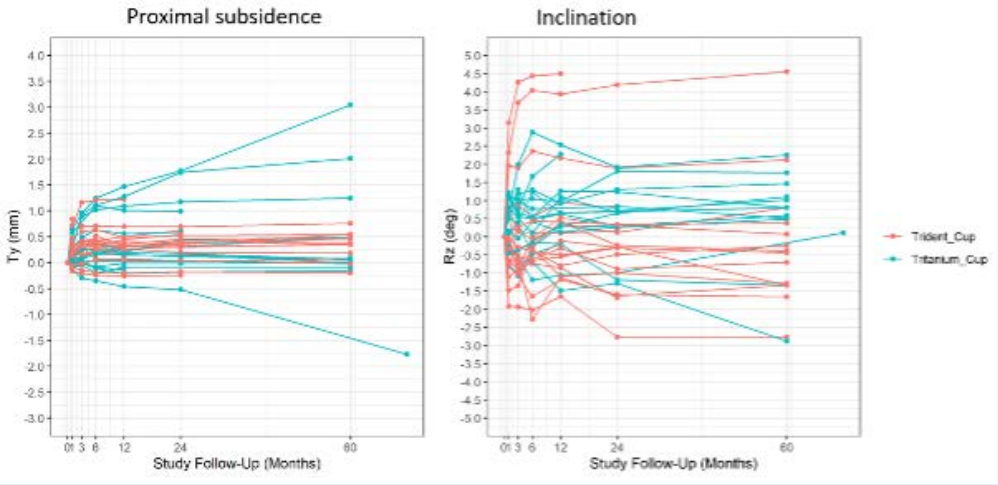


Figure Individual patient subsidence (Left panel) and inclination (Right panel) of the porous tritanium coated (Tritanium) and HA coated (Trident) components.

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E05

TWO YEAR MIGRATION RESULTS OF A NECK PRESERVING SHORT STEM – IS HA COATING NOT BENEFICIAL ANYMORE?

Stefan Budde, Christof Hurschler, Yvonne Noll, Alexander Derksen, Michael Schwarze
Hannover Medical School, Orthopaedic Department, Hannover, Germany

Introduction
Previous studies of uncemented implants have found an advantage for surface treatment with Hydroxyapatite regarding early migration and survival. The concept was widely adapted for uncemented short stems, but its efficacy was not proven in this special application. The primary endpoint of the study therefore is the difference in migration depending on surface coating of the A2 short stem (Artiqo, Germany) after 24 months.

Materials and Methods
Sixty patients were included in the study and randomly assigned to titanium plasma spray (TPS) coating only or additional HA (Bonit) coating.RSA examinations were conducted at the day of surgery or in the morning of the post-operative day before any loading of the affected leg, at hospital discharge, 1.5, 3, 6, 12 and 24 months post-operatively. Resulting migration over time was calculated using bone markers and CAD models.

Results (preliminary, last patient last visit in January 2023)
Resulting mean migration after 24 months was 0.74mm (SD: 1.17mm) for all patients. Migration for patients with TPS only was lower (0.46mm, SD: 0.46mm) than patients with HA coating (1.03mm, SD: 1.56mm; p=0.062). The main proportion of migration occurred between discharge (0.24mm, SD: 0.13mm) and 6 weeks follow-up (0.72mm, SD: 2.81mm).

Interpretation and Conclusion
Overall, the amount of migration is comparable to other uncemented short stems. Contrary to expectations, the additional coating did not reduce the initial migration. Whilst the proliferated osseointegration is unlikely to play an important factor in the early migration, the reduced surface roughness might reduce the initial stability and lead to a settling of a proportion of implants. Within this 2-year follow-up, no negative clinical complications were associated with this initial migration and all implants reached a steady state.

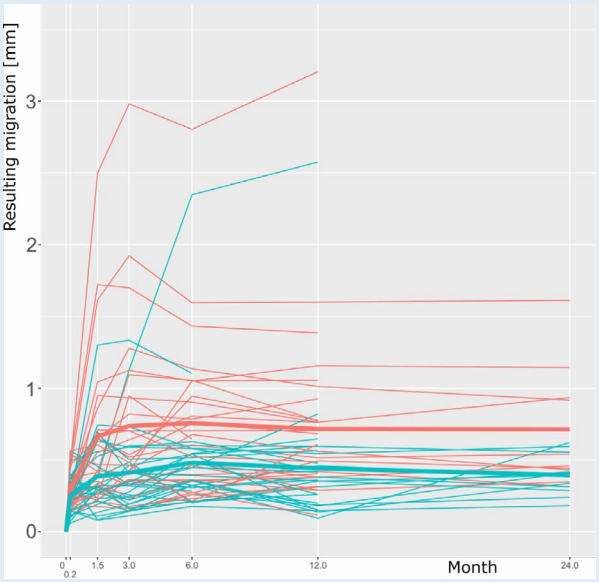


Figure : Resultant migration at each follow-up categorized by surface coating (red: HA coating; blue: TPS only). Two patients with migration >10mm and revision at 3 and 6 months follow-up were removed for clarity.

E06

A RANDOMIZED CONTROLLED TRIAL COMPARING TWO-YEAR POSTOPERATIVE FEMORAL AND TIBIAL MIGRATION OF A NEW AND AN ESTABLISHED CEMENTLESS ROTATING PLATFORM TOTAL KNEE ARTHROPLASTY

Lennard A. Koster[1], Rachid Rassir[2], Bart Kaptein[1], Inger Sierevelt[3], Marjolein Schager[2], Rob Nelissen[1], Peter A. Nolte[2]
[1]Department of Orthopaedic Surgery, Leiden University Medical Center, Leiden, the Netherlands
[2]Department of Orthopaedic Surgery, Spaarne Gasthuis, Hoofddorp, the Netherlands
[3]SCORE, Specialized Centre of Orthopedic Research and Education, Xpert Orthopedie Amsterdam

Introduction
Primary objective was to compare 2-year postoperative (PO) femoral and tibial component migration of the cementless rotating platform Attune and LCS Total Knee Arthroplasty (TKA) designs, using radiostereometric analysis (RSA) to assess the risk for aseptic loosening. Secondary objective was to compare clinical, and patient reported outcome measures (PROMs) between the TKA designs.

Methods
Sixty-one knees were analyzed in this randomized clinical RSA trial. RSA examinations were made 1-day, 3, 6, 12 and 24 months PO. Maximal total point motion (MPTM), translations and rotations of the components were analyzed. PROMs and physical examinations were collected preoperatively, 6 weeks, 3, 6, 12 and 24 months PO. Linear mixed effect modelling was used for statistical analyses.

Results
Mean 2-year PO MTPM (95% confidence interval)) of the Attune femoral component differed from the LCS with 0.92mm (0.75 to 1.11) and 1.72mm (1.47 to 2.00) respectively ($p<0.0001$). The Attune femoral component subsided, tilted (anteroposterior) and rotated (internal-external) less.
Tibial MTPM 2-year PO was comparable with 1.11mm (0.94 to 1.30) and 1.66mm (0.99 to 1.36), ($p=0.45$) for the Attune and LCS components respectively.
MTPM-rates in the second PO year were negligible for femoral and tibial components of both designs. Pain-at-rest (NRS-rest) for Attune was less over the entire FU-period compared to LCS. At 3-months PO, KOOS-PS, OKS, NRS-activity scores were superior for the Attune design.

Discussion / Conclusion
MTPM of the cementless rotating platform Attune femoral design was less compared to that of the LCS design. This reflected mainly in less subsidence, posterior tilting and internal rotation. Tibial MTPM was comparable. During the second postoperative year the components of both designs stabilized and low risks for aseptic loosening are expected.

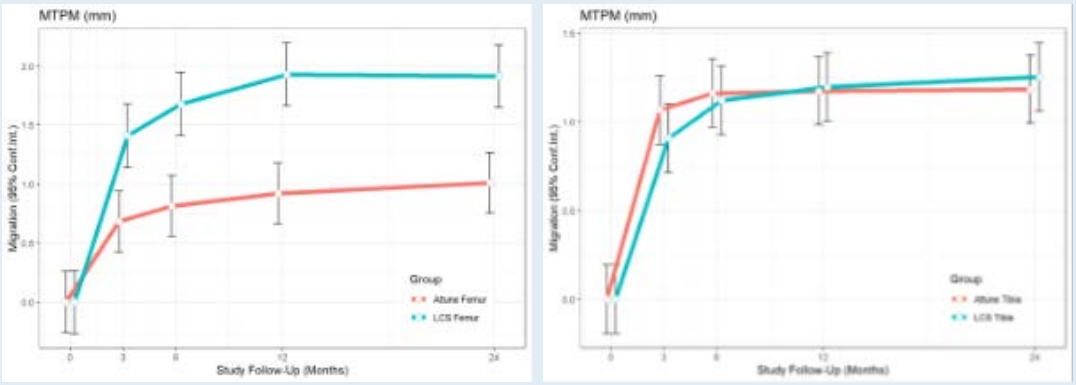


Figure: Mean MTPM of the femoral components (Left pane) and the tibial components (Right pane) of the Attune and LCS knee systems.

E07

LENGTH CHANGES OF THE MEDIAL PATELLOFEMORAL LIGAMENT DURING IN VIVO KNEE MOTION: A DYNAMIC EVALUATION USING COMPUTED TOMOGRAPHY

Miriam R. Boot[1], Sebastiaan A.W. van de Groes[2], Hans Dunning[1], Esther Tanck[1] and Dennis Janssen[1]
[1] Orthopaedic Research Laboratory, Radboud Institute for Health Sciences, Radboud university medical center, Nijmegen, The Netherlands
[2] Department of Orthopaedics, Radboud University Medical Center, Nijmegen, The Netherlands

Introduction
Medial patellofemoral ligament (MPFL) reconstruction is the primary treatment for patients with recurrent patellofemoral instability. Yet, the surgery is associated with high complication rates. Clinical outcomes can be improved by a better understanding of MPFL elongation patterns. Therefore, this study aimed to assess length changes of the MPFL throughout the range of knee motion.

Methods
A high resolution static and medium resolution dynamic CT scan of both knees were obtained in 134 knees of 73 healthy subjects. Static CT scans were obtained in full extension. Dynamic CT scans were obtained during an active flexion-extension-flexion movement (full extension to 90° flexion). Static and dynamic CT data were superimposed using image registration and transformations were interpolated to get 3D knee joint models per angle of flexion. Using the knee models, the MPFL length was measured based on anatomic studies from Schöttle's point on the femur to three insertion points on the superomedial border of the patella (proximal, central, and distal). The shortest wrapping path around the femoral condyle was selected as the MPFL length. Subsequently, MPFL length changes were assessed per flexion angle and expressed as percentual length changes relative to the length in full extension.

Results
The mean MPFL length in full extension was 58.4, 55.7 and 53.8 mm for the proximal, central and distal insertion. During knee flexion, the median percentual MPFL length changes varied between -6 to 4 % relative to full extension (range: -22 to +24 %) (Fig. 1). In the first 10° of flexion, the median MPFL length decreased by 2-3%. Beyond 10° of flexion, the elongation pattern depended on the patellar attachment site. The central fibre length restored to the full extension length between 50-60° of flexion (median (interquartile range (IQR)), 0 (10)%), whereas the proximal fibre length remained decreased (-4 (7)%) and the distal fibre length increased (+4 (9)%).

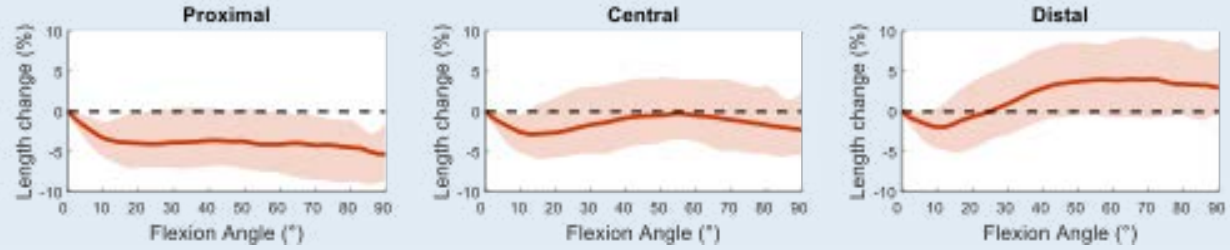


Figure. Percentual MPFL length changes relative to full extension during knee flexion (0 - 90°) for the proximal, central and distal patellar attachments. Solid lines represent inter-subject medians and shadings represent ± IQR. The horizontal dotted line represents an isometric behaviour of the MPFL.

Conclusion
The MPFL has on average a near-isometric behaviour during knee flexion but interindividual differences are large. These findings suggest that a personalized surgical approach may be desirable for reducing complication rates. Future studies should focus on anatomical causes underlying these differences in elongation patterns.

E08

3D VIRTUAL PLANNING TO ASSIST INTRA-OPERATIVE ARTICULAR REDUCTION AND IMPLANT CHOICE FOR PATIENTS WITH TIBIAL PLATEAU FRACTURES

Jellina M. Huitema[1], Nynke Van der Gaast[1,2], Dagmar S. Alderlieste[1,2], Britt Edwards[1,2], Joy Verbakel[1,2], Job N. Doornberg[3], Michael J.R Edwards[1], Ruurd L. Jaarsma[2], Erik Hermans[1]
[1]Department of Trauma Surgery, Radboud University Medical Center, Nijmegen, the Netherlands
[2]Department of Orthopaedic & Trauma Surgery, Flinders University, Flinders Medical Centre, Adelaide, Australia
[3]Department of Orthopaedic Surgery, University Medical Center Groningen, Groningen, the Netherlands.

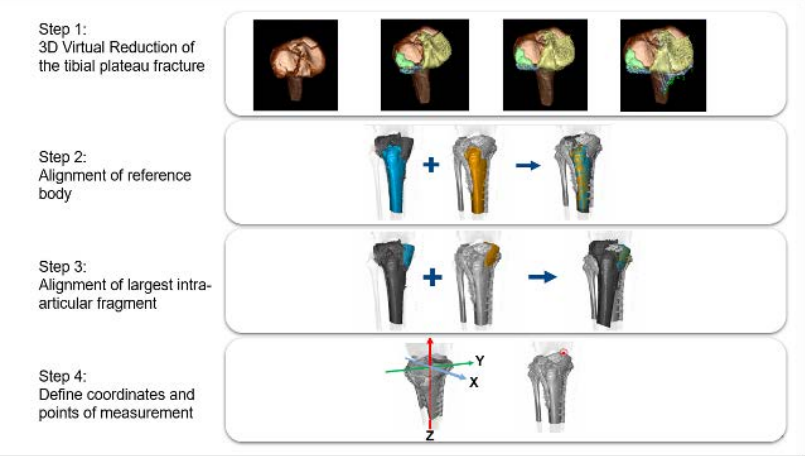
Background
Three-Dimensional Virtual Planning (3DVP) has been proven to be effective for the reduction of intra-articular screw penetration and the quality of reduction for different fractures. However, the value of 3DVP for patients with tibial plateau fractures has yet to be determined.

Purposes
The aim of this study is to determine the differences between 3D virtual planning and the postoperative reduction for tibial plateau fractures in terms of reduction of the largest intra-articular fragment?

Methods
Nine adult patients (mean age: 45.8 years) who received surgical treatment for a tibial plateau fracture and received pre- and postoperative Computed Tomography (CT) scans were included. The preoperative CT scans of the patients were uploaded in a 3DVP software (Sectra AB © '3D trauma for orthopaedics' Linköping, Sweden). In this software, fracture fragments were reduced and osteosynthesis material was placed. The quality of the reduction from the 3DVP software was compared with the postoperative results using CT-RSA (CTMA, Sectra AB ©, Linköping, Sweden). With this analysis, the translation of the largest intra-articular fragment was calculated by aligning the postoperative CT to the 3DVP. Coordinates and measurement points were defined in the x, y, and z axes (figure).

Results
The mean total translation of the largest intra-articular fragment in mm was X = 2.9 (Range 0.3 – 8.8); Y = 1.1 (Range 0.1 – 7.5); Z = 2.4 (Range 0.4 – 4.7). The choice of osteosynthesis material was different for 3 out of 12 plates that were used in 9 patients.

Conclusions
The difference between the virtual and real life reduction in regards to translation of the largest intra-articular fragment was acceptable. When looking at the z-axis, which is closest to determining step-off, we found a limited difference of 2.4mm (Range 0.4 – 4.7). We conclude that the use of 3DVP could be of additional value for the treatment of patients with tibial plateau fractures. A prospective study has been started to assess the value of 3D virtual planning preoperatively in terms of patient-related outcomes.



E09

RANDOMIZED CONTROLLED TRIAL COMPARING TIBIAL BASEPLATE STABILITY BETWEEN ANATOMIC (FEMUR-FIRST) AND MECHANICAL ALIGNMENT TECHNIQUES USING RADIOSTEREOMETRIC ANALYSIS

Turgeon T.R.[1,2,5], Lanting, B.[3], Vasarhelyi E.M.[3], Howard J.[3], Teeter M.G.[3,4], Gascoyne T.C.[5], Bohm E.R.[1,2,5]
[1]Concordia Joint Replacement Group
[2]University of Manitoba
[3]London Health Sciences Centre
[4]Lawson Health Research Institute
[5]Orthopaedic Innovation Centre

Purpose
Limb alignment following total knee arthroplasty (THA) is an important factor not only for post-operative function and patient satisfaction, but also regarding implant survivorship. This study aimed to compare migration patterns between mechanical and anatomic alignment surgical techniques for a single implant system using model-based RSA over the first 2 post-operative years.

Method
Fifty-seven patients requiring primary total knee arthroplasty for end-stage osteoarthritis were enrolled at two Canadian centres. All patients received an Attune S+ CR knee replacement and were randomized to either anatomical alignment or mechanical alignment as the surgical target. Mechanical alignment aimed to achieve a neutral hip-knee-ankle (HKA) alignment within ±3 degrees. Anatomical alignment respected the patient's unique anatomy within boundaries of a HKA alignment of 177-183 degrees, femoral valgus angle of <99 degrees, and a tibial joint line angle of 87-90 degrees as maximal values. Surgical approach, tourniquet use, and cement type were standardized between sites. Patients underwent supine RSA imaging at 6 weeks (baseline), 6, 12, and 24 months following surgery. The primary study outcome was tibial baseplate subsidence at 12 and 24 months. Patient reported outcome measures were captured throughout the study. Statistical analysis utilized paired and unpaired t-tests with significance set at $p \leq 0.05$.

Results
At the time of writing, 6 patients were withdrawn from the study, 30 patients completed the study to 12 months, and 18 patients completed to 24 months. Mean patient age was 67 years (SD=7.9) and body mass index was 31.4kg/m2 (SD=5.8). Cumulative tibial baseplate subsidence at 12 months was not significantly different between anatomical (0.006±0.043mm) and mechanical (0.018±0.035mm) alignment groups (p=0.44). Similarly, no significant difference was found at 24 months between anatomical (0.040±0.162mm) and mechanical (0.016±0.022mm) alignment groups (p=0.68). Total baseplate migration (maximum total point motion, MTPM) was also not significantly different at 12 or 24 months (p>0.34). All patients reported significant functional improvement from baseline to 12 and 24 months after surgery. No significant differences were found between patient groups.

Conclusion
The anatomical versus mechanical alignment techniques applied in this study for a single implant system do not have a significant effect on tibial baseplate migration.

E10

MID-TERM MIGRATION OF THE STEMLESS SIMPLICITI SHOULDER SYSTEM IN TOTAL SHOULDER ARTHROPLASTY: A RADIOSTEREOMETRIC AND CLINICAL STUDY WITH FIVE YEARS FOLLOW-UP

R. Oomen, B. ten Brinke, B. Hesseling, M. A. Hoelen, N.M.C. Mathijssen
Reinier Haga Orthopedisch Centrum, Zoetermeer, The Netherlands

Introduction
In shoulder arthroplasty, stemless implants have been developed to avoid drawbacks of stemmed arthroplasty. However, stemless implants have a reduced area of fixation, potentially leading to suboptimal fixation and loosening. In a short-term RSA study we previously demonstrated continuous migration in 4/24 implants two years postoperatively. The aim is to investigate migration patterns of the stemless humeral component of the Simpliciti Shoulder System using model-based RSA in mid-term follow-up.

Methods
Migration was calculated in 24 patients at baseline (<24h after surgery), six weeks, six months, one year, two years and five years postoperatively. Clinical outcomes were evaluated at the same time points using the visual analogue scale (VAS), the Oxford Shoulder Score (OSS), the Constant-Murley Score (CMS), and the Disabilities of the Arm, Shoulder and Hand (DASH) score. Mid-term migrations, clinical and survival data were compared with early migration.

Results
Two prostheses have been revised, one patient suffered a periprosthetic fracture, one patient could not visit our clinic but completed the questionnaire and one patient deceased so that migration could be measured in 19 patients. At five years, median translation along the x-, y- and z-axis was -0.11mm (IQR -0.47mm – 0.03mm), -0.20mm (IQR -0.28mm – 0.03mm), and 0.15mm (IQR -0.10mm – 0.34mm). Median rotation around the x-, y- and z-axis was -0.37° (IQR -0.70° – 0.28°), -0.10° (IQR -1.34° – 1.84°), and -0.09° (IQR -0.85° – 0.65°). Two implants with known continuous migration at two years continued to migrate between 2 and 5 years follow-up. Clinical scores improved significantly compared with baseline in 18/20 patients and were not significantly different between 2 and 5 years.

Discussion and Conclusion
This is the first RSA study presenting mid-term migration results of a stemless shoulder implant. No revision due to aseptic loosening occurred. Of 19 implants, 17 were stable. Two implants with continuous migration at 2 years, continued to migrate between 2 and 5 years postoperatively. Long-term follow-up is necessary to determine the significance of this continuous migration with respect to long-term outcomes. Clinical outcomes were good in 18/20 patients. Continuous migration did not affect clinical outcomes up to 5 years postoperatively.

E11

RANDOMIZED CONTROLLED TRIAL COMPARISON OF TWO HYDROXY-APATITE COATED HIP STEMS USING RADIOSTEREOMETRIC ANALYSIS

Canadian RSA Network, consisting of: Turgeon T.R.[1,2,3], Bohm E.R.[1,2,3], Gascoyne T.C.[3], Hedden D.R.[1,2,3], Burnell C.[1,2]
[1]Concordia Joint Replacement Group
[2]University of Manitoba
[3]Orthopaedic Innovation Centre

Purpose

This study used model-based radiostereometric analysis (MBRSA) to compare migration of a recently introduced cementless total hip arthroplasty (THA) stem to an established THA stem of similar design. Novel design features of the newer hip stem included a greater thickness of hydroxyapatite coating and a blended compaction extraction femoral broach.

Method

Sixty-seven patients requiring primary THA were enrolled at a single centre. Patients were randomized to receive either an Avenir collarless stem and Trilogy IT cup (Zimmer Biomet) or a Corail collarless stem and Pinnacle cup (DePuy Synthes) via a posterior or lateral approach. RSA beads (Halifax Biomedical) were inserted into the proximal femur during surgery. Patients underwent supine RSA imaging a 6 weeks (baseline), 6, 12, and 24 months following surgery. The primary study outcome was total subsidence of the hip stem as well as varus/valgus tilt, anteversion-retroversion, and maximum total point motion (MTPM) from baseline to 24 months. Patient reported health and function scores were collected at pre-operative and post-operative intervals. Analysis comprised of paired and unpaired t-tests and Fisher's exact tests with significance set at $p \leq 0.05$.

Results

Forty-six patients (29 males) were included for analysis; Mean age at time of surgery was 65.7 years (SD=7.3) and body mass index was 30.2 kg/m2 (SD=5.2). No statistical differences in stem subsidence, varus/valgus tilt, anteversion-retroversion, or MTPM were found between study groups at any follow-up ($p>0.10$). One patient in the novel stem group suffered recurrent dislocations within a year after surgery and underwent a full system revision at 13 months due to septic loosening. Examination of this patients' RSA data showed no discernable stem migration which is believed to be from ingrowth of the distal stem despite significant proximal radiolucency. No significant differences were found between study groups for any pre- or post-operative function scores ($p>0.10$) and all patients showed significant functional improvement following surgery.

Conclusion

We demonstrate no statistical or clinical difference in stem migration or patient-reported outcomes between the study groups. These results suggest both stem designs are at low-risk for aseptic loosening in the long-term.

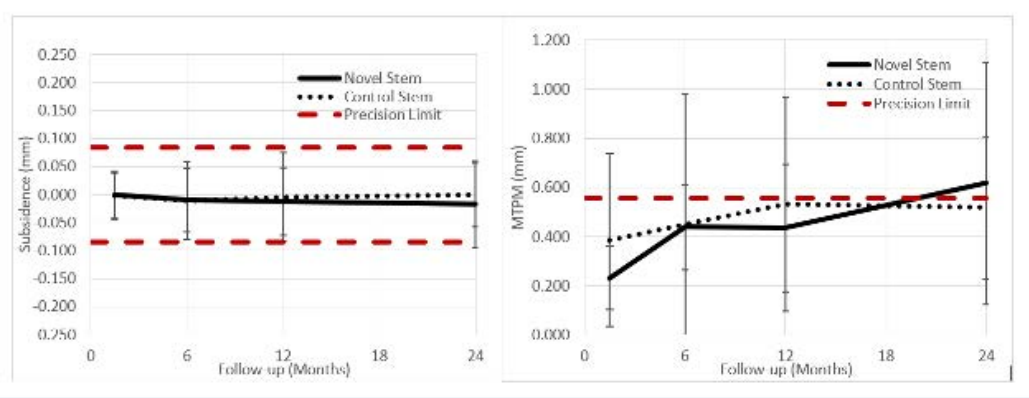


Figure: Hip stem migration graphs

ePosters

E12

OBJECTIVELY MEASURED KNEE INSTABILITY DURING PIVOT-SHIFT TEST - AN EXPERIMENTAL DYNAMIC RSA STUDY

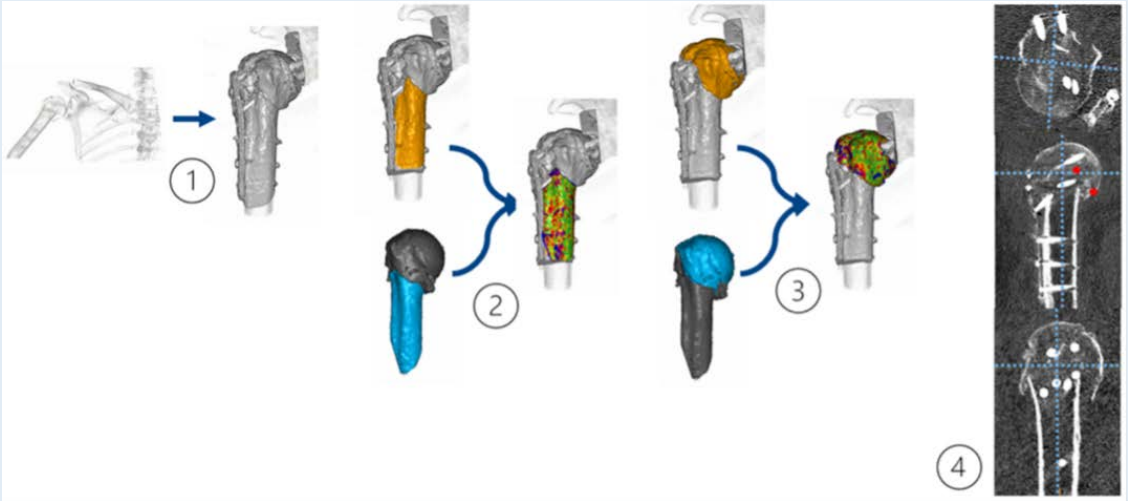
Vind T.[1,2], Petersen E.T.[1,2] , Sørensen O,G.[3,4], Lindgren L.[5], Stilling M.[1-3]
[1]Department of Clinical Medicine, Aarhus University, Aarhus, Denmark
[2]AutoRSA Research Group, Orthopaedic Research Unit, Aarhus University Hospital, Aarhus, Denmark
[3]Department of Orthopaedic Surgery, Aarhus University Hospital, Aarhus, Denmark
[4]Division of Sports Trauma, Orthopaedic Department, Aarhus University Hospital, Aarhus, Denmark.
[5]Department of Radiology, Aarhus University Hospital, Aarhus, Denmark.

Objective
The Pivot-shift test is a clinical test for knee instability for patients with Anterior cruciate ligament (ACL) lesions, however the test has low inter-observer reliability. Dynamic radiostereometry (dRSA) imaging is a highly precise non-invasive method for objective evaluation of joint kinematics. The aim of this study was to quantify precise knee kinematics by use of dRSA imaging during Pivot-shift test in knees with intact ligaments, in knees with ACL lesion, and in knees with a combined ACL and ALL lesion.

Method
Eight human donor legs with hemipelvis were evaluated. Ligament lesion intervention of the ACL was performed during arthroscopy and anterolateral ligament (ALL) section was performed as a capsular incision. Pivot-shift test examination was recorded with dRSA on ligament intact knees, ACL-deficient knees and ACL+ALL-deficient knees.

Results
A Pivot-shift pattern was identifiable after ligament lesion as a change in tibial posterior drawer velocity from 7.8 mm/s in ligament intact knees, to 30.4 mm/s after ACL lesion, to 35.1 mm/s after combined ACL-ALL lesion. The anterior-posterior drawer excursion increased from 2.8 mm in ligament intact knees, to 7.2 mm after ACL lesion, to 7.6 mm after combined lesion. Furthermore, a change in tibial rotation was found, with increasing external rotation at the end of the pivot-shift motion going from intact to ACL+ALL-deficient knees

Conclusion
This experimental study demonstrates the feasibility of dRSA to objectively quantify the kinematic laxity patterns of the knee during the Pivot-shift test. The dynamic parameters found through dRSA displayed the kinematic changes from ACL to combined ACL-ALL ligament lesion.



E13

CAN VIRTUAL THREE-DIMENSIONAL PLANNING FOR PROXIMAL HUMERUS FRACTURES REDUCE INTRA-ARTICULAR SCREW PENETRATION?

Spek R.W.A.[1], van den Bekerom M.P.J.[1], IJpma F.A.[2], Jaarsma R.L.[3], Doornberg J.N.[4], the Traumaplatform 3D Consortium
[1]Department of Orthopaedic Surgery, OLVG, Amsterdam, the Netherlands.
[2]Department of Trauma Surgery, University Medical Centre Groningen, Groningen, the Netherlands.
[3]Department of Orthopaedic Surgery, Flinders Medical Centre, Adelaide, Australia.
[4]Department of Orthopaedic Surgery, University Medical Centre Groningen, Groningen, the Netherlands

Background
Optimizing screw lengths in plated proximal humerus fractures may be challenging due to the mismatch between intra-operative fluoroscopy and the actual Three-Dimensional (3D) spherical shape of the humeral head: intra-articular screw penetration appears a preventable iatrogenic reason for re-operation. As it is unclear if surgeon-controlled pre-operative virtual planning can reduce this complication, this study was carried out.

Questions/Purposes
How does the virtually achieved fixation compares to the actual surgery with respect to fracture reduction, plate position and screw lengths?

Methods
This retrospective imaging study included CT scans from patients (aged ≥ 18) with operatively treated proximal humerus fractures fixed by either a Carbofix or Philos plate. These fourteen patients (median age 66 years (32 – 76), 10 females, 4 males) with 14 proximal humerus fractures were reduced and fixed with virtual planning software by eight attending orthopaedic surgeons. The reduction between the virtual planning and the actual operative results was compared with computed tomography micromotion analysis: a tool developed to detect micromotion between objects such as bones or implants (Figure). The plate positions and screw lengths were compared using postoperative CT scans.

Results
The mean difference in total fracture rotation of the head between the virtual and true surgical reduction was 22.0°. The medial hinge displacement was 7.9 ± 4.5 mm and the centre of rotation 4.2 ± 1.9 mm. The plate position in the virtual group was 3.2 mm higher than the surgical group, but still below the threshold for impingement. Apart from the superior posterior converging screw there were no significant differences in screw lengths.

Conclusions
This study shows a new application of computed tomography micromotion analysis in trauma surgery. As the true surgical results did not resemble the desired virtual model reductions, surgeons should re-assess their reduction and plate position if they measure a length other than their pre-planned screw dimensions during surgery.
Level of Evidence Level III, diagnostic study.

E14

TEN YEARS OF THE CANADIAN RSA NETWORK: PROGRESS, LESSONS, AND PROSPECTS FOR RSA IN CANADA

Trevor Gascoyne[1,2], Eric Bohm[1,2,3], Michael Dunbar[1,4,] Elise Laende[1,5], Brent Lanting[1,6], Douglas Naudie[1,6], Glen Richardson[1,4], Matthew Teeter[1,6], Thomas Turgeon[1,2,3]
[1]Canadian RSA Network
[2]Orthopaedic Innovation Centre
[3]University of Manitoba
[4]Dalhousie University
[5]Queen's University
[6]Western University

The Canadian RSA Network (CRSAN) was formed in 2013 and incorporated as a non-profit in 2014. The goals of this collaboration were to unify Canadian RSA centres, improve study quality and generalizability, attract industry-sponsored research, decrease study recruitment periods and provide accessible RSA science to manufacturers following phased innovation approaches. We reflect upon our 10-year history to provide insight on what can be accomplished through collaboration and a business-like approach to research.
CRSAN primarily acts as a contract research organization (CRO), providing overall study management, contracting, financial administration, and a communication conduit between industry and academic RSA centres which include Winnipeg MB, London ON, and Halifax NS. CRSAN facilitates both investigator initiated and sponsored research studies along with data ownership particulars of each. A central RSA analysis service (Halifax Biomedical) is contracted to provide standardized radiographic analyses.

Our first multi-centre RSA study was initiated in 2014 with 30 patients enrolled within 8 months across 2 centres. This study opened the door to numerous additional studies with this sponsor. Other major manufacturers soon became interested in CRSAN, which accelerated due to implementation of Europe's new MDR. Presently, CRSAN has numerous active and planned RSA studies from major manufacturers who account for 86% global market share of hip and knee reconstruction.

Several challenges remain for CRSAN including RSA bead supply, tightening restrictions on personal health information, and remaining price-competitive despite the additional overhead of coordinating multiple sites. Benefits of the network approach include shorter recruitment periods and access to diverse patients and surgical techniques. The advent of CT-based and biplanar line-emitted radiography migration analyses, while potentially competitive, are seen as opportunities for expansion of CRSAN to new sites and new disciplines of orthopaedics.
We anticipate the next decade of CRSAN will witness the normalization of RSA in pre-market release evaluation of joint replacement devices, particularly in the USA, as well as wider application of RSA to pediatrics, spine, and extremities. Growth of our fundamental technology is coming and collaboration amongst the originators and champions of RSA will continue to ensure the quality and novelty of research is maintained.

WITH THANKS TO OUR SPONSORS

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SECTRA CT-BASED MICROMOTION ANALYSIS

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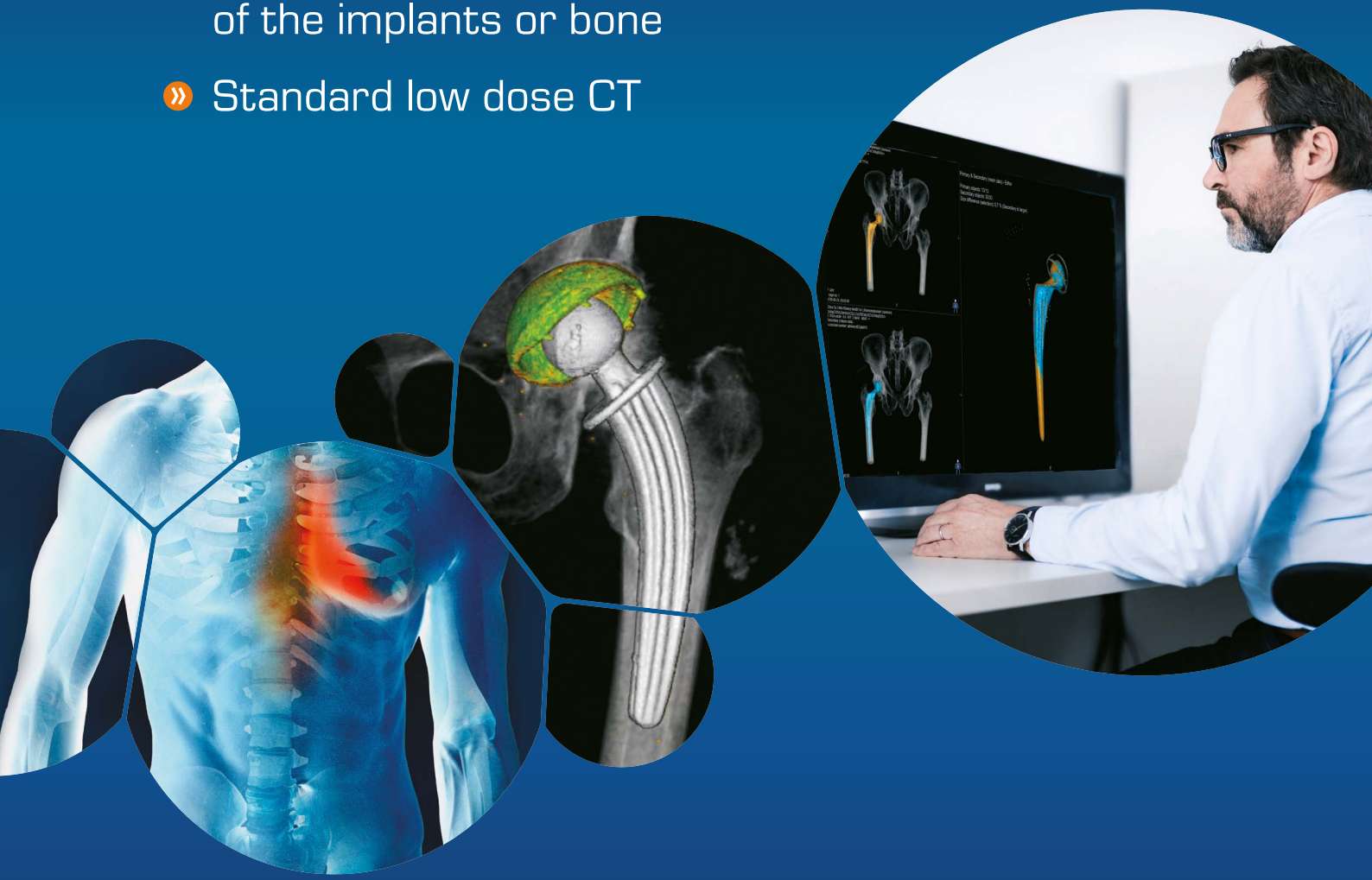
- No need for special marking of the implants or bone
- Standard low dose CT



SECTRA

Knowledge and passion

Organizing committee

Petra Heesterbeek
Senior scientist in the field of clinical orthopedics at Sint Maartenskliniek Nijmegen. Research Lead of Orthopedic Innovations and head of the orthopedic research team.

Bart Kaptein
Senior Researcher at the Department of Orthopaedics at Leiden University Medical Center working in Model-based RSA related research since 2000.

Lennard Koster
Model-based RSA software specialist. I enjoy providing training sessions in software use and assisting with clinical RSA studies.

Dennis Janssen
Associate professor at Radboudumc in Nijmegen and is specialized in orthopedic biomechanics.

Silvia de Bruin
Project manager at the Innovation department of the Sint Maartenskliniek.