Author's response to reviews

Title: The biomechanical differences of rotational acetabular osteotomy, Chiari osteotomy and shelf procedure in developmental dysplasia of hip

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Author's response to reviews: see over
Dear Dr. Kamath,

We would like to re-submit this manuscript entitled “The biomechanical differences of rotational acetabular osteotomy, chiari osteotomy and shelf procedure in developmental dysplasia of hip” for consideration for publication in BMC Musculoskeletal Disorders. We have revised our manuscript according to the reviewers’ comments. In the method section, we added more detail to describe the way to make dysplastic hip and the strain gauge measurements. For CE angles in every step, we added the X-ray pictures after shelf procedure, Chiari osteotomy and rotational acetabular osteotomy. We reviewed the manuscript thoroughly and corrected the misuse of terms “stress” and “strain”. We also made other suggested changes in the presentation and made the revision in the use of English. The responses for the reviewers’ comments are listed in detail below.

Thank you in advance for your time and consideration.

Sincerely,

Ming Fu, M.D.
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**Introduction**
We have revised our manuscript according to the reviewers’ comments. In the method section, we added more detail to describe the way to make dysplastic hip and the strain gauge measurements. For CE angles in every step, we added the X-ray pictures after shelf procedure, Chiari osteotomy and rotational acetabular osteotomy. We reviewed the manuscript thoroughly and corrected the misuse of terms “stress” and “strain”. We also made other suggested changes in the presentation and made the revision in the use of English. The responses for the reviewers’ comments are listed in detail below.

**Reviewer #1:**
1) Page7, line4 to 6: The method to make dysplastic hip with use of chisel must be described in detail. Readers could not understand.

**Author Response:**
We added more detail of the method to make dysplastic hip with use of chisel in Page 7. “Firstly, a homemade metallic scale with 2 mm accuracy of measurement was fixed just above the acetabulum of the specimen using two Kirschner wires. And X-ray was took repeatedly to ensure the lower edge of the scale was parallel to the connecting line between bilateral acetabular upper edges, so that it could be used as the reference when making a dysplastic hip (Figure 2c). Then we drew a predicted 1.0 cm bone-cut line on the posterior and superior border of acetabulum (Figure 2a and Supplemental Figure 1). After resecting the bone with a chisel (Figure 2b), the pelvis X-ray film was retaken to affirm that the CE angle of the build hip was 10 to 20 degrees (Figure 2d). So our model was consistent with DDH in morphology and imaging examination.”

2) Page7, line13 to 15: The width of bone fragment was too narrow to show real function of shelf operation.

**Author Response:**
Indeed, it seems unlikely that a bone fragment of width 1.0 cm will be clinically useful for shelf operation. However, we built the DDH model by cutting off a 1.0 cm wide bone fragment, and a bone fragment of 1.0 cm width had been able to make CE angles more than 20 degrees, which could be considered normal, after shelf operation. Furthermore, it may cause instability of antiseptic cadaveric pelvis if the osteotomied bone was moved inward more than 1.0 cm in Chiari osteotomy. And the present cadaveric pelvis research was aimed to compare the biomechanical changes of shelf operation to that of Chiari osteotomy and Rotational acetabular osteotomy in the same condition, as a result the width of bone fragment for shelf operation was also determine at 1.0 cm. In addition, our study focused on the biomechanical changes of different osteotomies and the results showed the strain value of hip were decreased in shelf procedure which had achieved expected aims.

3) Page7, line15-20: Movement of osteotomized bone by just only 1cm could not function really.

**Author Response:**
Similarly, in clinical practice, movement of osteotomized bone by just only 1.0 cm in RAO maybe does not work usually. However, after 1.0 cm rotary bone distance in DDH model, CE angles in DDH models were more than 20 degrees after RAO and Chiari osteotomy.
Moreover, with regard to the purpose of understanding the biomechanical change after RAO, we found that a distance of 1.0 cm for the movement of osteotomized bone had decreased the strained values dramatically, which revealed that RAO was able to relieve the abnormal stress to some extent. On the other hand, because the subjects of this study were antiseptic cadaver specimens, it may cause instability of cadaveric pelvis if the osteotomied bone was moved inward more than 1.0 cm in Chiari osteotomy.

4) CE angles should be clarified in every steps.

Author Response:
Not only had we measured the CE angle before and after establishment of DDH model, but also we had clarified CE angles after each osteotomy just as showed in Supplemental Figure 2. The statement that CE angle was clarified after shelf operation, Chiari osteotomy and RAO, as well as the X-ray pictures after osteotomies were added in the manuscript as the reviewer’s suggestion.

5) Quality of written English: Needs some language corrections before being published

Author Response:
We made the corrections in the use of language as the reviewer’s suggestion, and asked native English speaking experts to improve the language in our manuscript before resubmission.

Reviewer #2:
1) Major comments:
1- I agree with the authors that the biomechanical studies on hip dysplasia procedures are rare. However, expect them to provide a short review of the existing literature, such as:

Author Response:
We added these papers and made a short review in introduction section of the revision as the reviewer’s recommendation.

2- There is a need to describe the strain gauge measurements in more details. Where was the strain gauge attached to? To the articular cartilage, to a prosthesis, to an artificial femoral head, or something else? The strain gauges are usually sensitive to strains in the plane they are attached to. While here it seems that they have been used to evaluate the pressure that is applied to them perpendicularly. I am suspicious of the repeatability of the results of this type of application of strain gauges.

Author Response:
We added more details to describe the strain gauge measurements in Page 6 as the reviewer’s suggestion. In fact, we have clearly describe this methods in our previously paper (Zhang Z, Fu M, Kang Y, Chen Y, Liao W: Upward and inward displacements of

The center of the maximum stress region of femoral head was cleaned and marked for strain gauges (5mm×15mm) in biaxial as recommended by KYOWA (Tokyo, Japan). The size of strain gauges were 5mm×15mm, and the thickness were 33µm–38µm. The shape of the strain gauges (KFG-5-120-C1-11L3M2R, sensitivity coefficient ±2.08±1.0, KYOWA) were adjusted with dimensions based on the curve of the femoral head. The strain gauges were pasted onto articular cartilage at the marked central position in the superior and medial part of femoral head using one drop of rapid cure adhesive (cyanoacrylate adhesive CC-33A, KYOWA). The strain gauge covered 34% of the half sphere in the mediolateral direction of the femoral head. Then an accessory film of polyethylene resin from KYOWA was used to cover the strain gauges. A latex cover was placed over the strain gauges, and waited for about 60 minutes until the adhesive was completely harden.

For another thing, the strain of the femoral head was mostly exerted by acetabulum perpendicularly due to the weight of body and that was why the strain gauge was applied here to evaluate the perpendicular pressure. And the strain gauge was so sensitive that we measured the strain of every hip three times and took the average in each step.

3- The use of terms “stress” and “strain” in the manuscript is misleading and not accurate. For instance in the abstract it is stated that “the stress around the femoral head was evaluated by strain gages”. Also, in Figure 4, the vertical axis is considered as relative stress while in the text it is obvious that it is a measure of relative strain.

**Author Response:**
As the reviewer’s reminder, we have reviewed the manuscript thoroughly and corrected the misuse of terms “stress” and “strain”.

Minor Comments:
1- In the caption of Figure 1, it is a motioning of femur prosthesis which seems irrelevant.

**Author Response:**
Figure 1a was used to demonstrate the fixation method of the pelvic specimen and Figure 1b showed the area where color changed obviously on the pressure sensitive paper which helped determine the maximum stress region of femoral head. Also we corrected the description of the legend of figure 1.

2- Some of the abbreviations used have not been previously defined in the manuscript. For instance the term “EARO” in caption of Figure 3.

**Author Response:**
We have checked the abbreviations and defined them when they were mentioned for the first time in the article.

**Reviewer #3:**
1)1- The study design suffers a major problem which is comparing two salvage osteotomies to a reconstructive osteotomy, the goals and indications of each one are different.
Author Response:


2- Calculation of hip strain after shelf and Chiari osteotomy right after the osteotomy, is wrong because we need healing of the bone and changing of the capsule to fibrocartilage before any measurement,

Author Response:

Because the current study was a measurement study base on cadaver specimens, healing of the bone and changing of the capsule to fibrocartilage was impossible for a cadaver specimen. Certainly, we also pointed out this limitation in discussion section that we didn’t consider the healing process of bone and the transformation of soft tissue. In our further research, we already think about application of three-dimensional finite element
model and animal experiment to explore the influence of soft tissue and healing process in these osteotomies.

3- Saying that the stress reaction force increase in Chiari osteotomy is correct but this calculation was made only on a point sensor not a big surface after the osteotomy,

**Author Response:**
Indeed, the strain measured by only one point sensor rather than a big surface was a drawback of our study. Nevertheless, just as we mentioned in the discussion section, this strain point was located in the maximum stress region of femoral head so that we believed it was able to reflect the force condition of hip to some extent. Furthermore, we will also try to design more strain points to better reflect the force condition in our future research.

4- I think the concentration of the joint forces may change after the osteotomy, so the sensor location should change after the osteotomy,

**Author Response:**
We agree that the concentration of the joint forces may change after the osteotomy and the sensor location should change after the osteotomy. In fact, in our study, we used a piece of pressure sensitive paper to detect the maximum stress region of femoral head after every osteotomy in the same way before we located the sensor. So the sensor was always located in the center of the maximum stress region of femoral head in every measurement. We also added our statements about this work in method section.

5- Its grammar needs extensive revision to be understandable by readers.

**Author Response:**
We made the revision in the use of grammar as the reviewer’s suggestion, and asked native English speaking experts to improve the language in our manuscript before resubmission.

**EDITORIAL REQUIREMENT:**
Please include an acknowledgement section at the end of the manuscript before the reference list. Please acknowledge anyone who contributed towards the study by making substantial contributions to conception, design, acquisition of data, or analysis and interpretation of data, or who was involved in drafting the manuscript or revising it critically for important intellectual content, but who does not meet the criteria for authorship. Please also include the source(s) of funding for all authors. Authors should obtain permission to acknowledge from all those mentioned in the Acknowledgements.

**Author Response:**
We added an acknowledgement section at the end of the manuscript before the reference list as the editor’s recommendation. At the same time, we also included the sources of funding. And we obtained permission to acknowledge from all those mentioned in the acknowledgements. Besides, we request to add two authors, Xin Duan and Peihui Wu, who provided suggestions for the study and critically reviewed the manuscript.
Supplemental Figure 1  A predicted 1.0 cm bone-cut line was drawn on the posterior and superior border of acetabulum.

Supplemental Figure 2  The X-ray pictures after shelf procedure (a), Chiari osteotomy (b) and rotational acetabular osteotomy (c) showed that CE angles were all greater than 20 degrees.