Adherence of hip and knee arthroplasty studies to RSA standardization guidelines: A systematic review

Citation
Madanat, Rami, Tatu J Mäkinen, Hannu T Aro, Charles Bragdon, and Henrik Malchau. 2014. “Adherence of hip and knee arthroplasty studies to RSA standardization guidelines: A systematic review.” Acta Orthopaedica 85 (5): 447-455. doi:10.3109/17453674.2014.934187. http://dx.doi.org/10.3109/17453674.2014.934187.

Published Version
doi:10.3109/17453674.2014.934187

Permanent link
http://nrs.harvard.edu/urn-3:HUL.InstRepos:13347623

Terms of Use
This article was downloaded from Harvard University’s DASH repository, and is made available under the terms and conditions applicable to Other Posted Material, as set forth at http://nrs.harvard.edu/urn-3:HUL.InstRepos:dash.current.terms-of-use#LAA

Share Your Story
The Harvard community has made this article openly available. Please share how this access benefits you. Submit a story.

Accessibility
Adherence of hip and knee arthroplasty studies to RSA standardization guidelines

A systematic review

Rami Madanat¹, ³, Tatu J Mäkinen¹, Hannu T Aro², Charles Bragdon³, and Henrik Malchau³

¹Helsinki University Central Hospital, Helsinki; ²Turku University Hospital and University of Turku, Turku, Finland; ³Harris Orthopaedic Laboratory, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA.
Correspondence: rami.madanat@hus.fi
Submitted 13-08-19. Accepted 14-03-21

Background and purpose — Guidelines for standardization of radiostereometry (RSA) of implants were published in 2005 to facilitate comparison of outcomes between various research groups. In this systematic review, we determined how well studies have adhered to these guidelines.

Methods — We carried out a literature search to identify all articles published between January 2000 and December 2011 that used RSA in the evaluation of hip or knee prosthesis migration. 2 investigators independently evaluated each of the studies for adherence to the 13 individual guideline items. Since some of the 13 points included more than 1 criterion, studies were assessed on whether each point was fully met, partially met, or not met.

Results — 153 studies that met our inclusion criteria were identified. 61 of these were published before the guidelines were introduced (2000–2005) and 92 after the guidelines were introduced (2006–2011). The methodological quality of RSA studies clearly improved from 2000 to 2011. None of the studies fully met all 13 guidelines. Nearly half (43) of the studies published after the guidelines demonstrated a high methodological quality and adhered at least partially to 10 of the 13 guidelines, whereas less than one-fifth (11) of the studies published before the guidelines had the same methodological quality. Commonly unaddressed guideline items were related to imaging methodology, determination of precision from double examinations, and also mean error of rigid-body fitting and condition number cutoff levels.

Interpretation — The guidelines have improved methodological reporting in RSA studies, but adherence to these guidelines is still relatively low. There is a need to update and clarify the guidelines for clinical hip and knee arthroplasty RSA studies.

Although the importance of a stepwise introduction of new orthopedic implants was presented in 1995 (Malchau 1995), only recently has it been fully acknowledged that deletion of some of these crucial steps can have catastrophic consequences (Kärrholm 2012). The phased or stepwise introduction process is based on the hypothesis that a more precise and careful evaluation of new implants will reduce the number of patients at risk of unexpected failures. There are 4 suggested steps to this process (Malchau 1995). The initial step involves preclinical implant testing. After this, the first clinical step consists of prospective randomized studies that use RSA. The second clinical step involves multicenter studies and the final step is composed of registry studies.

The detection of early migration or accelerated wear using RSA are ways of predicting early implant failure, and are therefore important components of this stepwise introduction process (Kärrholm 2012). Although RSA would probably not have been able to forecast some of the problems related to the metal-on-metal articulation, it could have prevented the premature introduction of Boneloc cement. When Boneloc was introduced, the Norwegian Arthroplasty Register needed more than 1,000 patients before it could be proven to be an inferior cement based on a higher revision rate compared to regular bone cement (Havelin et al. 1995). Using RSA only, 30 patients were included in a study that—already after 6 months—showed that Boneloc-cemented implants were clearly less stable than those with conventional bone cement (Thanner et al. 1995). If Boneloc had been studied with RSA prior to being released onto the market, thousands of patients would have been spared from early revision. There are several other examples of poor orthopedic implants or materials that should have been tested with RSA prior to widespread release (Muirhead-Allwood 1998, Norton et al. 2002). In the past, many serious problems initially manifested as low-incidence events but only later proved to be the tip of the iceberg (Mal-
chau et al. 2011). Despite the fact that the algorithm for introduction of new implant designs was established more than 15 years ago, many new and untested implants still appear on the market. The orthopedic community has acknowledged that the fast spread of undocumented new implants is no longer acceptable (Kärrholm 2012).

With the increasing importance of RSA, it has also been recognized that reporting of RSA outcomes should be standardized. The guidelines for standardization of radiostereometry of implants were published in August 2005, to facilitate comparison of RSA outcomes reported from different centers (Valstar et al. 2005). In that paper, an appendix of 13 main items that should be used to account for the results of a clinical RSA study is outlined. Furthermore, since RSA is a highly technical method, the reliability and reproducibility of a study can only be assessed when all standardized output items have been adequately addressed.

We investigated whether the RSA guidelines have resulted in improved methodological reporting in clinical RSA studies of hip and knee arthroplasty. We also assessed the overall level of adherence to each of the individual guidelines following their introduction.

### Material and methods

We carried out a literature search using OVID Medline, the OVID Cochrane central register of controlled trials, and SCOPUS Embase to identify all articles published between January 2000 and December 2011 that used RSA in the evaluation of hip or knee prosthesis migration or wear. The search strategy included the following terms: radiostereometric analysis, radiostereometry, roentgen stereophotogrammetric analysis, RSA, hip, and knee. Only English language clinical studies with at least 2 follow-up time points were included. Case reports were excluded. Study identification was performed according to the PRISMA statement (Figure 1). 2 investigators (RM and TJM) independently evaluated each of the studies for adherence to the 13 individual guideline points (Table 1). Since most of the 13 guideline points included more than 1 issue that needed to be addressed, the individual guidelines were divided into subcategories (A to D) to facilitate the evaluation process. Studies were then assessed on whether each guideline was fully met, partially met, or not met. Other information collected from the studies regarding publication were the name of the journal, geographical region based on first author (Nordic countries, rest of Europe, USA/Canada, Australia) and the year of publication. We also collected data on the main study question (whether the study assessed hip or knee arthroplasty migration or wear), study design (retrospective, prospective cohort, or RCT), the period of data collection, the percentage of patients for whom RSA was not successful, and the formula used to calculate confidence intervals. Disagreement was resolved by consensus.

### Table 1. List of the 13 guidelines and subcategories used to evaluate study adherence (adapted from Valstar et al. 2005)

| Guideline number | Guideline                                                                 |
|------------------|---------------------------------------------------------------------------|
| Guideline number | Subcategory                                                               |
| 1                | A Translation units in millimeters                                        |
| 2                | A Rotation units in degrees                                               |
| 3                | A Accuracy presented                                                      |
| 4                | A Precision presented                                                    |
| 5                | A Precision determined                                                   |
| 6                | A Measurement interval mentioned                                          |
| 7                | A Window of tolerance mentioned                                           |
| 8                | A Type of calibration cage noted                                          |
| 9                | A Fixed or portable X-ray sources used                                   |
| 10               | A Subject positioning described                                           |
| 11               | A Method of image acquisition stated                                     |
| 12               | A Scanner or system details mentioned                                     |
| 13               | A Software name mentioned                                                |
| 14               | A Software version mentioned                                              |
| 15               | A Marker size mentioned                                                   |
| 16               | A Marker size validated (or manufacturer mentioned)                       |
| 17               | A RSA method mentioned                                                    |
| 18               | A Cutoff level for condition number noted                                 |
| 19               | A Cutoff level for mean error of rigid-body fitting noted                 |
| 20               | A Rigid-body fixed coordinate frames defined                              |
| 21               | A Angular rotation sequence mentioned if relevant                         |
| 22               | A Precision determined using double examinations                         |
| 23               | A Double examinations of all patients performed                          |
| 24               | A All 6 degrees of freedom reported                                       |
| 25               | A Point or segment motion used                                            |
| 26               | A Point(s) used to measure translation indicated                          |
Results

153 studies that met our inclusion criteria were identified (Figure 1). 61 of these were published before the guidelines (2000 to 2005) and the remaining 92 after the guidelines (2006 to 2011). 96 studies evaluated hip arthroplasty and 57 studies evaluated knee arthroplasty. Most of the studies (121) used RSA to assess migration and 22 studies used RSA to evaluate wear. Only 10 studies used RSA to measure both wear and migration. Over half of the studies were randomized controlled trials (81 studies), the remainder consisted largely of prospective cohort studies (66 studies), and a few were retrospective studies (6 studies).

None of the studies fully met all 13 guidelines. Only 7 studies published after the guidelines showed partial adherence to all guidelines. The highest number of guidelines fully met was 10 and this was achieved in 8 studies, all of which were published after the guidelines. Almost half of the studies published after the guidelines (43) showed partial adherence to 10 of 13 guidelines, and accordingly we selected this adherence level to mean high adherence. As expected, the methodological quality of the RSA studies published before the guidelines was low, with less than one-fifth (11) of the studies partially fulfilling 10 of 13 guideline items.

The methodological quality of studies clearly improved from 2000 to 2011 (Figure 2). The proportion of studies with high adherence increased almost 3-fold when we compared the means of time periods before and after the guidelines. The annual number of publications included in the analysis varied from 6 to 26. The largest number of publications was from 2006, during which a special Radiostereometric Analysis in Orthopaedic Surgery symposium issue of Clinical Orthopaedics and Related Research was published.

Following introduction of the RSA guidelines, the items with highest adherence were guideline 1 (measurement units), 9 (RSA method), and 11 (rigid-body fixed coordinate frames and angular rotation sequence) whereas those with poorest adherence were 3 (type of calibration cage), 4 (fixed or portable X-ray source), 6 (image acquisition method and system details), and 10 (cutoff level for condition number or CN and mean error of rigid-body fitting or ME) (Figure 3). Guideline 2 (accuracy, precision, measurement interval, and window of tolerance) generally only had partial adherence. Although the level of precision was presented in 60 studies (65%), the level of accuracy was only mentioned in 12 studies (13%). The measurement interval was mentioned in all studies, but the window of tolerance was generally only mentioned for the postoperative examination and was usually a one-week window. Surprisingly, 35 studies did not mention the window of tolerance for any of the RSA examinations. Only 2 studies mentioned the window of tolerance for RSA examinations after the postoperative examination and used a 5–10% tolerance limit.

Most of the studies evaluated were from Nordic countries, and these also had the highest level of adherence to the RSA guidelines when compared to the other geographical regions (Table 2). Similarly, the majority of the studies were published in Acta Orthopaedica (Table 3).
The proportion of patients for whom RSA was not successful was difficult to extract from most of the studies, especially from studies that included patients with bilateral arthroplasty procedures. From the 75 studies published after the guidelines with available data, RSA was not successful in 8% of knee arthroplasty patients and in 12% of hip arthroplasty patients. Furthermore, there was no mention of how the confidence interval (CI)—and hence precision of the method—was calculated in 34 studies. The remaining studies that did report these data used heterogeneous but accepted methods for calculating the confidence interval, with some studies reporting the 99% CI while others used the 95% CI. More than half of the studies published from 2006 to 2011 clearly mentioned the time period of patient recruitment, but this information was lacking in 43 studies.

### Discussion

The guidelines for standardization of radiostereometry of implants have clearly improved the methodological reporting in RSA studies during the last decade. Nevertheless, the overall level of adherence to the guidelines is still low. We believe that low adherence to some of the guidelines was due to oversight—or to the assumption that the reader is already aware of the methodological details. Examples of this include not mentioning the type of calibration cage, the image acquisition method, or whether a fixed or portable X-ray source was used. However, some guidelines such as the cutoff level for condition number and mean error of rigid-body fitting are more crucial to understanding of the validity of the results and consequently their clinical significance. Furthermore, the stability and distribution of RSA markers within a rigid body will influence the accuracy of the motion calculation and may affect the conclusions drawn from the study.

Guideline 2 (accuracy, precision, measurement interval, and window of tolerance) generally only had partial adherence. Although the level of precision was presented in 65% of the studies published after the guidelines, double examinations of all patients were performed in only 18% of these. This raises the question of whether it is reasonable to demand this, or if it would be sufficient to perform double examinations on a random selection of subcohort of the patients in a study. Similarly, the level of accuracy was only mentioned in 13% of the studies published after 2005. It is also noteworthy that several studies used the term accuracy to mean clinical precision. The measurement of true RSA accuracy requires data from phantom studies and although this information is important, it is not as clinically relevant as precision data from double examinations, which define the true clinical accuracy.

As expected, most of the RSA studies were from Nordic countries where the adherence to guidelines was also highest, probably for historical reasons. Journals with fewer RSA studies tended to have higher adherence. This could be due to more stringent enforcement during the peer review process, since the RSA method is less familiar to the reviewers of these journals. On the other hand, studies published in Clinical Orthopaedics and Related Research also showed a high level of adherence. This was clearly influenced by the RSA symposium issue published in 2006, which may have undergone a more stringent review process due to the special focus of the issue, and also as it was published soon after the guidelines.

Some information that is currently not included in the RSA guidelines is the proportion of patients for whom RSA was not successful. We feel that these data are important for 2 reasons: firstly, because this information is crucial in understanding the clinical relevance of the data; and secondly, because this information is valuable to other researchers when planning similar studies.

As model-based RSA is becoming more popular, it is necessary to also include parameters that give an indication of the quality of the data obtained. An example of this could be the difference value (DIF) that is used in MBRSA software (RSAcore, Leiden, the Netherlands), which is a surrogate for the difference of the actual implant contour and the virtual contour. Inclusion of such quality control parameters would further standardize new developments in the RSA methodology.

The strengths of this systematic review include the large number of studies included (153) over a 12-year period. This enabled us to gain a general understanding of the trends in adherence over time. To our knowledge, this type of study has not been published previously. One limitation of the study is that no attempt was made to contact the authors of the papers. This might have allowed us to obtain more information about some aspects of guideline adherence that could not be assessed from the papers directly. On the other hand, our aim was to assess adherence to guidelines based on the information available from publications. Another limitation of the present study is that it only assessed hip and knee arthroplasty studies and excluded studies related to other applications such as spinal fusion or fracture studies. Although these other applications...
of RSA are also relevant, we decided to focus on the 2 main applications of RSA.

In summary, RSA is important to ensure a safe yet effective stepwise introduction of new implants. New developments in RSA have enabled faster analysis and even measurement of marker-free implants. The RSA guidelines are an integral part of the methodology. Our study demonstrated that the guidelines have clearly had a positive effect on the methodological quality of RSA publications, but there is still room for improvement. The next step is to update, simplify, and clarify the guidelines and also promote their use in the peer review process. In future RSA publications, we suggest that an appendix, similar to the one shown in Table 4, be included in all future RSA publications.

RM and TJM collected the data and carried out the data analysis. All authors participated in the design of the study and in preparation of the manuscript.

We thank information specialist Tiina Heino of Helsinki University Library for assistance with the literature search.

RM is a stockowner and board member in RSA Biomedical Inc. This study was supported by grants from the Swedish Cultural Foundation in Finland, the Jane and Aatos Erkko Foundation, the Paulo Foundation, and the Finnish Medical Foundation.

Adalberth G, Nilsson K G, Byström S, Kostad K, Milbrink J. Low-conforming all-polyethylene tibial component not inferior to metal-backed component in cemented total knee arthroplasty: prospective, randomized radiostereometric analysis study of the AGC total knee prosthesis. J Arthroplasty 2000; 15 (6): 783-92.

Adalberth G, Nilsson K G, Byström S, Kostad K, Milbrink J. All-polyethylene versus metal-backed and stemmed tibial components in cemented total knee arthroplasty. A prospective, randomized RSA study. J Bone Joint Surg (Br) 2001; 83 (6): 825-31.

Adalberth G, Nilsson K G, Kärholm J, Hassander H. Fixation of the tibial component using CMW-1 or Palacos bone cement with gentamicin: similar outcome in a randomized radiostereometric study of 51 total knee arthroplasties. Acta Orthop Scand 2002; 73 (5): 531-8.

Alfaro-Adrián J, Gill H S, Murray D W. Should total hip arthroplasty femoral components be designed to subside? A radiostereometric analysis study of the Charnley Elite and Exeter stems. J Arthroplasty 2001; 16 (5): 598-606.

Astephen Wilson J L, Wilson D A, Dunbar M J, Deluzio K J. Preoperative gait patterns and BMI are associated with tibial component migration. Acta Orthop 2010; 81 (4): 478-86.

Ayers D C, Hays P L, Drew J M, Eskander M S, Usach D, Bragdon C R. Two-year radiostereometric analysis evaluation of femoral head penetration in a challenging population of young total hip arthroplasty patients. J Arthroplasty (6 Suppl) 2009; 24: 9-14.

Baad-Hansen T, Kold S, Nielsen P T, Laursen M B, Christensen P H, Soballe K. Comparison of trabecular metal cups and titanium fiber-mesh cups in primary hip arthroplasty: a randomized RSA and bone mineral densitometry study of 50 hips. Acta Orthop 2011a; 82 (2): 155-60.

Baad-Hansen T, Kold S, Olsen N, Christensen F, Soballe K. Excessive distal migration of fiber-mesh coated femoral stems. Acta Orthop 2011b; 82 (3): 308-14.

Baad-Hansen T, Storgaard Jakobsen S, Soballe K. Two-year migration results of the ReCap hip resurfacing system-a radiostereometric follow-up study of 23 hips. Int Orthop 2011c; 35 (4): 497-502.

Berend M E, Ritter M A, Hyldahl H C, Meding J B, Redelman R. Implant migration and failure in total knee arthroplasty is related to body mass index and tibial component size. J Arthroplasty (Suppl 1) 2008; 23 (6): 104-9.

Bottner F, Zawadsky M, Su E P, Bostrom M, Palm L, Ryd L, Sculco T P. Implant migration after early weightbearing in cementless hip replacement. Clin Orthop 2005; (436): 132-7.

Bourne R B, McCalden R W, Naudie D, Charron K D, Yuan X, Holdsworth D W. The next generation of acetabular shell design and bearing surfaces. Orthopedics (Suppl 2) 2008; 31 (12): [pages?].

Bragdon C R, Thanner J, Greene M E, Malchau H, Dugas G, Harris W H, Kärholm J. Standing versus supine radiographs in RSA evaluation of femoral head penetration. Clin Orthop 2006; (448): 46-51.

Bragdon C R, Greene M E, Freiberg A A, Harris W H, Malchau H. Radiostereometric analysis comparison of wear of highly cross-linked polyethylene against 36- vs 28-mm femoral heads. J Arthroplasty (Suppl 2) 2007; 22 (6): 125-9.

Bragonzoni L, Russo A, Lorette I, Montagna L, Visani A, Maracci M. The stress-inducible displacement detected through RSA in non-migrating UKR. Knee 2005; 12 (4): 301-6.

Bøe B G, Røhr 1 S M, Heier T, Snorrason F, Nordsetten L. A prospective randomized study comparing electrochemically deposited hydroxyapatite and plasma-sprayed hydroxyapatite on titanium stems. Acta Orthop 2011; 82 (1): 13-9.

Campbell D G, Field J R, Callary S A. Second-generation highly cross-linked X3™ polyethylene wear: a preliminary radiostereometric analysis study. Clin Orthop 2010a; (468) (10): 2704-9.
Campbell D, Mercer G, Nilsson K G, Wells V, Field J R, Callary S A. Wear of a highly cross-linked polyethylene liner: a preliminary RSA study. Eur J Orthop Surg Traumatol 2010b; 20: 23-7.

Campbell D, Mercer G, Nilsson K G, Wells V, Field J R, Callary S A. Early migration characteristics of a hydroxyapatite-coated femoral stem: an RSA study. Int Orthop 2011; 35 (4): 483-8.

Carlson A, Björkman A, Besjakov J, Onsten I. Cemented tibial component fixation performs better than cementless fixation: a randomized radiostereometric study comparing porous-coated, hydroxyapatite-coated and cemented tibial components over 5 years. Acta Orthop 2005; 76 (3): 362-9.

Carlsson L V, Albrektsson B E, Albrektsson B G, Albrektsson T O, Jacobsson C M, Macdonald W, Regnér L, Weidenheim L R. Stepwise introduction of a bone-conserving osseointegrated hip arthroplasty using RSA and a randomized study: I. Preliminary investigations–52 patients followed for 3 years. Acta Orthop 2006a; 77 (4): 549-58.

Carlsson L V, Albrektsson T, Albrektsson B E, Jacobsson C M, Macdonald W, Regnér L, Weidenheim L R. Stepwise introduction of a bone-conserving osseointegrated hip arthroplasty using RSA and a randomized study: II. Clinical proof of concept–40 patients followed for 2 years. Acta Orthop 2006b; 77 (4): 559-66.

Carlsson L V, Albrektsson B E, Regnér L R. Minimally invasive surgery vs conventional exposure using the Miller-Galante unicompartmental knee arthroplasty: a randomized radiostereometric study. J Arthroplasty 2006c; 21 (2): 151-6.

Catani F, Learndi A, Ensini A, Cucca G, Bragonzoni L, Toksvig-Larsen S, Giannini S. The stability of the cemented tibial component of total knee arthroplasty: posterior cruciate-retaining versus posterior-stabilized design. J Arthroplasty 2004; 19 (6): 775-82.

Catani F, Ensini A, Learndi A, Bragonzoni L, Toksvig-Larsen S, Giannini S. Migration of cemented stem and restrictor after total hip arthroplasty: a radiostereometry study of 25 patients with Lubinus SP II stem. J Arthroplasty 2005; 20 (2): 284-9.

Dahl-J. Söderlund P, Nibrant B, Nordoletten L, Röhl M S. Less wear with aluminium-oxide heads than cobalt-chrome heads with ultra high molecular weight cemented polyethylene cups: a ten-year follow-up with radiostereometry. Int Orthop 2012; 36 (3): 485-90.

Dalen T, Nilsson K G. VersaBond bone cement prospective randomized study of the clinical properties of a new bone cement in total knee replacement. Knee 2005; 12 (4): 311-7.

Decking J, Schuetz, Decking R, Puhl W. The migration of femoral components after total hip replacement surgery: accuracy and precision of software-aided measurements. Skeletel Radiol 2003; 32 (9): 521-5.

Derbyshire B, Porter M L. A study of the Elite Plus femoral component using radiostereometric analysis. J Bone Joint Surg (Br) 2004a; (429): 6-16.

Digas G, Kärholm J, Thanner J, Herberts P. Highly cross-linked polyethylene in cemented and uncemented sockets: two randomized studies using radiostereometric analysis. Acta Orthop 2007; 78 (6): 746-54.

Dunbar M J, Wilson D A, Hennigar A W, Amirlaft J D, Gross M, Reardon G P. Fixation of a trabecular metal knee arthroplasty component. A prospective randomized study. J Bone Joint Surg (Am) 2009; 91 (7): 1578-86.

Flivilg G, Sanfridsson J, Onnerfält R, Kesteris U, Ryd L. Migration of the acetabular component: effect of cement pressurization and significance of early radiolucency: a randomized 5-year study using radiostereometry. Acta Orthop 2005; 76 (2): 159-68.

Flivilg G, Kristiansson I, Kesteris U, Ryd L. Is removal of subchondral bone plate advantageous in cemented cup fixation? A randomized RSA study. Clin Orthop 2006; (448): 164-72.

Fukuoka S, Yoshida K, Yamano Y. Estimation of the migration of tibial components in total knee arthroplasty. A roentgen stereophotogrammetric analysis. J Bone Joint Surg (Br) 2000; 82 (2): 222-7.

Gao F, Henricson A, Nilsson K G. Cemented versus uncemented fixation of the femoral component of the NexGen CR total knee replacement in patients younger than 60 years: a prospective randomised controlled RSA study. Knee 2009; 16 (3): 200-6.

Garling E H, Valstar E R, Nelissen R G. Comparison of micromotion in mobile bearing and posterior stabilized total knee prostheses: a randomized RSA study of 40 knees followed for 2 years. Acta Orthop 2005; 76 (3): 353-61.

Gill H S, Alfaro-Adrián J, Alfaro-Adrián C, McLardy-Smith P, Murray D W. The effect of anteversion on femoral component stability assessed by radiostereometric analysis. J Arthroplasty 2002; 17 (8): 997-1005.

Glyn-Jones S, Hicks J, Alfaro-Adrian J, Gill H S, McLardy-Smith P, Murray D W. The influence of cement viscosity on the early migration of a tapered polished femoral stem. Int Orthop 2003; 27 (6): 362-5.

Glyn-Jones S, Gill H S, Mc-Lardy-Smith P, Murray D W. Roentgen stereophotogrammetric analysis of the Birmingham hip resurfacing arthroplasty. A two-year study. J Bone Joint Surg (Br) 2004; 86 (2): 172-6.

Glyn-Jones S, Alfaro-Adrian J, Murray D W, Gill H S. The influence of surgical approach on cemented stem stability: an RSA study. Clin Orthop 2006a; (448): 87-91.

Glyn-Jones S, Polgár K, Hicks J, Murray D W, Gill H S, RSA-measured inducible micromotion and interface modeling with finite element methods. Clin Orthop 2006b; (448): 98-104.

Glyn-Jones S, Isaac S, Hauptfleisch J, McLardy-Smith P, Murray D W, Gill H S. Does highly cross-linked polyethylene wear less than conventional polyethylene in total hip arthroplasty? A double-blind, randomized, and controlled trial using roentgen stereophotogrammetric analysis. J Arthroplasty 2008a; 23 (3): 337-43.

Glyn-Jones S, Mc-Lardy-Smith P, Gill H S, Murray D W. The creep and wear of highly cross-linked polyethylene: a three-year randomised, controlled trial using radiostereometric analysis. J Bone Joint Surg (Br) 2008b; 90 (5): 556-61.

Grant P, Aamodt A, Falch J A, Nordoletten L. Differences in stability and bone remodeling between a customized uncemented hydroxyapatite coated and a standard cemented femoral stem A randomized study with use of radiostereometry and bone densitometry. J Orthop Res 2005; 23 (6): 1280-5.

Hallan G, Aamodt A, Furnes O, Stkredlerstuen A, Haugan K, Havelin L I. Palamed G compared with Palacos R with gentamicin in Charnley total hip replacement. A randomised, radiostereometric study of 60 HIPS. J Bone Joint Surg (Br) 2006; 88 (9): 1143-8.

Hansson U, Toksvig-Larsen S, Jorn L P, Ryd L. Mobile vs. fixed meniscal bearing in total knee replacement: a randomised radiostereometric study. Knee 2005; 12 (6): 414-8.

Hansson U, Ryd L, Toksvig-Larsen S. A randomised RSA study of Peri-Apate HC coating of a total knee prosthesis. Knee 2008; 15 (3): 211-6.

Hansson U, Toksvig-Larsen S, Ryd L, Aspenberg P. Once-weekly oral medication with alendronate does not prevent migration of knee prostheses: A double-blind randomized RSA study. Acta Orthop 2009; 80 (1): 41-5.
Havelin L I, Espehaug B, Vollset S E, Engesaeter L B. The effect of the type of cement on early revision of Charnley total hip prostheses. A review of eight thousand five hundred and seventy-nine primary arthroplasties from the Norwegian Arthroplasty Register. J Bone Joint Surg (Am) 1995; 77 (10): 1543-50.

Henricson A, Dalen T,Nilsson K G. Mobile bearings do not improve fixation in cemented total knee arthroplasty. Clin Orthop 2006; (448): 114-21.

Henricson A, Linder L, Nilsson KG. A trabecular metal tibial component in total knee replacement in patients younger than 60 years: a two-year radiostereophotogrammetric analysis. J Bone Joint Surg (Br) 2008; 90 (12): 1585-93.

Hilding M, Aspengren P. Postoperative clodronate decreases prosthetic migration: a 4-year follow-up of a randomized radiostereometric study of 50 total knee patients. Acta Orthop 2006; 77 (6): 912-6.

Hilding M, Aspengren P. Local perioperative treatment with a bisphosphonate improves the fixation of total knee prostheses: a randomized, double-blind radiostereometric study of 50 patients. Acta Orthop 2007; 78 (6): 795-9.

Hilding M, Ryd L, Toksvig-Larsen S, Aspengren P. Clodronate prevents prosthesis migration: a randomized radiostereometric study of 50 total knee patients. Acta Orthop Scand 2001; 71 (6): 553-7.

Hurschler C, Seehaus F, Emmerich J, Kaptein B L, Windhagen H. Accuracy of model-based RSA contour reduction in a typical clinical application. Clin Orthop 2008; (466) (8): 1978-86.

Hurschler C, Seehaus F, Emmerich J, Kaptein B L, Windhagen H. Comparison of the model-based and marker-based roentgen stereophotogrammetry method in a typical clinical setting. J Arthroplasty 2009; 24 (4): 594-606.

Husby O S, Haugan K, Bemun P, Foss O A. A prospective randomised radiostereometric analysis trial of SmartSet HV and Palacos R bone cements in primary total hip arthroplasty. J Orthop Traumatol 2010; 11 (1): 29-35.

Hyldahl H C, Regnér L, Carlsson L, Kärrholm J, Weidenhielm L. Does metal backing improve fixation of tibial component in unicompartmental knee arthroplasty? A randomized radiostereometric analysis. J Arthroplasty 2001; 16 (2): 174-9.

Hyldahl H, Regnér L, Carlsson L, Kärrholm J, Weidenhielm L. All-polyethylene vs. metal-backed tibial component in total knee arthroplasty—a randomised RSA study comparing early fixation of horizontally and completely cemented tibial components: part 2. Completely cemented components: MB not superior to AP components. Acta Orthop 2005a; 76 (6): 778-84.

Hyldahl H, Regnér L, Carlsson L, Kärrholm J, Weidenhielm L. All-polyethylene vs. metal-backed tibial component in total knee arthroplasty—a randomised RSA study comparing early fixation of horizontally and completely cemented tibial components: part 1. Horizontally cemented components: AP better fixed than MB. Acta Orthop 2005b; 76 (6): 769-77.

Höstner J, Hultmark P, Kärrholm J, Malchau H, Tveit M. Impaction technique of highly cross-linked and conventional cemented polyethylene cups with cobalt chrome or Oxinium femoral heads: a randomized radiostereometric study of 150 patients. J Orthop Res 2011a; 29 (8): 1222-9.

Kadar T, Hallan G, Aamodt A, Indrekvam K, Badawy M, Skredderstuen A, Havelin L I, Stokke T, Haugan K, Espehaug B, Furnes O. Wear and migration of highly cross-linked and conventional cemented polyethylene cups: a radiostereometric analysis trial of the Spectron EF and the Charnley flanged 40 cemented femoral components using radiostereometric analysis at 2 years. Acta Orthop 2011b; 82 (5): 538-44.

Kellett C F, Short A, Price A, Gill H S, Murray D W. In vivo measurement of total knee replacement wear. Knee 2004; 11 (3): 183-7.

Kendrick B J, Simpson D J, Kaptein B L, Valstar E R, Gill H S, Murray D W. Hy-Polyethylene wear of mobile-bearing unimpelemental knee replacement at 20 years. J Bone Joint Surg (Br) 2011; 93 (4): 470-5.

Khan R J, Fick D, Alakeson R, Haebich S, de Cruz M, Nivbrant B, Wood D. A constrained acetabular component for recurrent dislocation. J Bone Joint Surg (Br) 2006; 88 (7): 870-6.

Khan R J, Fick D, Alakeson R, Li M G, Nivbrant B, Wood D. The constrained acetabular component for hip instability. J Arthroplasty 2007; 22 (3): 377-82.

Kienapfel H, Hildebrand R, Neumann T, Specht R, Koller M, Celic I, Mueller H H, Griss P, Klose K J, Georg C. The effect of Palamed G bone cement on early migration of tibial components in total knee arthroplasty. Inflamm Res (Suppl 2) 2004; 53: S159-63.

Kneif D, Downing M R, Ashcroft G P, Knight D J, Ledingham W M, Gibson P H, Hutchison J D. The correlation between intermediate radiolucent lines and early implant migration in cemented acetabular components. J Arthroplasty 2006; 21 (2): 215-20.

Kärrholm J. Radiostereometric analysis of early implant migration – a valuable tool to ensure proper introduction of new implants. Acta Orthop 2012; 83 (6): 551-2.

Kärrholm J, Razaznejad R. Fixation and bone remodeling around a low stiffness stem in revision surgery. Clin Orthop 2008; (466) (2): 380-8.

Kärrholm J, Anderberg C, Snorrason F, Thanner J, Langeland N, Malchau H, Herberts P. Evaluation of a femoral stem with reduced stiffness. A randomized study with use of radiostereometry and bone densitometry. J Bone Joint Surg (Am) 2002; 84 (9): 1651-8.

Kärrholm J, Hourigan P, Timperley J, Razaznejad R. Mixing bone graft with OP-1 does not improve cup or stem fixation in revision surgery of the hip: 5-year follow-up of 10 acetabular and 11 femoral study cases and 40 control cases. Acta Orthop 2006; 77 (1): 39-48.

Li M G, Nilsson K G. No relationship between postoperative changes in bone density at the proximal tibia and the migration of the tibial component 2 years after total knee arthroplasty. J Arthroplasty 2001; 16 (7): 893-900.

Li M G, Thorsen K, Nilsson K G. Increased bone turnover as reflected by biochemical markers in patients with potentially unstable fixation of the tibial component. Arch Orthop Trauma Surg 2004; 124 (6): 404-9.

Lindalen E, Nordsletten L, Röhrs M. Segment choice and cup stability influence wear measurements using radiostereometric analysis: a radiostereometric study comparing wear measured by markers in the polyethylene with markers in the periacetabular bone. Clin Biomech (Bristol, Avon) 2012; 27 (5): 511-4.

Lindstrand A, Stenström A, Ryd L, Toksvig-Larsen S. The introduction period of uncoated titanium ProxiLock femoral hip prosthesis. Clin Orthop 2000; 15 (6): 320-4.

Luites JW, Spruit M, Hellemondt GG, Horstmann WG, Valstar ER. Failure of the uncemented titanium ProxiLock femoral hip prostheses. Clin Orthop 2006; (448): 79-86.

Malchau H. On the importance of stepwise introduction of new hip implant technology. Thesis. Göteborg 1995. ISBN 91-628-1658-6.

Malchau H, Brandt C R, Muratoglu O K. The stepwise introduction of innovation into orthopaedic surgery: the next level of dilemmas. J Arthroplasty 2011; 26 (6): 825-31.

Maracci M, Soavi R, Loretii I, Bragonzoni L, Iacono F, Visani A. Micromotion between the halves bearing in the interax prosthesis: a roentgen stereophotogrammetric analysis. J Arthroplasty 2001; 16 (8): 991-7.

McCalder R W, Charron K D, Yuan X,bourne R B, Naudie D D, MacDonald S J. Randomised controlled trial comparing early migration of two collarless polished cemented stems using radiostereometric analysis. J Bone Joint Surg (Br) 2010; 92 (7): 935-40.

Meunier A, Aspengren P, Good L. Celecoxib does not appear to affect prosthesis fixation in total knee replacement: A randomized study using radiostereometry in 50 patients. Acta Orthop 2009; 80 (1): 46-50.
Moritz N, Alm J J, Lankinen P, Mäkinen T J, Mattila K, Aro H T. Quality of intertrochanteric cancellous bone as predictor of femoral stem RSA migration in cementless total hip arthroplasty. J Biomech 2011; 44 (2): 221-7.

Muirhead-Allwood S K. Lessons of a hip failure. BMJ 1998; 316 (7149): 644.

Nelissen R G, Valstar E R, Pöll R G, Garling E H, Brand R. Factors associated with excessive migration in bone impaction hip revision surgery: a radiostereometric analysis study. J Arthroplasty 2002; 17 (7): 826-33.

Nelissen R G, Garling E H, Valstar E R. Influence of cement viscosity and cement mantle thickness on migration of the Exeter total hip prosthesis. J Arthroplasty 2005; 20 (4): 521-8.

Nilsson K G, Henrikson A, Norgren B, Dalén T. Uncemented HA-coated implant is the optimum fixation for TKA in the young patient. Clin Orthop 2006; (448): 129-39.

Nivbrant B, Kärrholm J, Röhrs J, Hassander H, Wesslen B. Bone cement with reduced proportion of monomer in total hip arthroplasty: preclinical evaluation and randomized study of 47 cases with 5 years' follow-up. Acta Orthop Scand 2001; 72 (6): 572-84.

Norgren B, Dalén T, Nilsson K G. All-poly tibial component better than metal-backed: a randomized RSA study. Knee 2004; 11 (3): 189-96.

Norton M R, Ylaragadda R, Anderson G H. Catastrophic failure of the Elite Plus total hip replacement, with a Hylamer acetabulum and Zirconium ceramic femoral head. J Bone Joint Surg (Br) 2002; 84 (5): 631-5.

Olofsson K, Digas G, Kärrholm J. Influence of design variations on early migration of a cemented stem in THA. Clin Orthop 2006; (448): 67-72.

Omstein E, Franžén H, Johnsson R, Sundberg M. Radiostereometric analysis in hip revision surgery—optimal time for index examination: 6 patients revised with impacted allografts and cement followed weekly for 6 weeks. Acta Orthop Scand 2000; 71 (4): 360-4.

Omstein E, Atrosi I, Franžén H, Johnsson R, Sandquist P, Sundberg M. Results of hip revision using the Exeter stem, impacted allograft bone, and cement. Clin Orthop 2001; (389): 126-33.

Omstein E, Franžén H, Johnsson R, Stefánsdóttir A, Sundberg M, Táglí M. Hip revision with impacted morselized allografts: unrestricted weight-bearing and restricted weight-bearing have similar effect on migration. A radiostereometry analysis. Arch Orthop Trauma Surg 2003; 123 (6): 261-7.

Omstein E, Franžén H, Johnsson R, Karlsson M K, Linder L, Sundberg M. Hip revision using the Exeter stem, impacted morselized allograft bone and cement: a consecutive 5-year radiostereometric and radiographic study in 15 hips. Acta Orthop Scand 2004; 75 (5): 533-43.

Omstein E, Franžén H, Johnsson R, Stefánsdóttir A, Sundberg M, Táglí M. Five-year follow-up of socket movements and loosening after revision with impacted morselized allograft bone and cement: a radiostereometric and radiographic analysis. J Arthroplasty 2006; 21 (7): 975-84.

Palm L, Olofsson J, Aström S E, Ivarsson I. No difference in migration or wear between cemented low-profile cups and standard cups: a randomized radiostereographic study of 53 patients over 3 years. Acta Orthop 2007; 78 (5): 469-74.

Pitto R P, Schikora N. Acetabular reconstruction in developmental hip dysplasia using reinforcement ring with a hook. Int Orthop 2004; 28 (4): 202-5.

Rengén L, Carlsson L, Kärrholm J, Herberts P. Tibial component fixation in porous- and hydroxyapatite-coated total knee arthroplasty: a radiostereometric evaluation and randomized study of 33 patients with 5 years’ follow-up. J Arthroplasty 2000; 15 (6): 681-9.

Russo A, Montagna L, Bragonzoni L, Zampagni M L, Marcacci M. Fixation of total knee arthroplasty improved by mobile-bearing design. Clin Orthop 2005; (437): 186-95.

Russo A, Montagna L, Bragonzoni L, Visani A, Marcacci M. Changes in knee motion over the first 3 years with a mobile-bearing prosthesis. Knee 2006; 13 (4): 301-6.

Russo A, Bragonzoni L, Trozzi C, Iacono F, Visani A, Marcacci M. Radiostereometric measurement of polyethylene deformation pattern in meniscal bearing TKR at 5 years follow-up. Knee Surg Sports Traumatol Arthrosc 2008a; 16 (2): 142-7.

Russo A, Bragonzoni L, Trozzi C, Zaffagnini S, Neri M P, Bruni D, Marcacci M. Recurrence of varus-valgus deformity after TKR at 3 years’ follow-up. Knee 2008b; 15 (1): 20-5.

Röhrs J M, Nivbrant B, Ström H, Nilsson K G. Effect of augmented cup fixation on stability, wear, and osteolysis: a 5-year follow-up of total hip arthroplasty with RSA. J Arthroplasty 2004; 19 (8): 962-71.

Röhrs J, Nivbrant B, Mingguo L, Hewitt B. In vivo wear and migration of highly cross-linked polyethylene cups a radiostereometry analysis study. J Arthroplasty 2005; 20 (4): 409-13.

Röhrs J M, Li M G, Pedersen E, Ullmark G, Nivbrant B. Migration pattern of a short femoral neck preserving stem. Clin Orthop 2006b; (448): 73-8.

Röhrs J M, Li M G, Nilsson K G, Nivbrant B. Very low wear of non-remelted highly cross-linked polyethylene cups: an RSA study lasting up to 6 years. Acta Orthop 2007; 78 (6): 739-45.

Saari T, Uvehammer J, Carlsson L V, Røhr S, Kärrholm J. Influence of polyethylene constraint on tibial component fixation in total knee arthroplasty: follow-up report after 5 years. J Arthroplasty 2006; 21 (7): 1032-7.

Saari T, Li M G, Wood D, Nivbrant B. Comparison of cementing techniques of the tibial component in total knee replacement. Int Orthop 2009; 33 (5): 1239-42.

Simpson D J, Kendrick B J, Hughes M, Glyn-Jones S, Gill H S, Rushforth G F, Murray D W. The migration patterns of two versions of the Furlong cementless total hip femoral stem: a randomised, controlled trial using radiostereometric analysis. J Bone Joint Surg (Br) 2010; 92 (10): 1356-62.

Sköldenberg O G, Salemyr M O, Bodén S, Lundberg A, Ahl T E, Adolphson P. A new uncemented hydroxyapatite-coated femoral component for the treatment of femoral neck fractures: two-year radiostereometric and bone densitometric evaluation in 50 hips. J Bone Joint Surg (Br) 2011; 93 (5): 665-77.

Soavi R, Loreti I, Bragonzoni L, La Palombara P F, Visani A, Marcacci M. A roentgen stereophotogrammetric analysis of unicompartimental knee arthroplasty. J Arthroplasty 2002; 17 (5): 556-61.

Stefánsdóttir A, Franžén H, Johnsson R, Omstein E, Sundberg M. Movement pattern of the Exeter femoral stem; a radiostereometric analysis of 22 primary hip arthroplasties followed for 5 years. Acta Orthop Scand 2004; 75 (4): 408-14.

Stilling M, Larsen K, Andersen N T, Soballe K, Kold S, Rahbek O. The final follow-up plain radiograph is sufficient for clinical evaluation of polyethylene wear in total hip arthroplasty. A study of validity and reliability. Acta Orthop 2010; 81 (5): 570-8.

Stilling M, Madsen F, Odgaard A, Rømer L, Andersen N T, Rahbek O, Soballe K. Superior fixation of pegged trabecular metal over screw-fixed pegged porous titanium fiber mesh: a randomized clinical RSA study on cementless tibial components. Acta Orthop 2011; 82 (2): 177-86.

Ström H, Mallinn H, Milbrink J, Petren-Mallinn M, Nivbrant B, Kolstad K. The cone hip stem: a prospective study of 13 patients followed for 5 years with RSA. Acta Orthop Scand 2003; 74 (5): 525-30.

Ström H, Kolstad K, Mallinn H, Sahlstedt B, Milbrink J. Comparison of the uncemented Cone and the cemented Bimetric hip prosthesis in young patients with osteoarthritus: an RSA, clinical and radiographic study. Acta Orthop 2006; 77 (1): 71-8.

Ström H, Nilsson O, Milbrink J, Mallinn H, Larsson S. Early migration pattern of the uncemented CLS stem in total hip arthroplasties. J Arthroplasty 2007a; (454): 127-32.

Ström H, Nilsson O, Milbrink J, Mallinn H, Larsson S. Early migration pattern of the uncemented CLS stem in total hip arthroplasty. J Arthroplasty 2007b; 22 (8): 1122-9.

Sundberg M, Besjakov J, von Schewelow T, Carlsson L. Movement patterns of the C-stem femoral component: an RSA study of 33 primary total hip arthroplasties followed for two years. J Bone Joint Surg (Br) 2005; 87 (10): 1352-6.

Táglí M, Hansson U, Sigfusson R, Carlsson A, Johnell O, Lindgren L, Toksvig-Larsen S, Ryd L. Bone morphology in relation to the migration of porous-coated anatomic knee arthroplasties: a roentgen stereophotogrammetric and histomorphometric study in 23 knees. J Arthroplasty 2003; 18 (5): 649-53.
Thanner J, Freij-Larsson C, Kärrholm J, Malchau H, Wesslen B. Evaluation of Boneloc. Chemical and mechanical properties, and a randomized clinical study of 30 total hip arthroplasties. Acta Orthop Scand 1995; 66 (3): 207-14.

Thanner J, Kärrholm J, Herberts P, Malchau H. Hydroxyapatite and tricalcium phosphate-coated cups with and without screw fixation: a randomized study of 64 hips. J Arthroplasty 2000; 15 (4): 405-12.

The B, Flivik G, Diercks R L, Verdonschot N. A new method to make 2-D wear measurements less sensitive to projection differences of cemented THAs. Clin Orthop 2008a; (466) (3): 684-90.

The B, Hosman A, Kootstra J, Kralj-Iglić V, Flivik G, Verdonschot N, Diercks R. Association between contact hip stress and RSA-measured wear rates in total hip arthroplasties of 31 patients. J Biomech 2008b; 41 (1): 100-5.

Thero M, Lund B, Jensen K E, Schroder H M. Effect of bioactive coating of the tibial component on migration pattern in uncemented total knee arthroplasty: a randomized RSA study of 14 knees presented according to new RSA-guidelines. J Orthop Traumatol 2008; 9 (2): 63-7.

Thien T M, Ahnfelt L, Eriksson M, Strömberg C, Kärrholm J. Immediate weight bearing after uncemented total hip arthroplasty with an antverted stem: a prospective randomized comparison using radiostereometry. Acta Orthop 2007; 78 (6): 730-8.

Thien T M, Thanner J, Kärrholm J. Randomized comparison between 3 surface treatments of a single antverted stem design: 84 hips followed for 5 years. J Arthroplasty 2010b; 25 (3): 437-44.

Thomas G E, Simpson D J, Mehmood S, Taylor A, McLardy-Smith P, Gill H S, Murray D W, Glyn-Jones S. The seven-year wear of highly cross-linked polyethylene in total hip arthroplasty: a double-blind, randomized controlled trial using radiostereometric analysis. J Bone Joint Surg (Am) 2011; 93 (8): 716-22.

Timperley A J, Whitehouse S L, Hourigan P G. The influence of a suction device on fixation of a cemented cup using RSA. Clin Orthop 2009; (467) (3): 792-8.

Uvehammer J, Regnér L, Kärrholm J. Flat vs. concave tibial joint surface in total knee arthroplasty: randomized evaluation of 39 cases using radiostereometry. Acta Orthop Scand 2001a; 72 (3): 257-65.

Uvehammer J, Kärrholm J, Regnér L, Carlsson L, Herberts P. Concave versus posterior-stabilized tibial joint surface in total knee arthroplasty: randomized evaluation of 47 knees. J Arthroplasty 2001b; 16 (1): 25-32.

Uvehammer J, Kärrholm J, Carlsson L. Cemented versus hydroxyapatite fixation of the femoral component of the Freeman-Samuelson total knee replacement: a radiostereometric analysis. J Bone Joint Surg (Br) 2007a; 89 (1): 39-44.

Uvehammer J, Kärrholm J, Carlsson L. Influence of joint area design on tibial component migration: comparison among a fixed symmetrical, asymmetrical, and moveable bearing. J Knee Surg 2007b; 20 (1): 20-6.

Valstar E R, Gill R, Ryd L, Flivik G, Börnlin N, Kärrholm J. Guidelines for standardization of radiostereometry (RSA) of implants. Acta Orthop 2009; 76 (4): 563-72.

van der Linde M J, Garling E H, Valstar E R, Tonino A J, Nelissen R G. Periapatite may not improve micromotion of knee prostheses in rheumatoid arthritis. Clin Orthop 2006; (448): 122-8.

van Doorn W J, ten Have B L, van Biezen F C, Hop W C, Gini A Z, Verhaar J A. Migration of the femoral stem after impaction bone grafting. First results of an ongoing, randomised study of the Exeter and Elite Plus femoral stems using radiostereometric analysis. J Bone Joint Surg (Br) 2002; 84 (6): 825-31.

van Strien T, van der Linden-van der Zwaag E, Kaptein B, van Erkel A, Valstar E, Nelissen R. Computer assisted versus conventional cemented total knee prostheses alignment accuracy and micromotion of the tibial component. Int Orthop 2009; 33 (5): 1255-61.

van Schewelov T, Sanzén L, Onsten I, Carlson A. Catastrophic failure of an uncemented acetabular component due to high wear and osteolysis: an analysis of 154 omnifit prostheses with mean 6-year follow-up. Acta Orthop Scand 2004; 75 (3): 283-94.

von Schewelov T, Sanzén L, Onsten I, Carlson A, Besjakov J. Total hip replacement with a zirconium oxide ceramic femoral head: a randomised roentgen stereophotogrammetric study. J Bone Joint Surg (Br) 2005; 87 (12): 1631-5.

von Schewelov T, Onsten I, Markusson P, Carlson A. Weight bearing radiographs are not necessary for measurement of polyethylene penetration in total hip prostheses: a radiostereometric study of 111 patients examined in weight-bearing and supine position. Acta Orthop 2006; 77 (1): 104-8.

von Schewelov T, Besjakov J, Sanzén L, Carlson A. A clinical and radiostereometric study of the cemented PFC-sigma prosthesis: a 5-year study of 29 cases with a fixed bearing. J Knee Surg 2009; 22 (3): 231-6.

von Schewelov T, Sanzén L, Besjakov J, Carlson A. The Elite-Plus stem migrates more than the flanged Charnley stem. Acta Orthop 2010; 81 (3): 280-5.

Wilson D A, Astephen J L, Hennigar A W, Dunbar M J. Inducible displacement of a trabecular metal tibial monoblock component. J Arthroplasty 2010; 25 (6): 893-900.

Wolf O, Mattsson P, Milbrink J, Larsson S, Mallmin H. Periprosthetic bone mineral density and fixation of the uncemented CLS stem related to different weight bearing regimes: A randomized study using DXA and RSA in 38 patients followed for 5 years. Acta Orthop 2010a; 81 (3): 286-91.

Wolf O, Milbrink J, Larsson S, Mattsson P, Mallmin H. The optimal timing of baseline radiostereometric analysis of uncemented press fit cups. Scand J Surg 2010b; 99 (4): 244-9.

Wolf O, Mattsson P, Milbrink J, Larsson S, Mallmin H. The effects of different weight-bearing regimes on press-fit cup stability: a randomised study with five years of follow-up using radiostereometry. Int Orthop 2012; 36 (4): 735-40.

Wolterbeek N, Garling E H, Mertens B J, Nelissen R G, Valstar E R. Kinematics and early migration in single-radius mobile- and fixed-bearing total knee prostheses. Clin Biomech (Bristol, Avon) 2012; 27 (4): 398-402.

Zampelis V, Ornstein E, Franzén H, Atroshi I. First-time revision using impacted morsellised allograft bone with a cemented Exeter stem: radiostereometric analysis of stem migration over nine years. J Bone Joint Surg (Br) 2011; 93 (6): 746-50.

Zhou Z K, Li M G, Börlin N, Wood D J, Nivbrant B. No increased migration in cups with ceramic-on-ceramic bearing: an RSA study. Clin Orthop 2006; (448): 39-45.