



Evaluation of X-ray, Acetabular guides and CT in THR

## Evaluation of X-ray, Acetabular Guides and CT in THR

Short Title: EXACT  
Trial Protocol

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## **SIGNATURE PAGE**

The undersigned confirm that the following protocol has been agreed and accepted and that the Chief Investigator agrees to conduct the trial in compliance with the approved protocol and will adhere to the principles outlined in the Research Governance Framework, the ICH Good Clinical Practice guidelines and the Sponsor's SOPs.

I agree to ensure that the confidential information contained in this document will not be used for any other purpose other than the evaluation or conduct of the clinical investigation without the prior written consent of the sponsor.

I also confirm that I will make the findings of the study publically available publications or other dissemination tools without any unnecessary delay and that an honest accurate and transparent account of the study will be given; and that any discrepancies from the study as planned from this protocol will be explained.

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## 2. STUDY SUMMARY

<b>FULL TITLE</b>	Evaluation of X-ray, Acetabular Guides and CT in Total Hip Replacement	
<b>ACRONYM</b>	EXACT (Evaluation of <b>X</b> -ray, <b>A</b> cetabular Guides and <b>CT</b> in <b>THR</b> )	
<b>CLINICAL PHASE</b>	Pilot Study	
<b>HYPOTHESIS</b>	Acetabular alignment guide combined with three-dimensional CT-based planning using the Corin Optimized Positioning System will provide more accurate component alignment following primary total hip replacement compared with the current standard treatment	
<b>TRIAL DESIGN</b>	Single-centre, patient-assessor blinded, parallel-group, randomised-controlled trial	
<b>TRIAL POPULATION</b>	Patients aged 18-70 years with hip osteoarthritis undergoing total hip replacement with an uncemented acetabular cup	
<b>PLANNED SAMPLE SIZE</b>	54	
<b>TREATMENT DURATION</b>	As the timescale of a standard hip replacement. Treatment duration will be unaffected by participation in the trial.	
<b>FOLLOW UP</b>	6-weeks ( $\pm 2w$ ), 4-months ( $\pm 6w$ ) and 12-months ( $\pm 2m$ )	
<b>PLANNED TRIAL PERIOD</b>	The study will be last for 30 months and active recruitment will take place for 12 months.	
<b>TRIAL ARMS</b>	1:1 randomisation to:  1) Standard Group– Standard care where hip replacement is planned using 2D X-ray templating software  2) Interventional Group- where hip replacement is planned from 3D CT scan using Corin OPS™. Corin OPS™ acetabular guide provided for use during hip replacement.	
<b>STUDY OUTCOME</b>	<u>Objectives</u>	<u>Outcome measures</u>
Primary	Difference between planned and achieved acetabular component anteversion angle	CT Scan

Secondary	To quantify and draw inferences on the efficacy of the treatment groups using different measures and patient reported observed differences	CT scan, HOOS, OHS, EQ-5D, adverse events and motion-capture data.
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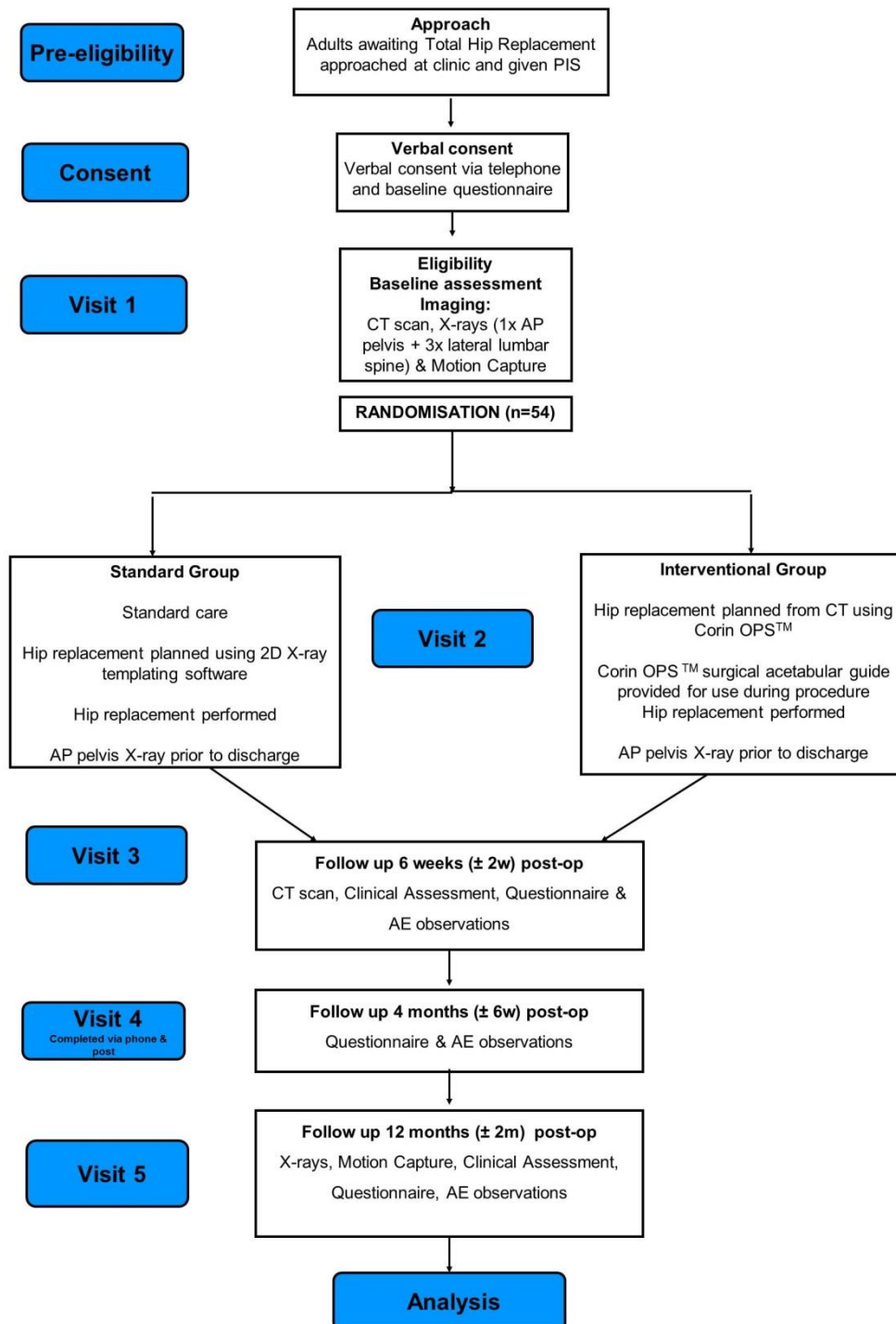
Keywords: hip replacement, acetabulum, anteversion, position, guide

### 3. LIST OF ABBREVIATIONS/GLOSSARY

Abbreviation	Explanation
2D	Two Dimensional
3D	Three Dimensional
AAOS	American Academy of Orthopaedic Surgeons
ADE	Adverse Device Effect
AE	Adverse Event
BHS	British Hip Society
BMI	Body Mass Index
BOA	British Orthopaedic Association
CI	Chief Investigator
CONSORT	<i>Consolidated Standards of Reporting Trials</i>
CORIN OPS™	CORIN Optimised Positioning System
CRF	Case Report Form
CT	Computed Tomography
DVT	Deep Vein Thrombosis
EC	European Commission
EQ-5D	EuroQol five dimensions questionnaire
EudraCT	European Clinical Trials Database
GCP	Good Clinical Practice
GP	General Practitioner
HOOS	Hip Disability & Osteoarthritis Outcome Score
HRA	Health Research Authority
IRAS	Integrated Research Application System
ISRCTN	International Standard Randomised Controlled Trial Number
MHRA	Medicines and Healthcare products Regulatory Agency
MRC	Medical Research Council
NHS	National Health Service
OHS	Oxford Hip Score
PE	Pulmonary Embolism
Post-Op	Post-Operative
PPI	Patient & Public Involvement
Pre-Op	Pre-Operative
R&D	Research & Development

RCT	Randomised Controlled Trial
REC	Research Ethics Committee
SADE	Serious Adverse Device Effect
SAE	Serious Adverse Event
SAP	Statistical Analysis Plan
SOP	Standard Operating Procedure
THR	Total Hip Replacement
TMG	Trial Management Group
UHCW	University Hospitals Coventry and Warwickshire
USADE	Unanticipated Serious Adverse Device Effect

#### 4. FIGURE 1 TRIAL FLOWCHART



**5. TABLE 1: SCHEDULE OF EVENTS**

Observations	Pre-eligibility*	Baseline & Imaging	Surgical admission	Follow- up		
		Pre-op	Post-Op			
(Time ± Range)		Visit 1*	Visit 2 0 weeks	Visit 3 6 weeks (± 2w)	Visit 4^ 4 months (± 6w)	Visit 5 12 months (± 2m)
Informed Verbal Consent	X					
Patient Questionnaires (HOOS, EQ-5D, Oxford Hip Score)	X		-	X	X	X
Eligibility assessment	X					
Demographics		X	-	-	-	-
Medical History		X	-	-	-	-
Current Medications		X	-	-	-	-
Clinical assessment		X	-	X	-	-
Motion capture (accelerometer) <sup>‡</sup>		X	-	-	-	X
X-Ray (AP pelvis,)		X*	X	-	-	X
X-Ray (x3 lateral spine)		X*	-	-	-	X
CT scan		X*	-	X <sup>#</sup>	-	-
Randomisation		X	-	-	-	-
Surgery		-	X	-	-	-
AEs/SAEs		-	X	X	X	X
End of Study		-	-	-	-	X

\*Completed via telephone

^Visit 4 follow up is not a clinic appointment. It will be completed via phone and post.

<sup>#</sup>CT scan, where possible, will be arranged on the same day as visit 3. However, on occasions, a separate appointment may be provided pending availability of imaging facility at the Trust. <sup>¥</sup> Motion capture will only be taken if the appropriate staff are available to do so.

## 6. BACKGROUND

### 6.1 Epidemiology and burden of the condition

Total hip replacement is one of the most successful surgical procedures of modern times, with over 80,000 performed each year in the UK<sup>1</sup>. The vast majority of patients experience dramatic pain relief and improvement in function for many years. Despite this, however, there remains a significant risk of complications, including dislocation, leg length discrepancy, squeaking, and premature wear and failure of the implant. It is known that such complications are more likely to occur if the acetabular component is incorrectly positioned during the surgery<sup>2-4</sup>. Up to 5% of all primary hip replacements need to be revised within the first 10 years<sup>1</sup>, and in many cases malposition of the acetabular (hip socket) component is implicated in the early failure.

### 6.2 Existing knowledge

Lewinnek defined a “safe zone” for positioning of the acetabular component, which, if achieved, should be associated with lower rates of complications<sup>5</sup>. The standard method of positioning the acetabular component is for the surgeon to be guided by a combination of the visible anatomical landmarks within the surgical field, and the wider environment of the operating theatre. For example, the surgeon will typically use their judgement to incline the acetabular component at 40° to the horizontal plane, as the patient lies on their side. This “freehand technique” is known to be prone to error, despite the added use of detailed surgical planning using CT scans<sup>6</sup>.

The advent of 3D printing has led to the development of custom-made surgical guides which can be used during surgery, in order to assist the surgeon in the positioning of instruments and devices. These surgical guides are manufactured based on CT or MRI imaging, and are designed to clearly indicate to the surgeon the desired location and orientation of bony cuts and implant positions. This is now well established practice in knee replacement surgery, with evidence that it can lead to improved accuracy of component positioning<sup>7,8</sup>. There have also been a small number of studies reporting improvements in acetabular component positioning during total hip replacement using custom acetabular guides<sup>9-11</sup>.

### 6.3 Hypothesis

The primary hypothesis is that an acetabular alignment guide combined with three-dimensional CT-based planning using the Corin OPS™ (Optimised Positioning System), will provide more accurate component alignment following primary total hip replacement compared with the current standard treatment.

### 6.4 Need for a trial

The Corin OPS™ offers such a custom-made acetabular alignment guide<sup>12</sup>. Prior to the patient's surgery, a CT scan of the patient's pelvis & legs is performed, and the images are used to produce a 3D computer model of the patient as they stand with a “virtual” hip replacement in place. Three additional X-rays of the pelvis and lumbar spine are also taken, with the patient adopting various predetermined “functional” positions (e.g. sitting in a chair, about to stand up). From these X-rays, the changes in the pelvic and femoral orientations can be measured for these functional positions. This data is then used to drive a simulation of the movement of the 3D computer model. The orientations of the components of the virtual hip replacement are then adjusted to optimise the biomechanical function of the joint. Once the proposed implant positions have been reviewed and approved by the surgeon, a custom-made acetabular orientation guide is 3-D printed and sterilised. During the surgery, this guide is fitted into the patient's acetabulum prior to implanting the components. Using a simple system of two sterile laser pointers, the orientation indicated by the guide can then be reproduced when the definitive acetabular component is implanted. (More details can be found on the Corin OPS™ website<sup>12</sup>). There is no published data, however, on the accuracy of acetabular component positioning using this particular method. The standard of care in the UK for acetabular component positioning is the “freehand technique” described previously. It is important that the impact of this acetabular guide on acetabular component positioning be assessed in order to determine whether this intervention is likely to improve patient outcomes and reduce the risk of complications of total hip replacement.

### 6.5 Ethical considerations

The trial will be conducted in full conformance with the principles of the Declaration of Helsinki and to MRC Good Clinical Practice (GCP) guidelines. It will also comply with all applicable UK legislation and the sponsor's Standard Operating Procedures (SOPs). All data will be stored securely and held in accordance with Data Protection Act 1998. Informed consent will be gained from all patients prior to entry in

the study. Data will be handled confidentially as laid out clearly in GCP and the sponsors SOP's. Patient's safety and well-being will be paramount and all patients will be treated with respect and dignity throughout the study.

## 6.6 Consort

The trial will be reported in line with the CONSORT (*Consolidated Standards of Reporting Trials*) statement<sup>13</sup>

## 6.7 Assessment and management of risk

There are risks and benefits to total hip replacement. The main benefit is pain relief resulting in improved function. The major surgical risks include infection, leg length discrepancy, venous thromboembolism, dislocation, fracture, nerve injury, arterial injury, and premature failure requiring revision. There are also "medical" risks related to anaesthesia and the stress of surgery (eg heart arrhythmias, renal failure, etc). The additional risks associated with the new technology are small and the technology is being used according to the manufacturer's guidelines, according to its usual indication. No attributable adverse events have been identified in over 2000 cases performed worldwide and over 100 cases in University Hospitals Coventry & Warwickshire (UHCW) NHS Trust. The theoretical additional risks of the intervention are:

- Malposition or incorrect preparation or insertion of the cup due to either instrument errors or surgeon errors in their use.
- Fracture or breakage of the devices, which would have the potential to cause harm, but this would be highly unlikely even in the event of an instrument or device breaking.

Both of these risks are theoretical and have not been observed despite this technology having been used extensively in a number of centres, including our own. The other risks are general to total hip replacement and are not unique to this study or increased by the study, these are listed under adverse event management.

# 7. OBJECTIVES AND OUTCOME MEASURES

## 7.1 Primary objective

The primary objective is to quantify and draw inferences on the technical accuracy of the treatment groups based on observed differences as shown by the difference between planned and achieved acetabular cup anteversion.

## 7.2 Secondary objectives

The secondary objectives are:

To quantify and draw inferences on the efficacy of the treatment groups based on patient reported observed differences.

- To assess other technical measurements related to implant positioning.
- To observe changes in pelvic motion that occurs because of hip replacement.
- To observe if additional complications from the procedure occur.

## 7.3 Primary Outcome Measure

- The difference between planned and achieved acetabular cup anteversion will be assessed by post-operative CT scan performed at 6 weeks.
- The planned angle in the OPS arm will be determined by the planning software. In the Standard Group, the surgeon will be asked before the operation to record the planned position of the cup that they are aiming for (angle of abduction and angle of anteversion). In all patients in both groups, the surgeon will also be asked at the end of the procedure to record the final position that they believe they placed the component, and to explain any deviation from the planned position.
- The CT scans will be measured by a trained medical professional blinded to the treatment allocation. A single individual will measure all of the angles but a cohort of 20 scans, randomly chosen, will be measured twice by that individual and by another observer to establish inter- and intra-observer error.

## 7.4 Secondary Outcome Measure

- The difference between planned and achieved acetabular cup abduction, assessed by post-operative CT scan performed at 6 weeks.
- Treatment efficacy as measured by the following at 6-weeks, 4- and 12-months:
  - a) Hip Disability & Osteoarthritis Outcome Score (HOOS)<sup>13</sup>: a validated, patient-reported measure of hip function.
  - b) Oxford Hip Score: a validated, patient-reported measure of hip function.
  - c) EQ-5D, which is a standardised measure of health and economic outcome.
- Adverse events data.
- Leg length discrepancy and femoral offset to be measured on post-operative CT scan by a medical professional blinded to the treatment allocation
- Motion capture data using an accelerometer based motion capture system, performed pre-operatively, and at 12-months.

## 8. TRIAL DESIGN

### 8.1 Trial Summary

A pragmatic single-centre, patient-assessor blinded, randomised controlled trial comparing parallel groups as defined in Figure 1. Trial Flowchart.

It is anticipated the trial will last a total of 30 months (of which 18 months will require funding): 3 months to gain the appropriate approvals, 12 months to recruit the patients, 3 months to collect scans required to assess the primary outcome, a further 9 months to collect the clinical outcomes and 3 months for analysis of data.

### 8.2 Trial Patients

We plan to recruit 54 patients with 27 patients per treatment group (standard and interventional group). All study visits and procedures will be conducted at University Hospitals Coventry and Warwickshire NHS Trust.

### 8.3 Eligibility criteria

Patients are eligible to be included in the trial if they meet the following criteria:

#### 8.3.1 Inclusion criteria

1. All patients undergoing an elective primary unilateral total hip replacement (THR) under the care of an orthopaedic consultant at UHCW NHS Trust are eligible for the trial.
2. Provision of written informed consent.
3. Male or Female aged 18-70 years.
4. Able and willing to comply with all study requirements.

#### 8.3.2 Exclusion criteria

1. Those patients deemed by the treating clinician as unsuitable for an uncemented primary acetabular implant for reasons such as:
  - Low demand patient
  - Osteoporosis
  - Significant acetabular bone loss

2. Patients with significant orthopaedic deformities (eg fused knee, hip or ankle).
3. Unable to undergo planning imaging (unable to stand or sit for X-rays, or to lie in a CT scanner).
4. Patients currently receiving ionising radiation treatment or scans for other medical conditions.
5. Previous entry in this trial (contralateral THR).
6. Participation in a clinical trial of an investigational medicinal product in the last 90 days.
7. Pregnant women or women who are trying to become pregnant.
8. Patients who are unable to provide informed written consent
9. Patients who require CT planning as part of their standard care

## **8.4 Trial Groups**

### **8.4.1 Standard Group**

Although the fundamental principles of hip replacement are well-established, there are several options at each step of the operation; patient positioning, the approach to the hip joint, the type and fixation of the acetabular and femoral components and the closure of the wound etc. Patients under this group will be provided THR as per standard care.

The surgeon will use 2D planning software from pre-operative X-rays to complete surgical planning, and will be asked to record the planned position of the acetabular cup at the beginning of the operation using Surgery CRF. Although all patients will undergo CT scans to maintain blinding the surgeon will not use the CT scan to plan the procedure, in this case and a custom surgical guide will not be provided. At the end of the procedure, the surgeon will be asked to record their assessment of the final orientation of the components, and to explain any deviation from the plan.

### **8.4.2 Interventional Group**

Each patient will undergo a pre-operative CT and four plain X-rays, which will be used to accurately plan the hip replacement using the Corin OPS™ (Corin Group, Cirencester, UK). All surgeons will have training in the interpretation of the plans produced by the OPS software, to ensure consistency with this planning process.

Surgical approach, patient positioning and local factors will be determined by the operating surgeon. Acetabular cup alignment is normally positioned based upon the surgeon's judgment, which obviously introduces some human error. In the interventional group, a custom-made alignment guide will be utilised to aid more accurate positioning of the cup based upon the preoperative CT scan, produced for that individual patient. The planned acetabular orientation and guide design will be reviewed pre-operatively by the surgeon, and may be amended according to their preferences. The guide is bespoke and fits into the native acetabular socket, and serves to indicate to the surgeon the planned acetabular orientation. The planned orientation of the cup will be recorded in the trial documentation. The guide does not enforce the surgeon to implant the acetabular component in the planned orientation: it serves purely as an indicator. At the end of the procedure, the surgeon will be asked to record their assessment of the final orientation of the components, and to explain any deviation from the plan.

All patients will receive the same design of acetabular component (uncemented Trinity, Corin). The femoral components used will normally be the uncemented Metafix stem (Corin), but in some patients a cemented Taperfit stem (Corin) will be used if the surgeon deems it to be more suitable for that particular patient. These implants are fully compatible with Corin OPS and non-OPS hip replacement procedures. All surgical procedures will be undertaken by consultant surgeons who are experienced in performing hip replacements both with and without the Corin OPS methodology, and in the use of the above implants.

All patients in the trial will undergo pre and postoperative CT scans to enable accurate assessment of the primary outcome.

Further details on the Corin OPS™ is attached in Appendix 1.

## **8.5 Surgical Device**

### **8.5.1 *Implant and device storage and implementation***

The trial surgeons have both had full training in the use of all techniques and devices used in the study. All surgical equipment required for the study will be stored at Rugby St Cross Hospital in the theatre suite. All implant guides will be clearly marked with the patient name and this will be checked both by the theatre staff and the surgeon as is normal practice. Representatives of the company will be available to give advice in the operating theatre if required, according to normal clinical practice.

Further details on the Corin OPS™ are attached in Appendix 1.

## **9. TRIAL PROCEDURES & VISITS**

### **9.1 Patient Identification**

Patients undergoing an elective primary unilateral total hip replacement (THR) under the care of an orthopaedic consultant at UHCW NHS Trust are potentially eligible to take part in the study. Such patients will be approached by a member of their direct healthcare team to inform them about the study. Patients that are interested in finding out more will be referred to a member of the study team, who will explain the study and provide the patient with the PIS to take home. At least 7 days after the patient has received the PIS, a member of the study team will call the patient to receive their verbal consent for participation over the telephone.

#### **9.1.1 *Informed Consent***

Patients will be asked to confirm whether they have read and understood the PIS and will be encouraged to ask questions and be provided enough opportunities to discuss before deciding to take part in the study. Patients will be free to discuss the study with friends and family before reaching their decision.

After confirming the patient's eligibility to take part, a qualified member of the research team, who has received training in obtaining informed consent, will ask the patient to provide verbal consent to each of the clauses contained within the telephone consent form. The research team member will record the participant's responses on the informed consent form, sign and send a copy to the patient in the post. The patient will be asked to countersign the consent form at their next face-to-face contact with the trial team.

Patients will be made aware that they are free to withdraw their consent to participate and/or their data at any time without giving a reason and that their decision to participate will not influence their current or future care in any respect. Patients will be asked to read the consent form thoroughly and initial against each point to signify their agreement at a time when it is convenient for the patient. Forms will be signed and dated by both the patient and the researcher taking consent. Patients will be provided with a copy of the consent form, a second (original) copy will be stored securely at the study site and a third will be stored in the patient's hospital medical notes.

Consent will be obtained prior to conducting any trial related assessments and/or procedures. Patients unable to consent for themselves will not be included in the trial.

If the patient verbally consents to participate, the study team will book the patient's baseline imaging to be taken at study visit 1 and complete baseline observations as follows:

1. Demographics – name, date of birth, hospital number, height, weight, ethnicity
2. Medical history – hip side, hip pathology, contralateral hip pathology or surgery, spine pathology or surgery, neurological conditions and other medical conditions
3. Current Medications – current and relevant medication
4. Clinical assessment – will be completed by the treating clinician to assess wound healing, perceived leg length difference, walking aids etc.
5. Patient questionnaire – the questionnaire will comprise of validated assessments: HOOS, EQ-5D and Oxford hip score

If any observations cannot be completed via telephone, they will be completed at visit 1.

It is expected that recruitment will take 12 months for the proposed trial. If recruitment is significantly behind target, other surgeons within the hospital will be asked to refer patients on to the CI for potential participation in the study.

## **9.2 Visit 1- Baseline & Imaging**

### **9.2.1 Baseline observations**

## **9.3 Imaging**

All patients will undergo the following imaging procedures at visit 1:.

X-ray and motion capture– standing AP pelvic X-ray, 3 lateral lumbar spine X-rays, with small wearable accelerometers simultaneously placed on the patient (using a Velcro strap). The date performed and problems encountered (practical, image quality), if any, will be recorded. Motion capture will only be taken if the appropriate staff are available to do so.

CT Scan – will be performed in accordance to the methodology attached in Appendix 2. Information will be recorded on Pre-Op Imaging CRF. If patients have had a valid CT scan 12 months prior to consenting for this study, they may not be required to have an additional baseline CT scan to avoid exposing the patient to more radiation if not necessary.

Randomisation – the research team will contact R&D Randomisation Unit to randomly assign patients to the Standard Group and Interventional Group as per section below.

## **9.4 Randomisation**

After completing imaging assessments, the researcher will contact R&D Randomisation Unit (contact details below) based at UHCW NHS Trust during office hours 9 am to 5pm to complete patient randomisation. Randomisation information will be recorded on the Randomisation CRF.

R&D Randomisation Unit  
University Hospitals Coventry & Warwickshire NHS Trust  
4<sup>th</sup> Floor Rotunda, Clifford Bridge Road  
Coventry CV2 2DX  
Office hours: 9 am to 5 pm.  
Tel: 024 7696 6199 or 024 7696 27476

As this is an elective surgery study, there is no need for out-of-hours randomisation.

Participants will be randomised strictly sequentially as participants are eligible for randomisation using a 1:1 ratio. The randomisation will be stratified by operating surgeon and by patient BMI group (BMI<30 v ≥30). Randomisation information will be recorded on Randomisation CRF.

## **9.5 Visit 2 – Surgery**

The surgeries will be performed at Rugby St Cross Hospital. The treating surgeon who will remain unblinded to the study will record relevant information on Surgery CRF. More information on blinding and unblinding can be found in section 10. Prior to discharge all patients will receive AP pelvic X-ray as part of standard care.

## **9.6 Visit 3- Follow Up (6 weeks ± 2 w)**

This will be the first follow up post-surgery and patients will be required to complete CT scan. Where possible, CT scan will be completed at visit 3. However, on occasions, patients may be provided with a separate appointment to complete scanning depending on availability of the imaging facility at the Trust. Information will be recorded on Post-Op Imaging CRF. Clinical assessment will be performed at visit 3 and information collected will be recorded on the Follow up CRF and patient questionnaires will be collected. Any adverse events (AEs) will be observed face to face at consultation or based on information volunteered by the patient at the visit. AEs will be recorded on to the

CRF and reported as per procedure described in section 13. If the patient's follow-up appointment is delayed outside this 6 week time point range, then their data can be collected by phone.

### **9.7 Visit 4 – Follow Up (4 months $\pm$ 6w)**

Visit 4 follow up is not a clinic appointment. It will be completed via phone and post. Patient questionnaires will be provided via post to return to the research team using a pre-paid self-addressed envelope. Information collected at the visit will be recorded on the Follow up CRF. AEs, if any, will be recorded on to the CRF and reported as per procedure described in section 13.

### **9.8 Visit 5 – Follow Up (12 months $\pm$ 2m)**

This is the final follow up and denotes the end of participation for patients. Patients will be required to complete motion capture, X-ray imaging and patient questionnaire. Motion capture will only be taken if the appropriate staff are available to do so. Information collected at the visit will be recorded on the Follow up CRF. AEs, if any, will be recorded on to the CRF and reported as per procedure described in section 13. End of study CRF will be completed as this will be the last scheduled study visit. Following this the patients will be either be followed up as per standard care or discharged back to GP. If the patient's follow-up appointment is delayed outside this 12 month time point range, then their data can be collected by phone.

## **10. BLINDING & UNBLINDING**

This is a patient-assessor blinded study where neither the patient nor the study team recording data will know what arm the patient has been allocated to.

However, the CI and/or senior-most scrubbed surgeon will remain unblinded to the treatment allocation as it is not possible to blind them to the allocation group.

### **10.1 Methods for ensuring blinding**

It will not be possible to blind the surgeon administering the intervention. However, the patients and researcher recording study data and performing follow ups will be blinded as there will be no external difference in the appearance to inform which operation has taken place (the scar and approach is identical).

Primary outcome measures will be assessed via CT and all staff performing scans and measuring the outcome will be blinded to the allocation. Secondary outcome measures will be collected, either prior to discharge, by post, by telephone or by the research team, who will be blinded to the treatment allocation.

The trial statistician will also be blinded to the intervention groups throughout. Blinding will be maintained when generating the randomisation lists by using group names "A" and "B". The patients will be assigned to these groups by the R&D Randomisation Unit which is independent from the rest of the study team.

### **10.2 Methods for unblinding the trial**

Unblinding in the study is not allowed unless there are medical or safety reasons to do so. Unblinding can occur 24 hours a day and 7 days a week during office hours (Monday to Friday; 9 am to 5pm) by calling the clinical team on 024 7696 4209 or 024 7696 5065 or if out of hours, ring hospital switchboard on 02476 964000 and ask for Prof King or Mr. Foguet. Where possible, the CI and/or the sponsor should be informed before unblinding. Treatment codes will not be broken for the planned analyses of data until all decisions on the evaluability of the data from each individual patient have been made and documented.

The method of unblinding ensures that the data for only one patient is disclosed at any one time. This will be by code break envelopes made by trial statistician. There will be 2 sets of envelopes providing emergency unblinding to treatment code, one to be kept with the clinical team in the Orthopaedic department for use in-case of unblinding, and the second set to be kept with the Sponsor as a backup in the R&D office.

## **11. TRIAL WITHDRAWALS**

Patients may be discontinued from the trial treatment and/or the trial at any time without prejudice. The data collected up to the point of withdrawal will be retained unless a patient specifically requests it to be removed

### **11.1 Post-randomisation withdrawals**

Should a patient withdraw from the trial after randomization, he/she will continue to be treated as per routine clinical practice.

### **11.2 Concomitant illness withdrawals**

Details of any concomitant illness (any illness present at the start of the trial) will be recorded at trial entry. If the change influences the patient's eligibility to continue in the trial (i.e. the patient is unable to have the planned surgery or continue participation), the CI must be informed and the patient withdrawn.

### **11.3 Concomitant medication withdrawals**

Details of any relevant concomitant medication (any medication that could affect the performance of the surgery, such as anticoagulants) should be recorded at trial entry. Any changes in relevant concomitant medication should be recorded at each visit. If the change influences the patient's eligibility to continue in the trial (i.e. the patient is unable to have the planned surgery), the CI must be informed and the patient withdrawn

### **11.4 Other withdrawals**

The patient will be required to discontinue participation in the trial under the following circumstances:

- Patient wishes to withdraw for any reason
- Non-compliance to protocol
- CI's decision that withdrawal from the trial is in the best interest of the patient
- AE related
- Sponsor's decision
- Lost to follow up

If the patient needs to be withdrawn from the trial for any of the above reasons, Withdrawal CRF will be completed. Where possible, the reason for the withdrawal from the study will be recorded.

## **12. END OF TRIAL**

The trial will end when all patients have completed their 12-month follow up, although long term follow up (5 and 10 years) may be planned depending on further funding. At this 12-month point, all patients will be treated as per the standard of care.

The trial will be stopped prematurely if:

- Mandated by the regulatory authorities
- Funding for the trial ceases

The regulatory authorities will be notified in writing within 90 days when the trial has been concluded or within 15 days if terminated early.

## **13. SAFETY MONITORING AND REPORTING**

### **13.1 Definitions (from ISO/FDIS 14155)**

#### **13.1.1 Adverse Device Effect (ADE)**

Adverse event related to the use of an investigational medical device.

NOTE 1- This includes any adverse event resulting from insufficiencies or inadequacies in the instructions for use, the deployment, the installation, the operation, or any malfunction of the investigational medical device.

NOTE 2- This includes any event that is a result of a use error or intentional misuse.

### **13.1.2 Adverse Event (AE)**

Any untoward medical occurrence, unintended disease or injury or any untoward clinical signs (including an abnormal laboratory finding) in subjects, users or other persons whether or not related to the investigational medical device.

NOTE 1: This includes events related to the investigational device

NOTE 2: This includes events related to the procedures involved (any procedure in the protocol).

NOTE 3: For users or other persons this is restricted to events related to the investigational medical device.

The following adverse events are expected and will be recorded on the CRF::

#### **Related in general to surgery and anaesthetic**

- Chest infection
- Urinary tract infection
- Myocardial infarct
- Stroke

#### **Related to Total Hip Replacement**

- Infection
- Dislocation
- Leg length discrepancy
- Bleeding
- DVT/PE
- Damage to nerves in the surgical area

### **13.1.3 Device deficiency**

Inadequacy of a medical device related to its identity, quality, durability, reliability, safety or performance, such as malfunction, misuse or use error and inadequate labelling.

### **13.1.4 Investigational medical device**

Medical device being assessed for safety or performance in a clinical investigation.

### **13.1.5 Serious Adverse Device Effect (SADE)**

Adverse device effect that has resulted in any of the consequences characteristic of a serious adverse event.

### **13.1.6 Serious Adverse Event (SAE)**

Adverse event that:

- a) led to a death,
- b) led to a serious deterioration in health that either:
  - 1) resulted in a life-threatening illness or injury, or
  - 2) resulted in a permanent impairment of a body structure or a body function, or
  - 3) required in-patient hospitalisation or prolongation of existing hospitalisation, or

4) resulted in medical or surgical intervention to prevent life threatening illness or injury or permanent impairment to a body structure or a body function.

c) led to fetal distress, fetal death or a congenital abnormality or birth defect.

NOTE 1: This includes device deficiencies that might have led to a serious adverse event if: a) suitable action had not been taken or b) intervention had not been made or c) if circumstances had been less fortunate. These are handled under the SAE reporting system.

NOTE 2: A planned hospitalization for pre-existing condition, or a procedure required by the Clinical Investigation Plan, without a serious deterioration in health, is not considered to be a serious adverse event.

### **13.1.7 Unanticipated Serious Adverse Device Effect (USADE)**

Serious adverse device effect which by its nature, incidence, severity or outcome has not been identified in the current version of the risk analysis report.

NOTE: Anticipated: an effect which by its nature, incidence, severity or outcome has been previously identified in the risk analysis report.

## **13.2 Reporting procedures**

Patients will have direct contact with the trial team by telephone and email to report any events themselves.

### **13.2.1 Reporting of ADEs and AEs**

AEs and ADEs could be observed directly when patients attend follow-up appointments or when volunteered by the patient. Unscheduled clinic visits will be arranged if further clinical care is required following an AE. All non-serious AEs/ADEs should be reported or documented as soon as possible but no later than a month on the AE form and then recorded onto the trial database. If the outcome to the AE is serious then an SAE form should be completed.

### **13.2.2 Reporting of SAEs/SADEs and USADEs**

The EC Medical Devices Directive (93/42/EEC) requires a manufacturer to fully record all adverse incidents that occur during a clinical investigation and include them in the annual reports to the main REC (and MHRA if appropriate). The legal responsibility for reporting SAEs/SADEs lies with the manufacturer or their authorised representative. However, the MHRA also has a voluntary reporting requirement for 'users' of devices i.e. where a device is being used in a trial in which the manufacturer has no involvement, and in this case, the coordinating centre would submit the appropriate reports and also inform the manufacturer of the event.

All SAEs/SADEs and USADEs occurring from the time of surgery until 90 days post-surgery must be recorded on the SAE form and reported to the Sponsor **within 24 hours** of the research staff becoming aware of the event. An initial report may be made orally but must be followed up promptly by a detailed written report. SAE form will be completed together with relevant supporting documents, including an assessment of severity, causality and expectedness, as reviewed by the chief investigator or other medical professional. SAE form should be submitted to the sponsor's office at [RD&Isponsorship@uhcw.nhs.uk](mailto:RD&Isponsorship@uhcw.nhs.uk). A report will also be submitted to the manufacturer (Corin) via their existing vigilance system.

For each **SAE** the following information will be collected:

- full details in medical terms and case description
- event duration (start and end dates, if applicable)
- action taken
- outcome
- seriousness criteria
- causality (i.e. relatedness to trial device / investigation), in the opinion of the investigator
- whether the event would be considered expected or unexpected.

The seriousness, causality & expectedness of an SAE will be reviewed by the CI for reporting purposes

<b>Relationship to trial procedure</b>	<b>Description</b>
Unrelated	There is no evidence of any causal relationship
Unlikely to be related	There is little evidence to suggest there is a causal relationship (e.g. the event did not occur within a reasonable time after administration of the trial medication or device). There is another reasonable explanation for the event (e.g. the patient's clinical condition, other concomitant treatment).
Possible relationship	There is some evidence to suggest a causal relationship (e.g. because the event occurs within a reasonable time after administration of the trial medication or device). However, the influence of other factors may have contributed to the event (e.g. the patient's clinical condition, other concomitant treatments).
Probable relationship	There is evidence to suggest a causal relationship and the influence of other factors is unlikely.
Definitely related	There is clear evidence to suggest a causal relationship and other possible contributing factors can be ruled out.

Any change of condition or other follow-up information should be emailed to the Sponsor as soon as it is available or at least within 24 hours of the information becoming available. Events will be followed up until the event has resolved or a final outcome has been reached.

## **14. TRIAL RESPONSIBILITIES**

### **14.1 Sponsor:**

UHCW NHS Trust has agreed to act as sponsor for this trial and will undertake the responsibilities of sponsor as defined by the Research Governance Framework and ICH Good Clinical Practice. An authorised representative of the Sponsor has approved the final version of this protocol with respect to the trial design, conduct, data analysis and interpretation and plans for publication and dissemination of results. The sponsor provides indemnity for this trial and, as such, will be responsible for claims for any non-negligent harm suffered by anyone because of participating in this trial. The indemnity is renewed on an annual basis and will continue for the duration of this trial.

### **14.2 Chief Investigator:**

CI's responsibilities include, but are not limited to:

- Ensuring that the trial is conducted as set out in the protocol and supporting documents.
- Delegating trial related responsibilities only to suitably trained and qualified personnel and ensuring that those with delegated responsibilities fully understand and agree to the duties being delegated to them.
- Ensuring that CVs and evidence of appropriate training for all Site staff are available in the Trial Site File
- Ensuring that all delegated duties are captured in the study Delegation Log
- Ensuring all Adverse Events are documented and reported promptly to the Trial Manager
- Prepare an annual safety report for the REC and MHRA
- Accountability for trial treatments at their site
- Ensuring the trial is conducted in accordance with ICH GCP principles
- Allowing access to source data for monitoring, audit and inspection

### **14.3 Trial Management Group (TMG):**

TMG will have the responsibility for overseeing the day to day coordination of the trial, monitoring all aspects of the conduct and progress of the trial, ensuring that the protocol is adhered to and taking appropriate actions to safeguard participants and the quality of the trial itself. TMG meetings will take place regularly throughout the project along with the CI.

## **15. DATA MANAGEMENT**

Personal data collected during the trial will be handled and stored in accordance with the 1998 Data Protection Act and GCP.

### **15.1 Data collection and management**

Case Report Forms (CRFs) will be developed to collect all required trial data and will be designed by the trial team in consultation with the chief investigator and statistician. All participants will be assigned a unique trial ID, which will be used to identify all data associated with the patient for the duration of the trial.

All of the data collected in this trial will be entered into a secure trial database held at University Hospitals Coventry and Warwickshire.

Specifications for the trial database will be agreed between the statistician and the CI. The procedure for data entry will be confirmed upon construction of the database and a trial specific data management plan will be developed.

In the event of missing data, the relevant clinical databases and case report forms will be accessed to complete the database.

### **15.2 Data storage**

All essential documentation and trial records will be stored by UHCW in conformance with the applicable regulatory requirements and access to stored information (paper and electronic) will be restricted to authorised personnel. All paper data will be stored in a designated storage facility within the Clinical Sciences Building on the research site at UHCW. Data will also be stored on password protected University of Warwick and UHCW NHS Trust computers in a restricted access building.

### **15.3 Data access and quality assurance**

All data collected will be anonymised after the collection of the baseline demographic data for each patient. Confidentiality will be strictly maintained and names or addresses will not be disclosed to anyone other than the staff involved in running the trial. Identifiable patient data will be held in a locked filing cabinet and coded with the trial number to tag identifiable data to the outcome data.

Direct access to source data/documents will be available for trial-related monitoring or audit by UHCW for internal audit, regulatory authorities or ethics committees.

### **15.4 Archiving**

Trial documentation and data will be archived for 25 years after completion of the trial, in line with current UHCW Trust policy.

## **16. STATISTICAL ANALYSIS**

### **16.1 Power and sample size**

A sample size of **54 patients** has been calculated.

The primary outcome for the study is the difference between the planned and achieved acetabular cup position. Assuming a standard deviation of the difference in cup position of 10° (based on multiple studies of both standard techniques and computer aided techniques) and a minimal clinically important difference of 10° in the primary outcome (based on Lewenick's 'safe zone' concept), power of 90% and alpha set at 0.05, a sample size of 44 was calculated. With 20% added for loss to follow up, 54 patients will be recruited into this study, 27 in each allocation arm.

## **16.2 Statistical analysis of efficacy and harms**

### **16.2.1 Data analysis**

The study statistician will be responsible for the overall analysis of the data in conjunction with the CI and co-investigators

The main analysis will investigate differences in the primary outcome measure : difference between planned and achieved acetabular anteversion angle (as defined above). An intention to treat analysis will be used unless otherwise specified. Therefore, all randomised patients will be included, regardless of protocol adherence and will be retained in the group to which they were allocated in the randomisation.

Standard statistical summaries (e.g. medians and ranges or means and variances, as appropriate) and graphical plots will be presented for the outcome measures described above. Baseline data will be summarised to assess comparability between treatment arms.

The mean of the primary outcome measure between treatment groups will be assessed using t-tests; based on an assumed approximate normal distribution for this outcome. Tests will be two-sided and considered to provide evidence for a significant difference if p-values are less than 0.05 (5% significance level). Estimates of treatment effects will be presented with 95% confidence intervals.

The randomisation will be stratified according to surgeon and BMI group, however the effects of patient age and gender on the treatment effect will be quantified using linear regression analysis that includes these two variables in addition to the main treatment factor. Results from these adjusted and the unadjusted analyses will be presented graphically, to aid interpretation. The reasons and patterns of any missing data will be carefully considered, and if judged significant, missing data will be imputed.

Depending on the nature of the data, various derived variables (e.g. logarithmic transformations of scores) may be created and analysed, in addition to the primary outcome. Secondary outcome measures will be analyzed in a similar manner. The statistical analysis will mainly be carried out using R (<http://www.r-project.org/>) . A consort flow diagram will be produced (<http://www.consort-statement.org/>).

### **16.2.2 Planned recruitment rate**

Over 500 patients have their hip arthroplasty at UHCW each year. From our previous investigations, we estimate that approximately 80 patients annually would be suitable for this trial. In a previous study, comparing two different types of hip replacement surgery, it was shown that patients willingness to take part in trials comparing two different surgical procedures is very high (80%). With a conservative estimate of 70% of patients willing to take part in this trial, it is expected that recruitment will take 12 months for the proposed trial. Therefor our planned recruitment rate is 4.5 patients/month.

## **17. TRIAL ORGANISATION AND OVERSIGHT**

### **17.1 Sponsor and governance arrangements**

The trial will be sponsored by the University Hospitals Coventry and Warwickshire NHS Trust and funded by Corin Ltd, UK.

### **17.2 Regulatory authorities/ethical approval**

All required ethical approval(s) for the trial will be sought using the Integrated Research Application System. The trial will be conducted in accordance with all relevant regulations. Patients will not be enrolled into the trial until written confirmation of R&D approval is received by the research team.

Substantial protocol amendments will be submitted (e.g. changes to eligibility criteria, outcomes, analyses) to relevant parties i.e. investigators, RECs, patients, NHS Trusts, regulators, trial registries, journals as required.

Annual reports will be submitted to the REC within 30 days of the anniversary date on which the favourable opinion was given, and annually until the trial is declared ended. The REC will be notified of the end of the trial (whether at planned time or prematurely). The CI will submit a final report to the required authorities with the results, including any publications within one year of the end of the trial.

### **17.3 Trial Registration**

The trial will be registered with the International Standard Randomised Controlled Trial Number (ISRCTN) Register and also on clinicaltrials.gov.

### **17.4 Notification of serious breaches to GCP and/or trial protocol**

A “serious breach” is a breach which is likely to effect to a significant degree –

- (a) the safety or physical or mental integrity of the subjects of the trial; or
- (b) the scientific value of the trial

In the case of a serious breach of the trial protocol:

- the sponsor will be notified immediately of any case where the above definition applies during the trial conduct phase
- the sponsor will notify the REC in writing of any serious breach of
  - (a) the conditions and principles of GCP in connection with that trial; or
  - (b) the protocol relating to that trial, as amended from time to time, within 7 days of becoming aware of that breach

### **17.5 Indemnity**

NHS indemnity covers NHS staff, medical academic staff with honorary contracts, and those conducting the trial. NHS bodies carry this risk themselves or spread it through the Clinical Negligence Scheme for Trusts, which provides unlimited cover for this risk.

### **17.6 Trial timetable and milestones**

**Start Date: August 2017**

**Prior to start of funding (-3 to 0)**

Compilation of CRF's, Research Ethics Application – to be led by the CI along with the TMG.

**Lead time (Months 0 to 3):**

Finalisation of data collection sheets relevant approvals and contracts to be led by the CI along with TMG

Training of research team to be led by the CI and co-investigators

**Recruitment of patients (Months 3 to 15): Trial starts**

Recruitment targets to be achieved through clinical collaborations between the CI and local research associates. Recruitment targets to be monitored by the TMG.

**Follow-up of patients for the primary outcome (Months 15 to 18):**

Clinical follow up at six weeks, by the research team. Requesting of CT scans by the clinical teams caring for the patient, monitored by the research team. Measuring of the CT scans by an appropriately trained professional, after training by the CI and/or co-investigators.

**Follow-up of patients for the secondary outcomes (Months 15 to 27):**

Follow-up at four and twelve months by the research associate under the supervision of the CI.

**Analysis and reporting (Months 27-30):**

Trial statistician will be responsible for the overall analysis of the data in conjunction with the CI and co-investigators.

### **17.7 Essential Documentation**

A Trial Master File will be set up according to sponsor's SOP and held securely at the R&D department.

## **18. INTELLECTUAL PROPERTY**

There is the potential for the generation of Intellectual Property (IP) as a result of the findings of this trial. Should any IP sensitive findings be uncovered, the Research Team will liaise direct with the Trust IP adviser (G. Smallman) and an exploitation plan will be developed.

## **19. MONITORING, AUDIT AND INSPECTION**

Adverse event monitoring and procedures have been dealt with in section 8.

The trial will be regularly audited and monitored by UHCW in their role as sponsor. The analysis of the primary outcome measure will be audited by the research team and a random sample of the CT's will be measured by a second observer to assess the inter-observer reliability of the measurement.

## **20. PATIENT AND PUBLIC INVOLVMENT (PPI)**

As part of patient and public involvement in our study, we have asked a patient to comment on the design and undertaking of the research. This included consultation on key trial documents such as protocol, PIS and consent form.

## **21. DISSEMINATION AND PUBLICATION**

The results of the trial will be reported first to trial collaborators. The main report will be drafted by the trial team who will agree on the final document.

The trial will be reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines ([www.consort-statement.org](http://www.consort-statement.org)).

In consultation with our patient members, we plan to present the research findings to the entire NHS via the NHS national electronic Library for Health (NHS Evidence).

The study protocol for the full trial will be published in a high impact peer reviewed journal. The final results will be submitted for publication, alongside presentations at annual meetings of the British Orthopaedic Association (BOA), and the British Hip Society (BHS). We also plan to present internationally at the American Academy of Orthopaedic Surgeons (AAOS).

We anticipate that the results of this trial will also inform the development of future multi-centre trials in hip arthroplasty with the potential to influence policy and practice in the UK and worldwide.

## **22. REFERENCES**

1. National Joint Registry. 12th Annual Report. 12th Annu Rep. 2014;12(December 2014):81–8.
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# OPS™ Dynamic Hip Analysis

## INSTRUCTIONS FOR USE

[www.coringroup.com](http://www.coringroup.com)  
[OPS.customerservice@coringroup.com](mailto:OPS.customerservice@coringroup.com)

Manufacturer	Authorised Representative
Optimized Ortho Pty Ltd	Corin Limited
17 Bridge Street Pymble	The Corinium Centre
NSW 2073 AUSTRALIA	Cirencester GL7 1YJ
	UNITED KINGDOM

**Intended Use**

The Optimized Positioning System™ (OPS™) Dynamic Hip Analysis is intended to assist with alignment of components during total hip arthroplasty.

**Product Description**

The OPS™ Dynamic Hip Analysis is a computer software package used to generate simulations of a total joint replacement from patient imaging. The dynamic simulation is used for operative planning, including implant selection, sizing and placement; and to create custom instruments or delivery specifications referencing the patient's anatomy and bio-mechanics. The simulation can also be used for the post-operative evaluation of joint performance.

**Materials**

OPS™ Dynamic Hip Analysis is Class IIa standalone medical device software. The simulation code is compiled in MSC Adams, a computer aided engineering package for multi-body dynamics and motion analysis. OPS™ Dynamic Hip Analysis can be used for patient specific post-operative or pre-operative analysis.

A suite of macros apply the same physical manoeuvres and test conditions to any number of patient inputs. A unique three-dimensional musculoskeletal model is created for each individual that defines the position of implant components in the joint.

The hip model simulates a sit-to-stand event and a step-up event.

**Software Modules and Functions**

Surgery	Analysis Type
Total Hip Arthroplasty	Post-Operative
	Pre-Operative

**Indications**

Post-operative OPS™ Dynamic Hip Analysis is indicated for patients who have received a total hip replacement where implant geometry is supported by the software.

Pre-operative OPS™ Dynamic Hip Analysis is indicated for primary total hip replacement and revision hip arthroplasty where the implant system is supported by the software.

- Contraindications**
- OPS™ Dynamic Hip Analysis is contraindicated for:
- Patients in which total hip arthroplasty is contraindicated
  - Patients with significant orthopaedic deformities, e.g. fused knee, hip or ankle.
  - Patients who are unable to comply with imaging requirements
  - Patients currently receiving ionising radiation treatment or scans for other medical conditions
  - Implant systems that are not supported by the software – if unsure of whether a hip arthroplasty system can be analysed, contact your product representative or Corin before placing a booking or requesting patient imaging.

- Conditions Affecting Performance, Side Effects and Adverse Effects**
- The accuracy of the reported information and quality of the simulation is dependent on a number of factors:
- Quality of CT scans – the prescribed Corin protocol has been designed to minimise the radiation dosage, while retaining sufficient detail in the structures for a patient specific three dimensional model of the joint.
  - Quality of X-rays – the protocol describes the key landmarks and functional positions required for the patient specific dynamic analysis.
  - Provision of correct implant system details (manufacturer, model, and size for a post-operative analysis) to import matching implant geometry into the model.

Corin requires patient details and imaging for pre-operative analyses a minimum of five weeks prior to the surgery date. For requests submitted after this time, delivery of the report cannot be guaranteed; however, all attempts will be made to accommodate requests at short notice.

Incorrect use of the OPS™ Dynamic Hip Analysis information may lead to an increased risk of poor functional outcomes including, but not limited to, hip dislocation, hip edge loading, squeaking in ceramic hip implants, increased wear debris, pain, decreased range of motion and soft tissue impingement.

- Warnings and Precautions**
- The information generated by the software are predictions of the dynamic behaviour of the total joint replacement, derived from a three dimensional model constructed using the patient's bone geometry.
  - The information applies only to the patient identified, listed implant models and side of analysis.
  - The dynamic results must not be used to alter the treatment regime of another patient.
  - The dynamic results must not be used to treat a side other than what is specified in the analysis.
  - The information applies only to controlled dynamic events (sit-to-stand and step-up) and must not be used to draw conclusions outside the simulated actions.

**Restrictions and Limitations on Use**

IRAS ID: 218310

Use of information generated with OPS™ is restricted to registered orthopaedic surgeons. The information may not be used by implant manufacturers for unauthorised purposes, including evaluation and design of total joint replacement systems.

The results of the patient specific analyses are based on radiographic imaging acquired on the date specified in the patient specific reports.

**Report Contents and Interpretation of Results**

The results of the analysis are presented in PDF format, with embedded Flash video clips.

Corin takes all feasible measures to ensure that the report file is not corrupted and free from malware. In the event of a corrupted or infected file, do not attempt to open the report. Contact your product representative or Corin for a replacement file.

Use the following controls to view and navigate the animations in the report.

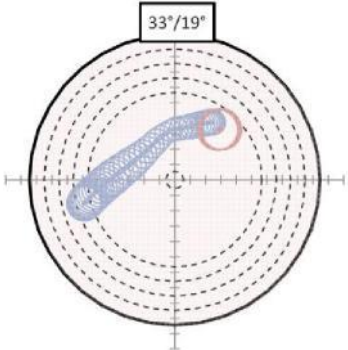
- Play - click to start the video clip
- Pause - click to pause the video clip
- Stop - click to stop the video clip
- Current Time Indicator - click and drag this along the time bar to move forward or backward in the video clip

The hip animations display the model and implants during the simulated sit-to-stand activity and step-up event in medial-lateral and anterior-posterior views.

The polar plots display the articulating surface of the acetabular liner, divided into 5 concentric rings, where the angle subtended at the liner centre corresponds to 5% increments of the cup articular arc angle. The outermost bolded ring represents the rim of the acetabular liner. The polar plots are specific to the implant model, type and size used in the analysis.

Hip joint mechanics are represented by a circle (contact patch area between liner and femoral head, derived from Hertzian contact mechanics) and the centre point of this circle (resultant hip force).

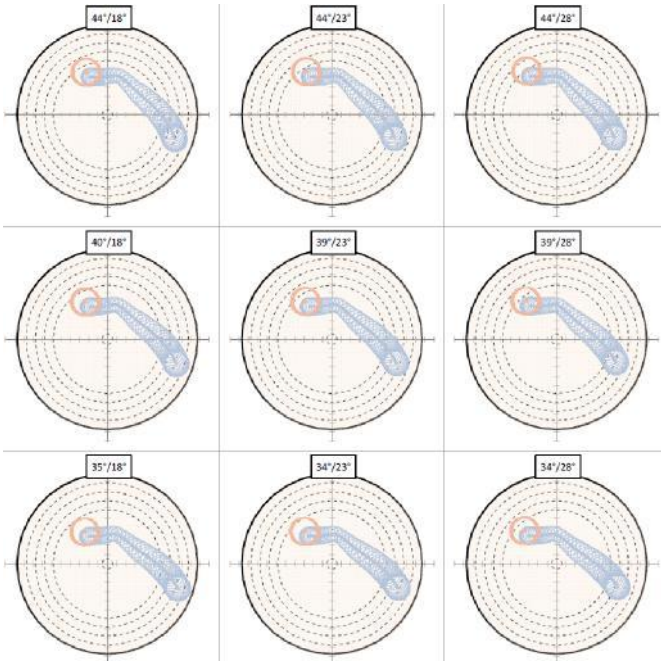
During motion the contact patch and resultant hip force trace a path on the articulating surface of the acetabular liner. This is dependent on individual pelvic dynamics. The polar plot shows the locus of the resultant hip force and path of the head-liner contact patch for the specified acetabular orientation during the sit-to-stand event (blue) and the step-up event (red).



The cup orientation for each polar plot is given in degrees of radiographic inclination, followed by degrees of radiographic anteversion referenced to the coronal plane when supine. The following definitions are applied:

- Inclination - angle between the longitudinal axis and the acetabular axis when this is projected on to the coronal plane
- Anteversion - angle between the acetabular axis and the coronal plane (Murray, 1993)<sup>1</sup>
- Edge loading - when contact patch between the femoral head and acetabular liner passes over the true rim of the liner
- Supine pelvic tilt - angle between the coronal plane and anterior pelvic plane when supine; a negative value represents a posterior pelvic tilt

In pre-operative hip simulations, unless otherwise specified by the orthopaedic surgeon user, the preferred cup orientation is derived from a series of clinical preferences, captured for each surgeon user and aimed to maximise the distance of both outermost contact patch areas from the rim of the acetabular liner, across the full motion of sit-to-stand and step-up events. The results of the pre-operative analysis allow determination of cup orientation to an accuracy of 5 degrees of inclination and anteversion.



The cup orientations displayed on the polar plots are in degrees of radiographic inclination and anteversion (Murray, 1993)<sup>1</sup> referenced to the coronal plane when supine. The nine polar plots are equivalent to 35-45 degrees of inclination and 20-30 degrees of anteversion, in the radiographic definitions referenced to the coronal plane when standing.

Post-operative acetabular cup orientations are reported to an accuracy of  $\pm 2$  degrees. The representation of the combined implant and joint biomechanics on the acetabular liner is accurate to  $\pm 0.5$  zones (which is equivalent to a 5% increment of the cup articular arc angle displayed on the report).

The software version number and date of analysis can also be found on the report. If any assistance in interpreting the dynamic results is required, contact your Corin representative.

**System Requirements for Viewing Report**

The report is best viewed on a personal computer and requires Adobe Acrobat Reader and Flash Player software.

The latest version of Adobe Acrobat Reader can be downloaded from [www.get.adobe.com/reader/](http://www.get.adobe.com/reader/)





The latest version of Adobe Flash Player can be downloaded from [www.get.adobe.com/flashplayer/](http://www.get.adobe.com/flashplayer/)

Refer to [www.adobe.com](http://www.adobe.com) for minimum system requirements prior to installing software.

Note that if viewing the dynamic report on a tablet or smart phone, Flash Player is not supported and the animation will not be displayed.

**Symbols Used**

Please contact your local Corin representative for the Product Information, Imaging Protocol or for further information.

	Caution		Manufacturer
	Consult instructions for use		Authorised Representative

**References**

<sup>1</sup> Murray, D.W., *The definition and measurement of acetabular orientation*. The Journal of bone and joint surgery. British volume, 1993. 75(2):228-3

# OPST<sup>TM</sup> Femoral Plan

## INSTRUCTIONS FOR USE

[www.coringroup.com](http://www.coringroup.com)  
[OPS.customerservice@coringroup.com](mailto:OPS.customerservice@coringroup.com)

### Manufacturer

Optimized Ortho Pty Ltd  
 17 Bridge Street Pymble  
 NSW 2073 AUSTRALIA

### Authorised Representative

Corin Limited  
 The Corinium Centre  
 Cirencester GL7 1YJ  
 UNITED KINGDOM

### Intended Use

The Optimized Positioning System<sup>TM</sup> (OPST<sup>TM</sup>) Femoral Plan is intended to assist with alignment of components during total hip arthroplasty.

### Product Description

The OPST<sup>TM</sup> Femoral Plan is a custom made device used to assist the surgeon in determining a target osteotomy level. The Plan is used for operative planning, including implant selection, sizing and placement, quantifying changes to leg length and offset; and to create custom instruments or delivery specifications referencing the patient's anatomy.

### Materials

OPST<sup>TM</sup> Femoral Plan is a custom made medical device and is presented in the form of a PDF report.

### Indications

OPST<sup>TM</sup> Femoral Plan is intended to be used in conjunction with a total hip replacement system, for patients in which total joint arthroplasty is indicated.

### Contraindications

OPST<sup>TM</sup> Femoral Plan is contraindicated for:

- Patients in which total hip arthroplasty is contraindicated
- Patients with significant orthopaedic deformities, e.g. fused knee, hip or ankle.
- Patients who are unable to comply with imaging requirements
- Patients currently receiving ionising radiation treatment or scans for other medical conditions
- Any other implant system apart from the Corin Hip Product Range

### Conditions Affecting Performance, Side Effects and Adverse Effects

The accuracy of the reported measurements and quality of the implant sizing and positioning is dependent on a number of factors:

- Quality of CT scans – the prescribed Corin protocol has been designed to minimise the radiation dosage, while retaining sufficient detail in the structures for a patient specific three dimensional model of the joint.
- Quality of X-rays – the protocol describes the key landmarks and functional positions required for patient specific analysis.
- Provision of correct implant system details to ensure the correct implant geometry is imported into the model, and planned according to the surgeon's surgical choices.

Corin requires patient details and imaging for pre-operative analyses a minimum of five weeks prior to the surgery date. For requests submitted after this time, delivery of the plan cannot be guaranteed; however, all attempts will be made to accommodate requests at short notice.

Incorrect use of the OPST<sup>TM</sup> Femoral Plan information may lead to an increased risk of poor functional outcomes including, but not limited to, limb length discrepancies, laxity or stiffness of the surrounding tissues, hip dislocation, pain, decreased range of motion and soft tissue impingement.

### Warnings and Precautions

- The information generated in the plan is a prediction of the implant sizing and subsequent leg length and offset changes as a result of the total joint replacement, derived from a three dimensional model constructed using the patient's bone geometry.
- The information applies only to the patient identified, listed implant models and side of analysis.
- The results must not be used to alter the treatment regime of another patient.
- The results must not be used to treat a side other than what is specified in the analysis.
- The information applies only to specific implant system, sizes and positions and must not be used to draw conclusions outside the plan.

### Restrictions and Limitations on Use

Use of information generated with OPST<sup>TM</sup> is restricted to registered orthopaedic surgeons. The information may not be used by implant manufacturers for unauthorised purposes, including evaluation and design of total joint replacement systems.

The results of the patient specific analyses are based on radiographic imaging acquired on the date specified in the patient specific reports.

### Report Contents and Interpretation of Results

The Femoral Plan is presented in PDF format. Corin takes all feasible measures to ensure that the report file is not corrupted and free from malware. In the event of a corrupted or infected file, do not attempt to open the report. Contact your local product representative or Corin for a replacement file.

- The reduced hip illustration represents the supine position from CT.
- Increase in Leg Length (LL) refers to the superior/inferior change in leg length from the pre-operative state.
- Increase in Offset is the overall change in offset measured along the femoral neck, perpendicular to the anatomical axis.
- Unless otherwise specified in the Warnings or Surgeon Notes, the stem and head are positioned to target the native, pre-diseased femoral head height.
- The acetabular shell is positioned 2mm off the true acetabular floor, unless stated otherwise in the Warnings or Surgeon Notes.
- The Greater Trochanter (GT) measurement refers to the height of the native head centre, relative to the superior tip of the greater trochanter. A positive value indicates the prosthetic head is superior, and a negative value indicates the prosthetic head is inferior to the GT. This measurement is taken parallel to the anatomic axis
- The Contralateral GT measurement shown in the Warnings section refers to the height of the contralateral head centre, relative to the superior tip of the contralateral greater trochanter. A positive value indicates the contralateral head centre is superior, and a negative value indicates the contralateral head centre is inferior to the GT. This measurement is taken parallel to the anatomical axis of the contralateral proximal femur. The measurement is only displayed if the difference from the GT measurement on the replaced side is >3mm.
- The anteversion of the native femur, posterior cortex and femoral stem are measured relative to the posterior condyles of the distal femur.

- The posterior cortex anteversion is defined by two landmarks on the posterior cortex at the level of the osteotomy. The landmarks are indicated on the front page of the report.
- Where possible, the stem is orientated to reproduce the native femoral anteversion.
- Native femoral offset is the perpendicular distance from the centre of the native femoral head to the anatomical axis.
- The Lesser Trochanter (LT) measurement refers to the distance between the medial point of the osteotomy and a medial point along the femoral neck, which is level with the superior junction of the lesser trochanter. These landmarks are identified on page 2 of the report.
- The osteotomy is at the level of the Hydroxyapatite (HA) for all uncemented stems, and at 45° at the level of the proximal mark for TaperFit stems. The angle will only be altered to avoid a step-cut if specified in the surgeon's preferences; this will be indicated in the Warnings section.
- A step-cut is defined by a cut that leaves a vertical face of bone at the anterior aspect of the GT of >5mm.
- Unless otherwise specified by the orthopaedic surgeon, the preferred cup orientation is derived from a series of clinical preferences, captured for each surgeon user.

The date of analysis is presented at the bottom of the report. If any assistance in interpreting the results is required, contact your local product representative or Corin.

### System Requirements for Viewing Report

The report may be viewed on a personal computer, smart phone or tablet and requires Adobe Acrobat Reader.

The latest version of Adobe Acrobat Reader can be downloaded from [www.get.adobe.com/reader/](http://www.get.adobe.com/reader/)

Refer to [www.adobe.com](http://www.adobe.com) for minimum system requirements prior to installing software.

### Symbols Used

	Caution		Manufacturer
	Consult instructions for use		Authorised Representative
	Do not re-use		

Please contact your local Corin representative for the Product Information, Imaging Protocol or for further information.

# OPST<sup>TM</sup> Delivery System

## INSTRUCTIONS FOR USE

The PSV report may be viewed on a personal computer (requires Adobe Acrobat Reader software) or an Apple smart phone or tablet (requires 3D PDF Reader application).

### Manufacturer

Optimized Ortho Pty Ltd  
17 Bridge Street Pymble  
NSW 2073 AUSTRALIA

[www.coringroup.com](http://www.coringroup.com)  
[OPS.customerservice@coringroup.com](mailto:OPS.customerservice@coringroup.com)

### Authorised Representative

Corin Limited

The Corinium Centre Cirencester GL7 1YJ UNITED  
KINGDOM

### Intended Use

The Optimized Positioning System<sup>TM</sup> (OPST<sup>TM</sup>) Delivery System is intended to assist with alignment of components during total hip arthroplasty.

### Product Description

The system consists of single use patient specific components and a set of reusable surgical instruments.

- Acetabular cup orientation is assisted intraoperatively through the use of the custom made acetabular guide, custom made trial acetabulum (replica of the patient's acetabulum, into which the guide fits) and reusable instruments (Class I). A custom made Patient Specific Visualisation (PSV) report provides the surgeon with a visual representation of the prescribed orientation and associated custom made patient specific guides.
- Femoral neck osteotomy is assisted through the use of the custom made femoral osteotomy guide and custom made trial femoral head (replica of the patient's femoral head, onto which the guide fits), if applicable. A custom made Femoral Plan enables the surgeon to prescribe the planned osteotomy level and a custom made PSV report provides the surgeon with a visual representation of the prescribed osteotomy and associated custom made patient specific guides.

For each patient, one PSV report is provided to the surgeon preoperatively, and it may contain up to three 3D images, depending on the OPST<sup>TM</sup> products requested.

For bilateral referrals, one PSV report is provided for each hip, each with their own prescribed component alignment and patient specific guide(s).

OPST<sup>TM</sup> uses laser pointers to identify the orientation of the trial acetabular cup and patient specific acetabular guide and to align the final component.

### Materials

Materials have been selected in accordance with ISO or ASTM standards and are biocompatible for surgically invasive short term use. OPST<sup>TM</sup> reusable instruments are primarily manufactured from 630 and 316 stainless steel and polyoxymethylene (acetal) as per ASTM A564 / A564M-10, ASTM A967-05 and ASTM F1855. The custom made guides are manufactured from polyamide (nylon) as per ISO 16061(2008).

### System Requirements for Viewing PSV Report

The latest version of Adobe Acrobat Reader can be downloaded from

[www.get.adobe.com/reader/](http://www.get.adobe.com/reader/).

Refer to [www.adobe.com](http://www.adobe.com) for minimum system requirements prior to installing software.

For Apple smartphones or tablets, the latest version of *3D PDF Reader* can be downloaded from your smart phone or tablet app store.

Currently, the PSV report is not supported by applications for Android hardware.

### Indications

OPST<sup>TM</sup> Delivery System is intended to be used in conjunction with a total hip replacement system, for patients in which total joint arthroplasty is indicated.

### Contraindications

OPST<sup>TM</sup> Delivery System is contraindicated for:

- Patients in which total hip arthroplasty is contraindicated
- Patients with significant orthopaedic deformities (e.g. fused knee, hip or ankle), anatomical disruption or distortion of the pelvis
- Patients who are unable to comply with imaging requirements
- Patients currently receiving ionising radiation treatment or scans for other medical conditions
- Patients with insufficient bone structure or quality, which may not allow for rigid attachment of instruments
- Other disorders that affect pelvic anatomy and bony landmark recognition
- Patients with active infection
- Any other implant system apart from the Corin Hip Product

Range

### Conditions Affecting Performance, Side Effects and Adverse Effects

The accuracy of the reported measurements and quality of the implant sizing and positioning is dependent on a number of factors:

- Quality of CT scans – the prescribed Corin protocol has been designed to minimise the radiation dosage, while retaining sufficient detail in the structures for a patient specific three dimensional model of the joint.
- Provision of correct implant system details to ensure the correct implant geometry is imported into the model, and planned according to the surgeon's surgical choices.

Acetabular cup alignment is achieved using coincident laser beam projections on the operating wall or ceiling. This may be affected by:

- Operating theatre size
- Surgical equipment or structures obstructing the laser pointers

The patient specific guides are designed to match the patient's native bone. Errors within the operative technique and improper positioning or inadequate fixation of OPST<sup>TM</sup> components may result in:

- Limb length discrepancies
- Sub-optimal acetabular component orientation

Adverse effects of any orthopaedic procedure may include infection, venous thrombosis, pulmonary embolism, cardiovascular disturbances, vascular or nerve injury, osteolysis, periarticular ossification, allergy, pain.

### Warnings and Precautions

This system requires the use of Class 2 lasers. Do not stare directly into the laser beam as prolonged exposure may cause retinal damage.



The patient specific instruments within OPST<sup>™</sup> are custom made and must only be used for the individual named on the packaging and on the part. These components are for single use only. Do not re-sterilise for reuse.

The patient specific visualisation (PSV) and femoral plan reports are custom made and must only be used for the individual named on the report. These reports are for single use only.

OPST<sup>™</sup> has been designed for use with total hip replacement implant systems. Do not use OPST<sup>™</sup> with incompatible implant systems as this may compromise the effectiveness of the total hip arthroplasty.

Take care to select the appropriate instrument size for the patient. Correct instrument size will increase potential for success in the operative technique.

#### Restrictions on Use

Use of OPST<sup>™</sup> is restricted to registered orthopaedic surgeons. This device should only be used in a sterile operating room of an accredited hospital.

The patient specific guides, trial components, femoral plan and PSV report are custom made. As such they must only be used for the specified patient and referred hip (left or right), and must be used within their specified expiry date

#### Packaging

All OPST<sup>™</sup> parts are packaged in protective non-sterile packing. The patient specific instruments (guides and trials) must be removed from packaging and placed in an appropriate container or wrap for cleaning and sterilisation. Instruments that are provided in surgical trays may be steam autoclaved in these containers.

Refer to full instructions for processing single use instruments and reprocessing reusable instruments.

#### Handling and Storage

OPST<sup>™</sup> parts should be stored in their surgical trays when not in use to prevent damage to fragile instruments.

Items should be stored in a limited access location, protected from sunlight, heat and moisture. Prior to sterilisation, inspect all instruments for visible damage and ensure that mating components can be assembled. Damaged instruments must not be used. Contact your local Corin representative for replacement parts.

Refer to full instructions for processing single use instruments and reprocessing reusable instruments.

#### Cleaning and Sterilisation

All OPST<sup>™</sup> parts are provided non-sterile and must be cleaned prior to sterilisation. The patient specific instruments must be removed from packaging for cleaning and sterilisation.

Cleaning and disinfection is achieved through enzymatic soak and scrub followed by sonication. Automated cleaning using a washer/disinfector without manual pre-cleaning is not recommended. OPST<sup>™</sup> instruments are intended for sterilisation by steam autoclave only. Other methods of sterilisation are not recommended.

Instruments must be disassembled prior to cleaning, disinfection and sterilisation. It is important that the autoclave is maintained and calibrated so that the required temperatures and durations of sterilisation cycles are observed.









NOTE: Laser pointers and batteries DO NOT undergo cleaning and sterilisation.

Refer to full instructions for processing single use instruments and reprocessing reusable instruments.

#### Operating Instructions

Refer to OPST<sup>™</sup> Surgical Technique for complete operating instructions.

#### Symbols Used

	Fragile, handle with care	
Catalogue number	Keep away from	
Batch code	sunlight	
Caution	Keep dry	
Consult instructions manufacture	Date of	
for use		
Do not re-use	Manufacturer	
Authorised Representative	Do not use if package is damaged	
Date of expiry		

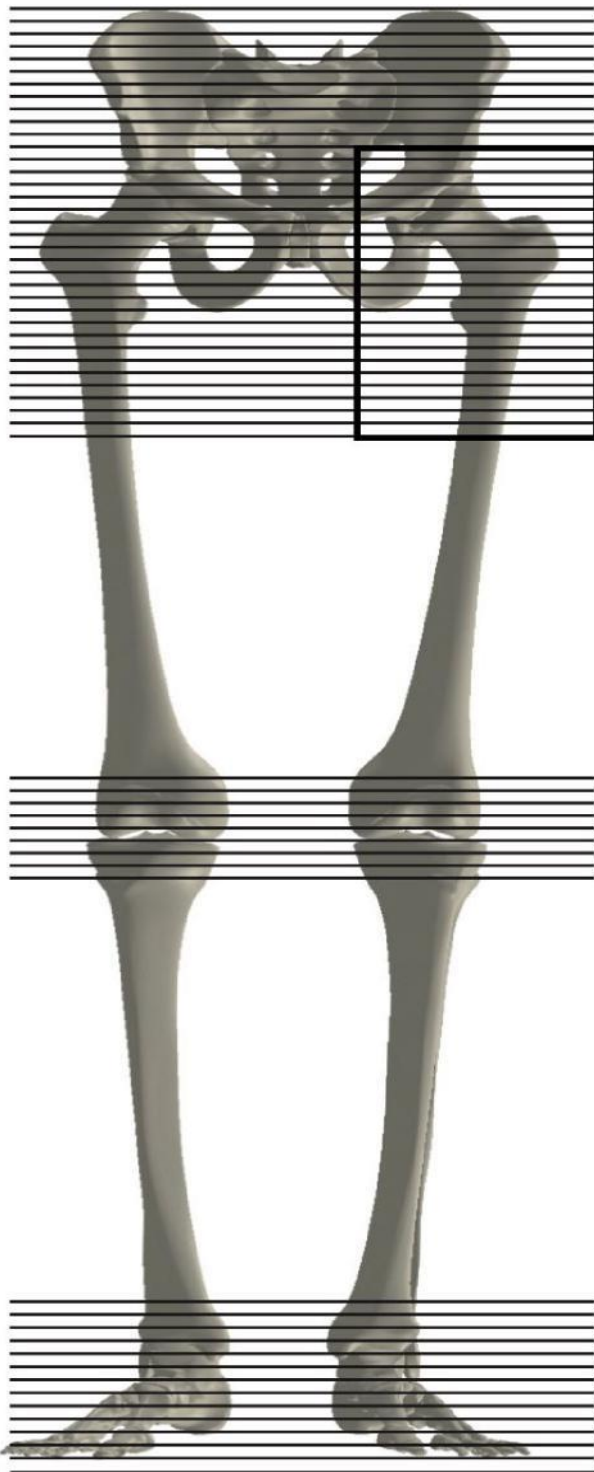
Please contact your local Corin representative for the Product Information, Surgical Technique, Reprocessing of Surgical Instruments, Cleaning and Sterilisation of Single-Use Instruments, Imaging Protocol or for further information.

**24. APPENDIX 2.**

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Symbios latest Version Dec 2016

**PELVIS**



To include both iliac crests, entire pelvis, and **proximal half of both femurs**

1.25mm slice thickness

**SINGLE HIP (in black box) with is the 3<sup>rd</sup> series**

zoomed

To include entire hip joint cavity and proximal half of single femur

0.625mm slice thickness

If scan request is for both hips, then another single hip series is required for the other hip

#### **BOTH KNEES**

To include both distal femoral condyles and proximal tibias (as far as tibial tubercles) 2.5mm slice thickness

#### **BOTH ANKLES & FEET**

To include both ankle joints and whole of feet

2.5mm slice thickness

**This page is slightly different to the images on page 6 of this document. This page is provided to the radiographer to clarify certain aspects of the way the scan should be performed. The overall radiation dose of the CT is not affected by these modifications.**

# HIP-PLAN<sup>®</sup>

CT scan protocol

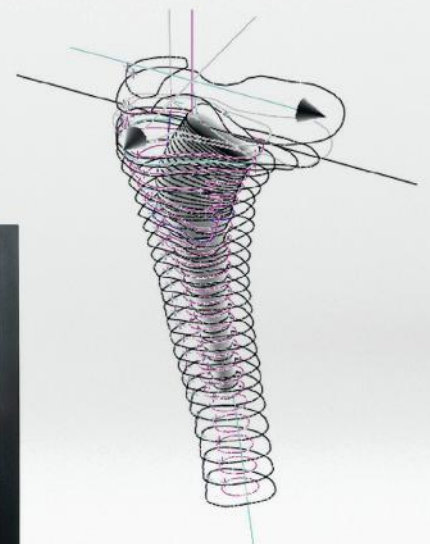


 **symbios**  
custom-made for you

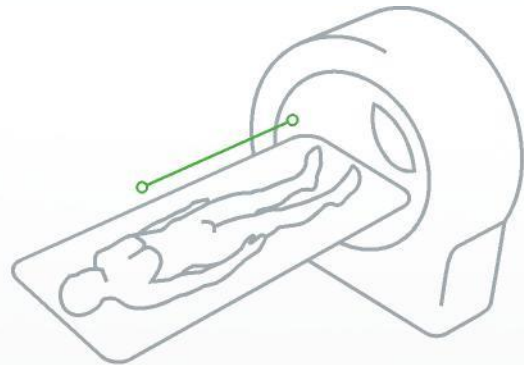
## Document objective

This document specifies the protocol for the acquisition of CT images that are compatible with the HIP-PLAN<sup>®(1)</sup> 3D hip planning software. When combined with Symbios standard hip implants, the HIP-PLAN<sup>®</sup> allows orthopaedic surgeons to plan and reconstruct their patients with an increased accuracy<sup>(3)(4)(5)</sup> compared to conventional x-ray templating. Since 1989, Symbios also uses its 3D planning software to design custom-made hip prosthesis<sup>(6)(7)(8)</sup>.

As the accuracy of the HIP-PLAN<sup>®</sup> relies on the CT images that have been acquired, it is essential to follow as closely as possible the parameters described in this protocol, even though it might differ from hip imaging protocols routinely used by your institution for diagnosis purpose.



## Patient's position

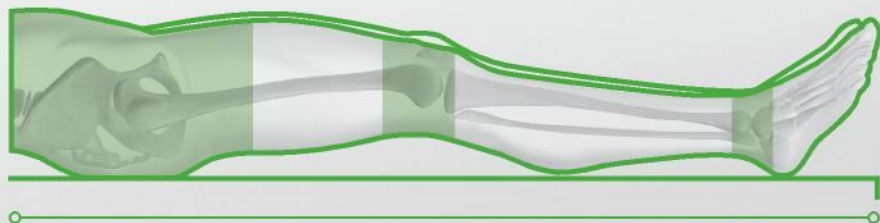


1

The patient should be supine with the feet forward.

2

The legs of the patient should be extended and aligned to the table axis. Slight hip flexion is permitted if the patient is experiencing pain.



COURSE RANGE TO BE COVERED  
DURING ACQUISITION


3

Check that the maximum course range of the table is sufficient to allow an examination starting from the top of the pelvis to the foot on the side to be operated.

**Important:** It is essential that the patient is comfortably settled in order to prevent motion during the examination. Cushions and straps may be used to maintain the patient's position.

## Image series

The protocol consists of a single acquisition composed of three separate spiral scans. The three reconstructed series should be axial and should provide slices that are adjacent.

	Series	Slice thickness and spacing	Reconstructed FOV (mm)	Resolution (px)	Voltage (kV)
	PELVIS	1.25 to 2 mm	500	512 x 512	120
	<b>RIGHT / LEFT</b>	<b>0.5 to 0.8 mm</b>	200	512 x 512	120
	KNEES	1.25 to 2 mm	500	512 x 512	120
	ANKLES	1.25 to 2 mm	500	512 x 512	120
	SCOUTVIEW FACE	-	-	-	-
	SCOUTVIEW PROFIL	-	-	-	-

**Note:** Both frontal and sagittal scout views (topograms) are required for the proper use of HIP-PLAN®, and they should be performed with the highest possible resolution.

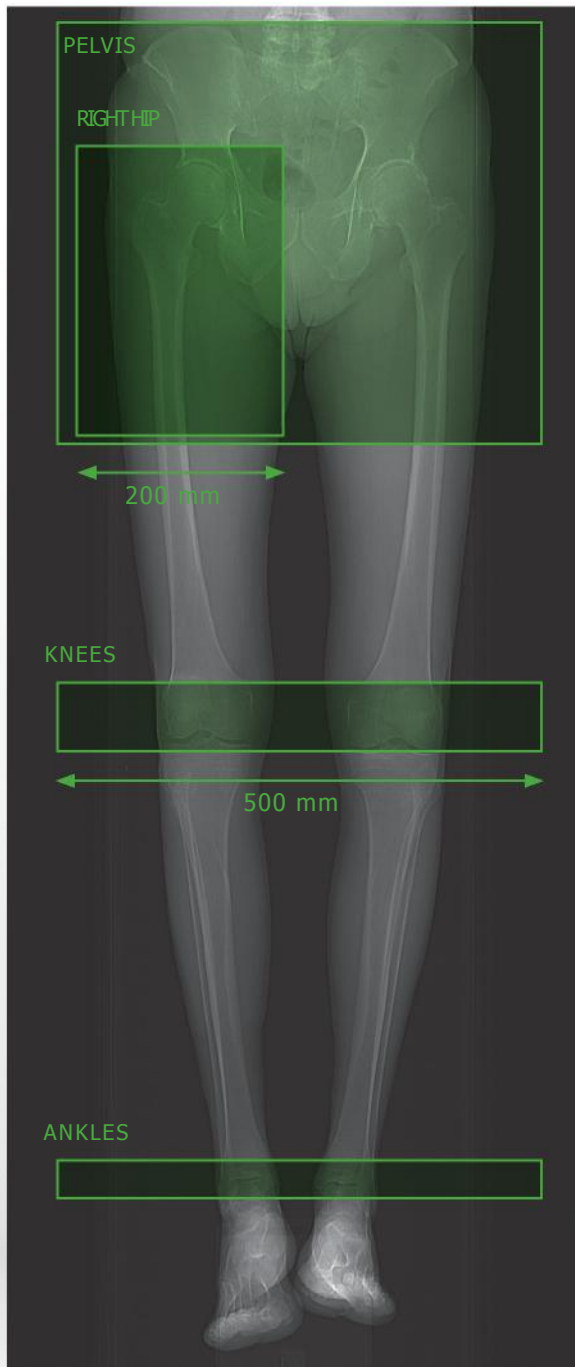
## Scanner settings

Acquisition mode	Spiral
Collimation and pitch parameters	Define parameters as to allow a reconstruction with the lowest slice thickness as possible* (max. 0.8 mm)
Reconstruction kernel for soft tissue**	GE Healthcare <a href="#">Detail</a>
	SIEMENS <a href="#">B31</a>
	TOSHIBA <a href="#">FC13</a>
	PHILIPS <a href="#">B</a>
Images resolution	512 x 512 pixels
Voltage	120 [kV]
Charge (mAs)	Adapted to avoid artifacts according to the patient's morphology

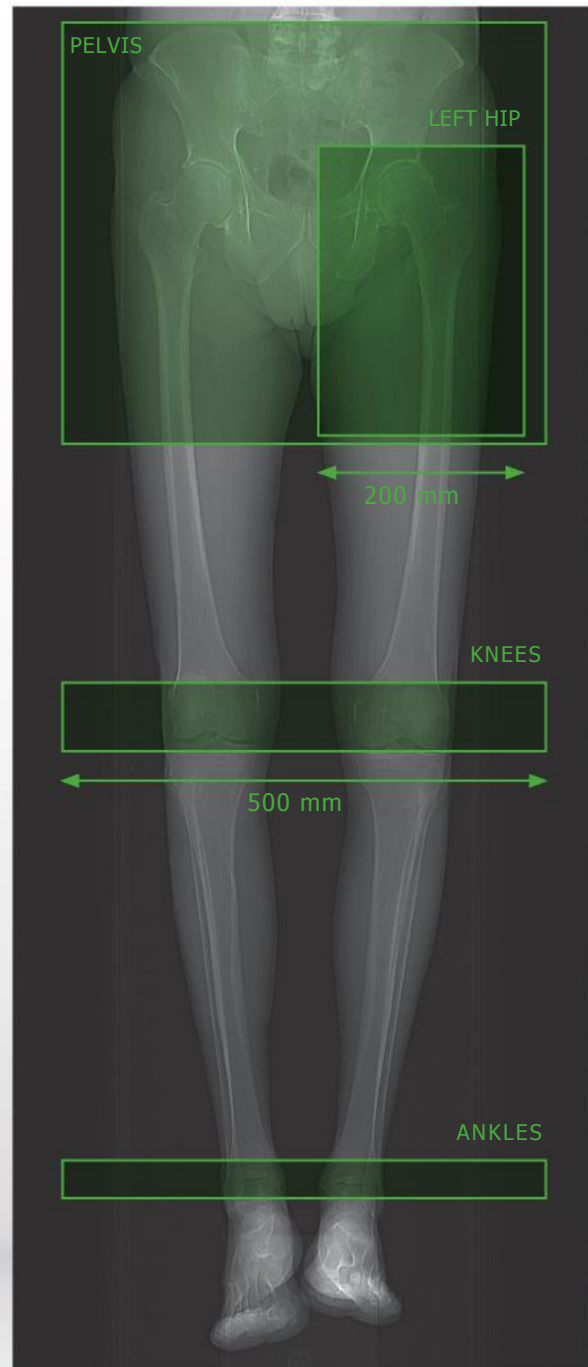
(\*) The minimum slice thickness can vary from a machine model to another according to the parameters that are set. However, the expected optimal thickness should be in between 0.5 mm and 0.8 mm.

(\*\*) For better imagery quality (noise reduction), the reconstruction filter for soft tissue is recommended.

Right hip protocol



Left hip protocol



**Important:**

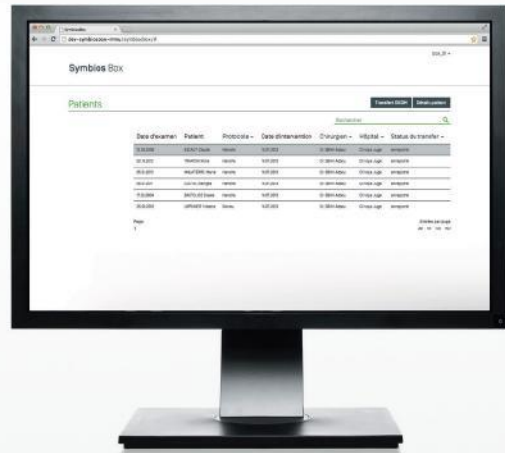
Adhere to the series as indicated above, particularly:

- PELVIS series: Include the **iliac crests** as well as the distal **femoral isthmus**.
- HIPS series: Include the **acetabulum** as well as the **distal femoral isthmus** (including the false acetabulum in cases of congenital hip dysplasia).
- KNEES series: Include the entire **distal femoral epiphysis**.
- ANKLES series: Base the series around **tibio-talar articulation**.

# Sending images to Symbios

There are several methods available for sending scanned images to Symbios:

1



## Online (Symbios Box)

The most simple and effective method is to transfer the scanned images to Symbios via the Symbios Box. The Symbios Box is compatible with PACS/DICOM and is installed on the local area network (LAN) at your medical imaging center. This allows it to communicate with your PACS

and to send DICOM data directly to Symbios via the Internet.

### Safer

The Symbios Box uses a highly sophisticated algorithm in order to encode the DICOM data during online transfer. Data confidentiality for your patients

### Faster

Because the data is sent directly via the internet, we receive the DICOM images at Symbios in less than 20 minutes\*. We are therefore able to get a head start on designing custom-made implants for surgeons and their

### Simpler

All you need is a regular internet browser (such as Chrome, Safari, Internet Explorer, Firefox, etc) to access the patient list and transfer the relevant

For more information about the Symbios Box, contact your Symbios representative.

(\*) Time taken to send images online may change subject to image size and the speed of your internet connection.

2

In person

or by post (CD-ROM)

You can save the DICOM images onto a disk (CD-ROM or DVD-ROM] in uncompressed format and give them to your Symbios representative yourself or send them by post to the following address:

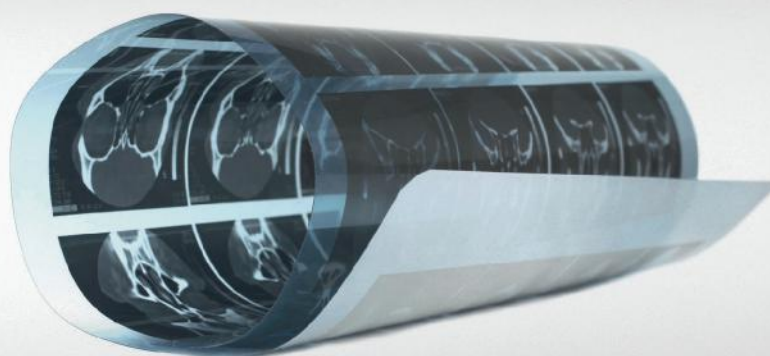
Symbios Orthopédie SA  
Custom Hip Department  
Avenue des Sciences 1  
1400 Yverdon-les-Bains  
Switzerland

#### Radiation exposure

As reported by Huppertz et al.<sup>(2]</sup>, "a mean effective dose of 4.0 mSv (SD 0.9 mSv] modeled by the BMI ( $p < 0.0001$ ] was calculated" when using

#### Data confidentiality

Symbios undertakes to respect the confidentiality of the patient's data,



References

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(4) **Comparisons of preoperative three-dimensional planning and surgical reconstruction in primary cementless total hip arthroplasty.** Hassani H, Cherix S, Ek ET, Journal of Arthroplasty. Epub 8 Jan 2014.

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(7) **Three-dimensional custom-designed cementless femoral stem for osteoarthritis secondary to congenital dislocation of the hip.** Flecher X, Parratte S, Aubaniac JM, Argenson JN. Journal of Bone and Joint Surgery (British) 2007, vol. 89-B, n°12.

(8) **Three-dimensional computed cementless custom femoral stems in young patients: midterm follow-up.** Wettstein M, Mouhsine E, Argenson JN, Rubin P, Aubaniac JM, Leyvraz PF.



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