Author’s response to reviews

Title: Are changes in radiological leg alignment and femoral parameters after total hip replacement responsible for joint loading during gait?

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Author’s response to reviews:

General comments

We found a small error in the postoperative data of one subject. We have updated all affected values in the manuscript and redid the statistical analysis. The main results and conclusions were not affected by this correction, only the mean values and the corresponding p-values slightly changed.

All changes made to the manuscript are marked “red”.

Reviewer reports:

F Braatz (Reviewer 1):

Excellent work and an important topic. We recommend the publication of the paper in BMC Musculoskeletal Disorders. The analysis of the effects of THR on function and gait deviations requires further investigation to get better functional results.

However please add information about the preoperative gait analysis and the influence of typical changes in ROM in OA Patients on the gait. For better understanding of the postoperative changes add a postoperative X-ray with typical changes in the described angles. Maybe you can
use the pelvic frontal kinematic data to give an Information about the changes of the leg length pre-post THA.

Dear Dr. Braatz,

Thank you very much for your valuable comments and the recommendation of publication of our manuscript.

However please add information about the preoperative gait analysis.

We have added information on the preoperative gait analysis in the new manuscript. We added the information as an appendix as the main focus of the paper was and should stay on the postoperative gait analysis in relation to leg alignment (appendix A).

However please add information about the influence of typical changes in ROM in OA Patients on the gait.

We hope that we understood your question right. We agree that changes in passive ROM might have an influence on the kinematics and the kinetics of gait in our patients. However the inclusion of the clinical examination, range of motion and maybe even muscle strength, should be investigated in a separate paper as it will be out of proportion for the present paper. Including the changes in ROM would not only mean new correlations in the result section, we would need to formulate further hypotheses and this topic should be derived from the literature in the introduction and should be described in the methods section.

For better understanding of the postoperative changes add a postoperative X-ray with typical changes in the described angles.

We have added a second EOS image to show the typical changes in the described angles (Figure 1)

Maybe you can use the pelvic frontal kinematic data to give an Information about the changes of the leg length pre-post THA.

On your question regarding pelvic frontal kinematics and changes in leg length we would like to mention that also the determination of leg length difference (LLD) and their influence on frontal
plane hip and knee kinematics and kinetics during walking should be investigated in a separate paper rather than including the aspect of LLD in the present paper. We understand that LLD is an important theme for orthopedic surgeons, as LLD should be minimized by THR, but we decided to leave LLD out of the present paper. Like for the passive ROM/clincial examination we would need to formulate further hypotheses and also this topic should be derived from the literature in the introduction section as well as extensively described in the methods section.

In our limitation section there is a statement “Important factors when performing a THR are the torsion of the stem and leg length. These parameters were outside the scope of this research, but could have an effect on the changed joint moments and warrants further investigation” (page 16, lines 391-393).

David Lunn (Reviewer 2):

Thank you for the opportunity to review this paper. The paper aims to understand the effects of total hip replacement on joint moments during gait, specifically trying to determine if leg alignment and joint orientation plays a role in any postoperative changes. The paper presents some interesting findings regarding leg alignment changes and gait differences from pre to post op in THR patients. However there are a number of issues which need clarifying and areas where more information is required. Some general points are listed below with more detailed queries listed successively.

Dear Dr. Lunn,

Thank you very much for your extensive review of our manuscript. We have changed the manuscript according to your comment.

General points-

There is no mention about how the gait data was modelled, for example how was the hip joint centre determined? Modelling of the skeleton during gait analysis can have large impacts on both the kinematics and kinetics. Through the EOS scans it should be possible to include patient specific hip joint centres to a certain degree of accuracy. Can this be included in the modelling if not already done so?
We agree that modelling of the skeleton can have a large impact on the kinematics and kinetics of gait. In our study we used the standard Plug in Gait model in which the center of the hip joint is calculated with a standardized geometrical prediction method using regression equations (Davis, Õunpuu, Tyburski and Gage, 1991). This method is common in the clinical gait community (Stief F. 2018. Variations of marker sets and models for standard gait analysis. In: Müller B, Wolf S, editors. Handbook of Human Motion). We have updated the methods section by explicitly stating how the hip joint center was calculated (page 6, lines 149-152).

You are right that with EOS it is possible to calculate patient specific joint centres. However, for that you must have the patient first in the gait laboratory to put on specific markers which can be seen in EOS, do the gait analysis and bring the patients to EOS afterwards. Logistically this was not an option with our preoperative patients as we were happy to have them in the gait lab whenever they had time during the preoperative appointment here in our clinic. We plan to look into the different options to model the hip joint (functional approaches like SCORE, EOS etc.), but for that we need those special markers and must rearrange the preoperative appointment to our needs. As this was a prospective study, we can’t model anything different anymore.

Was there a reason why only stance phase was considered for the kinematics? Considering the largest range of movement is seen in the swing phase for the knee this would be an important phase to study and should be included. This is understandable for kinetics but not so much for kinematic analysis.

We have limited the analysis to the stance phase of gait as the main focus was on the joint load in relation to leg alignment and not on the kinematics of gait. We have included the kinematics during the stance phase to be able to explain differences in joint loading during the stand phase.

From a clinical point of view you are right the swing phase is important as well especially in the light of rehabilitation.

Discussion- The main findings aren't restated at the beginning of the discussion which loses the impact of the main findings.

The main findings have been restated at the beginning of the discussion (page 13, lines 314-318).

The discussion is overstating the findings. Few gait differences were observed however the discussion reads as though there is evidence of differences which were caused by changes in alignment, which from the results isn't apparent.
Thank you for your comment. We have rewritten the discussion. We have removed the borderline significant correlations and focused on the main correlations between the leg alignment and the joint load (pages 13-16, lines 311-387).

Specific point-

Line 91 and 92- "Leg alignment"- which variable be more specific.

The leg alignment variables have been specified in the abstract (page 2, lines 30-32) and the introduction of the manuscript (page 4, lines 93-95).

Line 100- Was the same implant used? Implants can have an effect on the alignment and each implant can have a different templating procedure which might influence overall leg alignment. This information should be included to ensure it is either controlled for or highlighted as a limitation.

Unfortunately the implants were not all the same. We have added the influence of the type of implant to the discussion/limitations section. Looking in more detail to the effect of implant on the leg alignment and on the kinetics during gait will be investigated in a separate study (page 16, lines 398-400)

Line 106- Was pain assessed as part of the exclusion criteria?

Pain was not a specific exclusion criteria. All patients experienced pain as this is a main reason for them to have surgery. Only if the pain was so severe that the patients could not walk freely the patients were excluded. We now mention in the method section that we included symptomatic unilateral hip OA patients who were scheduled for THR (page 5, lines 111-112).

Line 113- Why was this comparison to healthy group necessary. Change from pre-op is more important as it is patient specific change. The cohort used seems to be from an entirely different population and comparisons between the two groups does not add anything to the results.

We wanted to show that the leg alignment after THR is not normal, for that we needed to know whether the leg alignment was normal before surgery. Bendaya et al. (2015) showed that osteoarthritis patients had a difference in leg alignment compared to healthy controls. These differences suggest either degenerative change over time or inherent differences between individuals that may contribute to the disease progression. However, as the non-affected leg is
“not healthy” and the leg alignment of this leg might have suffered under the increased loading due to a deviating gait pattern over a prolonged time, we could not use this leg as a reference.

We have included this in the introduction (page 4, lines 88-92) and the discussion (pages 13-14, line 327-333).

Line 148- I am not sure this processing is correct. It would be more reliable to calculate the peak of each trial and average the peak, rather than a peak of an averaged trial. Can this way of averaging be justified?

There is a lively discussion on average values, average trial, or most representative trial, however, and as suggested, we have calculated the peak of each trial and averaged over the trials.

The writing was erroneous; it should have said “Data were exported to Matlab (version R2016b, The Mathworks Inc., Ismaning, Germany) and patterns, which were normalized over the gait cycle, were calculated. To represent the knee and hip joint load, the maximum external knee and hip adduction moment during the first (KAM_1 and HAM_1) and second (KAM_2 and HAM_2) phase of stance were determined for each trial and averaged over the trials” (page 6-7, lines 154-158).

Line 171- delete the additional )

The additional “)” belongs to the “(“ in front of ANCOVA. The sentence reads: “Walking speed was considered as a covariate to eliminate the effect of speed on the dependent kinematic and kinetic variables (ANCOVA: univariate analyses of variance with walking speed as a covariate and group as a fixed factor (operated leg or non-operated leg vs. controls)). (page 7, lines 177-179)

Line 320- "again" suggests that medial OA has been previously discussed, which it hasn't.

We have deleted “again” from the sentence (page 13, lines 324-327).

Line 370- This isn't correct the contralateral limb shouldn't be classed as healthy limb. Irrelevant of how close it is to healthy data it will be compensating for the operated limb in some way.

We have deleted the sentence stating that the contralateral limb is healthy. You are right that the contralateral limb will always compensate in some way (page 15, line 375).
Line 393- Why was leg length not measured? This should have been included as an exclusion/inclusion criteria.

Leg length can and has been measured with EOS. However we decided to leave leg length and leg length differences out of this paper because in our opinion leg length difference (LLD) and their influence on frontal plane hip and knee kinematics and kinetics during walking should be investigated in a separate paper. We understand that LLD is an important theme for orthopedic surgeons, as LLD should be minimized by THR. However, we would need to formulate further hypotheses and also this topic should be derived from the literature in the introduction section as well as extensively described in the methods section.

In our limitation section there is a statement “Important factors when performing a THR are the torsion of the stem and leg length. These parameters were outside the scope of this research, but could have an effect on the changed joint moments and warrants further investigation” (page 16, lines 391-393).

Table 2- Why compare to healthy controls? They are not a patient group I am not sure what this adds to this part the story. Justification needs to be included about why they are being compared.

See the reaction to the comment of line 113 and the text in the introduction (page 4, lines 88-92) and the discussion (pages 13-14, line 327-332).

Table 3- "Hip ROM" is this sagittal?

Yes the Hip RoM and Knee RoM are in the sagittal plane as was mentioned in the methods section. We have added “in the sagittal plane” to the explanation of table 3 (page 10, lines 233-249), table 4 and appendix A and B. We also added “in the transverse plane” to foot progression angle and “in the frontal plane” to the trunk displacement. Further we added which direction of movement is positive and which direction is negative to table 3 and appendix A.