Author’s response to reviews

Title:Biomechanical comparison of a novel transoral atlantoaxial anchored cage with established fixation technique - a finite element analysis

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Response to Reviewers

Dear BMC editor and reviewers:

We would like to thank all of you for your valuable comments which have been very helpful to improve the quality of our manuscript. We have modified our paper according to your comments. A summary of changes is listed below. We have responded to each reviewer’s comments in the manuscript. We are now re-submitting the revised manuscript to BMC. Thanks a lot in advance for your reconsideration about our paper.

Main Changes:
1. Provide more information about BI model as below:
   “For the unstable BI model, we removed all elements representing transverse ligament from the intact model. In addition, BI with IAAD always had assimilation of C1, with rates up to 92.0%[1], thus we defined the C0–C1 joint as tie contact to simulate such anatomical abnormality of BI.”
2. Show the ROM with original data.
3. Make arrows to direct the right point of the maximum stress area.
4. Provide more information about transoral procedure in Transoral Surgical Technique simulations as below:
   With the neck in hyperextension and mouth opened wide, the transoral approach generally accesses C0 to C3, and specialized retractors are used to maintain the access for transoral procedure [22]. To achieve ideal reduction and fusion of C1–C2, the cortical bone of the anterior arch of C1, contractural scar tissue between atlas and odontoid, contractural articular capsule, as well as the articular cartilage were removed. Sometimes a high-speed burr, or an angled curette is used to resect the cortex [4, 7-9]. Then a fusion cage filled with bone graft was inserted into the C1-2 joint in a direction parallel to the sagittal plane. After cage placement, a suitable TARP plate was rigidly fixed to screws from C1 to C2 to provide additional stability for fusion. For the Cage+Plate device, two diverging locking intraarticular screws were constructed from titanium plate, which was integrated with the self-designed cage. The specialized screwdrivers may be used to implant screws with bending angle for Cage+Plate device.
5. Calculate the enter angles and the length of the screws using trigonometric functions in Abaqus 6.9 for two devices.
6. Add two essential References as below:

We have changed the manuscript giving a point-by-point response to the concerns to address here.

Referee 1:
General comment:
The author established a FE model of new device for atlantoaxial fixation from anterior approach and compared the biomechanical properties between Cage+plate and Cage+TARP. The author’s purpose was to prevent potential disadvantages related to TARP fixation in treating of BI by using a Cage+plate device. Though the FE model has little to do with BI and it is very difficult to simulate BI, the FE result still can provide some advice for the treatment of BI using different fixation techniques.

- Major Compulsory Revisions

1. As the author said: It is challenging to model various conditions of BI, and the unstable model in the study was removing all transverse ligament elements. It is more like instability upper cervical model than BI. So maybe the FE model could not stand for BI very well.

   Response: Thank you for your comments. In fact, we have removed all elements representing transverse ligament and made the C0–C1 joint as tie contact to simulate the unstable BI model in this study. We have showed that the ROM of C0-C1 joint in unstable model was “zero” in Table 2, but we did not explain the BI model with more details in our paper. Now, in the revised paper we provide more information about BI model as below:

   “For the unstable BI model, we removed all elements representing transverse ligament from the intant model. In addition, BI with IAAD always had assimilation of C1, with rates up to 92.0%[1], thus we defined the C0–C1 joint as tie contact to simulate such anatomical abnormality of BI.”

   Another paper about TARP and Goel technique, which will be published in Chinese journal of spine and spinal cord in September or October, also use the same method to simulate the BI model.

   However, the BI is likely to have various conditions, such as deformation of the bones (slope shape of C2 articular surface/ assimilation of C1), laxity of the ligaments. The unstable BI model in this study could not stand for various conditions of BI, but it may represent an important proportion of BI, and provide a new way for the treatment of BI.

2. The traditional TARP technique is without cage, so maybe it is better to compare with only TARP additional.

   Response: We agree that the traditional TARP technique is without cage, however, recently the TARP team have designed a circular-shaped atlantoaxial cage with traditional TARP instead of granulated iliac crest autograft, and found that the circular-shaped cage with TARP can provide better biomechanical stability than iliac crest with TARP[2]. The Patent No. of the circular-shaped atlantoaxial cage in China is CN 103142331 A. We discuss the advantages of transoral atlantoaxial fusion cage in our paper. Additionally, as we know it is impossible to make two identical iliac crests to surgeon, but we can manufacture the same size cage filled with two different iliac crests for fusion and we may use titanium cage or nano-materials cage containing pores instead of PEEK cage for bony ingrowth. Therefore, we compared the biomechanical properties of cage with plate to cage with TARP, but not to the traditional TARP technique.

   In our paper, we design an symmetrical hexagon-shape cage according to the anatomy of the atlas. This hexagon-shape design is meant to avoid injury of the spinal cord, VA and internal carotid artery, and it may provide larger internal graft window than circular-shaped cage. We will further design and quantify such cage based on computed tomography images.
3. For the figure showed the result of ROM, it is better to represent the original data rather than the percent.

*Response*: Thank you for your comments. We have shown the ROM with original data in our manuscript.

- Minor Essential Revisions
1. For Fig.5, the author should check again of the arrow that showed the maximum von Mises stress. For example, the arrows in Fig. 5 A, 5B and 5C of cage+plate definitely didn’t direct the right point of the maximum stress area.

*Response*: Thank you for your careful review of our paper. We have corrected the error accordingly.

**Referee 2:**

Reviewer's report:
The authors have done a great job. The cage+plate devices have been used worldwide for the procedure of ACDF with excellent clinical and radiological outcomes. The authors put the device into C1-2 facet joint one each side and fix the cage with screw into the lateral mess of C1 and C2. The strength of the screw against pulling-out power is depended upon the angle and the length of the screw. The author need to describe the surgical procedure including the enter angle and the length of the screw. The cortex of the articular process is very hard and transoral procedure does not have enough space to manipulate the instruments. How does the surgeon deal with these problems? The authors need to provide more information.

*Response*: Thank you for your comments. With the neck in hyperextension and mouth opened wide, the transoral approach generally accesses C0 to C3, and specialized retractors are used to maintain the access for transoral procedure [3]. As for the cortical bone, resection of the cortex is performed with a high-speed burr, or an angled curette.
The specialized retractor for transoral procedure [3]

The enter angles and the length of the screws are calculated using trigonometric functions in Abaqus 6.9, and we have shown the data in our paper.

The specialized screwdrivers have allowed surgeons to implant screw with bending angle for total hip replacement, so we confirm that the intraarticular screws could be constructed from titanium plate to fix the C1-C2 joint through transoral procedure, and we will further develop such instruments for the Cage+Plate device.

References

With your useful comments, we believe that the quality of the revised manuscript has been improved. If there are further questions, please do not hesitate to contact me.

Thanks a lot in advance reviewing our paper again.

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