Author’s response to reviews

Title: Vertebral column decancellation in Pott's deformity: use of Surgimap Spine for preoperative surgical planning, retrospective review of 18 patients

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Dear Editors and Reviewers,

Thank you for your letter and for the reviewers’ comments concerning our manuscript entitled “Vertebral column decancellation in Pott's deformity: use of Surgimap Spine for preoperative surgical planning, retrospective review of 18 patients” (BMSD-D-17-01110). The comments were valuable and have greatly helped us revise and improve our paper. We have studied the comments carefully and have made corrections, which we hope will meet with your approval. The revised portions of the manuscript are written in red font. Our point-by-point responses to the reviewers’ comments are as follows.

Replies to Ajoy Prasad Shetty T (Reviewer 1):

1. Introduction. inadequate: what are limitations of the traditional methods.

Answer: We appreciate this comment. Several mathematical formulas and graphical methods for preoperative planning have been described. For most methods, however, global sagittal balance was not accurately evaluated and the effect of spinopelvic parameters, especially pelvic incidence (PI) and pelvic tilt (PT), were neglected, leading to postoperative undercorrection. Moreover, these are relatively complex for routine clinical use. An optimal approach to quantifying sagittal parameters and planning precise correction is lacking. This information has been addressed in the revised version (page 5, lines 89-96).

2. Advantages of surgimap in other deformities.
Answer: Thanks for the comment and we have carefully re-read the relevant articles. Surgimap Spine has been used in the surgical treatment of kyphosis deformity secondary to ankylosing spondylitis, osteomalacia, or inappropriate past fusion procedures. The software not only provides a practical and convenient method to analyze preoperative sagittal parameters and predict proper postoperative alignment, but also simulates the procedure of osteotomy to help surgeons select appropriate surgical methods. This information has been addressed in the revised version (page 5, lines 102-108).

3. Paucity of literature on the use of surgimap in TB kyphosis

Answer: Surgimap has reportedly been used in the surgical treatment of kyphosis deformity secondary to ankylosing spondylitis, osteomalacia, or inappropriate past fusion procedures. To the best of our knowledge, the use of Surgimap in TB kyphosis has never been reported. Our research is the first to present the use of the software in kyphosis secondary to spinal tuberculosis; this is one of the innovative features of our study.

4. Spelling mistakes

Answer: Thanks for the comment, and correction has been made as suggested by the reviewer (page 4, line 70). And the revised manuscript has been edited and proofread by a medical editing company.

5. Material methods. Inclusion criteria: should clearly define whether the patients had healed TB or in the late stages of active TB

Answer: Thanks for the comment. Patients with healed tubercular kyphosis were included in our study. This information has been addressed in the revised version (page 6, lines 119-120).

6. Exclusion criteria: SHOULD BE MORE SPECIFIC. DOES MENTION THAT PTS WITH ACTIVE TB EXCLUDED, ALONG WITH PTS WITH FUSED THORACIC & LUMBAR SPINE. HEALED TB USUALLY PRESENTS WITH FUSION OF 2-4 FOUR VERTBRAE AS A SINGLE MASS.

Answer: Surgical planning was performed using Surgimap Spine, development of an accurate plan required determination of parameters such as thoracic kyphosis (TK) and lumbar lordosis (LL). Patients whose fused vertebrae involved both T12 and L1, in which TK and LL cannot be measured, were also excluded. Correction has been made in the Exclusion criteria (page 6, lines 123-127).

7. How was the plain radiographs taken (standing or supine) - It would be difficult to get a standard standing radiographs in Pts with ASIA C neurology.

Answer: Thanks for the comment. The plain radiographs were taken in the standing position for all patients. One American Spinal Injury Association (ASIA) C patient (Case 7) had standing radiographs two weeks prior to admission. At that time, he had ASIA grade D and could stand
unsupported. However, he declined surgery because of financial issues. However, his neurological deficits rapidly progressed and his ASIA grade deteriorated to C before surgery. This information has been addressed in the revised version (page 6-7, lines 130-136).

8. The authors do mention that "it was checked whether VCD was sufficient IF not VCR was planned". This is in contrast to the statement in introduction That VCD is superior to VCR in correction of deformity.

Answer: As a published study reported (Y. Wang, L.G. Lenke. Vertebral column decancellation for the management of sharp angular spinal deformity. Eur Spine J (2011) 20:1703–1710), the average correction angle of VCD was 82.2°, which is effective for most patients with TB kyphosis. Additionally, this technique is relatively safe. However, in some cases of severe kyphosis, VCD cannot restore sagittal alignment to the normal physiological limits according to simulation of the osteotomy procedure using Surgimap Spine. VCR, as the most aggressive method, allows a greater correction angle than VCD (Enercan M, Ozturk C et al. Osteotomies/spinal column resections in adult deformity. European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society 2013;22 Suppl 2:S254-264.). However, it is a technically demanding and exhausting procedure with higher risk of major complications. VCR is a formidable last-resort technique for severe spinal deformity (Suk SI, Kim JH et.al. Posterior vertebral column resection for severe spinal deformities. Spine 2002;27(21):2374-2382.). VCD is simpler and safer, despite not achieving a greater correction angle. The text was modified accordingly. (page 4, lines 85-87, Pages 7-8, lines 153-157).

9. TO correct - pts had previously underwent an initial debridement (see attachment of the article - highlighted by colours)

Answer: Thanks for the comment, and correction has been made as suggested by the reviewer (page 8, lines 165-166).

10. One patient had transient neuro deficit _ was it recognized intraoperatively

Answer: Correction has been made as suggested by the reviewer (page 11, line 234).

11. The technique of VCD described is almost like PSO, The middle column also is removed as depicted in the diagram (but it is mentioned that the middle column acts like a hinge).

Answer: The difference between VCD and PSO is that VCD is a “Y” type osteotomy and PSO is a “V” type osteotomy. The hinge in PSO is located at the anterior cortex of the vertebral body, while the hinge in VCD is located at the border of the anterior and medial column. The text was revised accordingly (page 10, lines 201-203), and Figure 5 has been added to show the difference.

12. Need at least one more case eg with K angle of 100 degrees especially of thoracic spine.
A 36-year-old patient with Pott’s deformity. The patient’s main complaints were increasing neurological deficit and cosmetic issues. Pre-operative radiographs (a), CT(b) and MRI (c) show that the apex of kyphosis is located at T6-T9. The Konstam’s angle was 101° and the TK was 77°. The simulation of VCD osteotomy in Surgimap (d). The Konstam’s angle was corrected to 29° and the TK was 28° immediately after the surgery (e,f). 28 months follow-up X-ray (g) and CT (h) scan show a solid fusion.

13. Discussion. How was the use of surgimap software useful in planning the wedge & how the plan was carried intraoperatively has to be discussed.

Answer: As VCD technique is a “Y” type osteotomy, the Wedge Osteotomy tool was used in surgical planning using Surgimap. The portion of the wedge-shaped resection was determined by two lines consisting of three points. The anterior point was located at the border of the anterior and medial column. The cephalad and caudad junction points of the pedicle and vertebral body were selected as the posterior points of the upper and lower resection line. The wedge shape was set to a 50:50 angle bisector. Upon application of the osteotomy, the image was modified directly: the wedge shape portion was removed, the posterior column closed, and the anterior column opened (Figure 1d and Figure 2d). Then, the key parameters were measured to determine whether sagittal alignment was restored to the normal physiological limits. Subsequently, the optimal surgical strategy was decided. Intraoperatively, it was essential to determine the anterior point of the wedge-shaped resection. Generally, the length between the anterior point and the pedicle is measured in Surgimap; after placing the pedicle screw above and below the damaged vertebral body, a pedicle probe with appropriate depth was inserted into the targeted vertebral body through the pedicle hole. C-arm fluoroscopy confirmed the exact location of the probe and the anterior point was determined. A high-speed drill was used to enlarge the pedicle hole both cephalad and caudad, until the corresponding walls were penetrated. The three points of the wedge-shaped resection were determined intraoperatively. This information has been addressed in the revised version (pages 13-14, lines 280-302).

14. The paper should discuss more on the benefits of the use of surgimap software & less on the advantages of VCD.

Answer: More information about the benefits of the use of Surgimap software was added in the revised version and the information about advantages of VCD has been reduced as suggested by the reviewer. Good surgical planning requires exact and full evaluation of sagittal alignment. Surgimap not only measures global and local key parameters, but also takes compensatory mechanisms used in an effort to maintain the trunk and the effect of spinopelvic parameters into account. As a geometrical method, Surgimap allows the surgeon to introduce given angular corrections at any given point of the spine and mimic the surgical maneuvers on preoperative X-rays, thus providing an estimate of the postoperative results. Its novel approach provides a virtual preview of the result of a surgical procedure, and allows the surgeon to evaluate the amount of correction needed and to determine its potential effect. Moreover, Surgimap, an open source archive system and software, is very easy to learn and convenient to use. It is an effective and practical tool for spine surgeons (Discussion section, pages 302-315, lines 91-96).
Replies to Zairan Liu (Reviewer 3):

1. while demonstrating the advantages of using VCD for Pott’s kyphosis, the authors should also discuss in detail what are the challenges and why it has not prevailed before. Then the authors should explain how they solved the challenges.

Answer: We are sincerely grateful for your kindness and support. The main challenge for VCD is in determining the exact location of the hinge intraoperatively. The location of the hinge differs and the postoperative correction angle is variable. Until now, the surgeon’s experience was the determinant. To solve this challenge, Surgimap was used for preoperative planning and C-arm technique was used to confirm the appropriate position. Additionally, VCD is a newer technique, with insufficient data on long-term outcomes for assessment of effectiveness. As our medical team follows up all patients, more long-term outcomes of VCD technique for spinal deformity will be reported. This information has been addressed in the revised version (pages 12-13, lines 262-271).

2. the authors mentioned there were 26 patients and they are only reporting 18. They should explain what happened to the rest of the patients and why VCD would not work for them.

Answer: Of 26 patients, 2 were excluded because of poor cardiopulmonary function and inability to tolerate surgery; 3 only had mild back pain without a neurological deficit, and refused surgery; and 3 were advised to have VCR surgery because their severe kyphosis was found to be inappropriate for VCD, based on osteotomy simulation using Surgimap. This information has been addressed in the revised version (page 8, lines 158-162).

3. in order to make a comprehensive comparison between VCD and VCR and PSO, the authors need to show the statistics of disease parameters and rates of complications and recovery of VCR and PSO as well.

Answer: As suggested, we retrospectively reviewed 51 patients with Pott’s kyphosis who underwent three-column osteotomies (PSO, n=23; VCD, n=18, VCR, n=10) between May 2010 and May 2015 in our department by 2 spinal deformity surgeons. All the patients completed a minimum of 2 years of follow-up. The data comparing radiological and clinical outcomes in the PSO, VCD, and VCR groups are shown in Table 3. Paired t tests were used to determine significant changes between data that were collected preoperatively and postoperatively; the Wilcoxon signed rank test was used as a nonparametric alternative for which the required conditions were not satisfied, and the one-way ANOVA test was performed to compare mean values of three samples (Table 3).

4. the authors should describe the process of using Surgimap Spine in more detail with a figure to demonstration its ability to aid pre-op design.

Answer: Figure 3 has been provided as suggested by the reviewer. A: Measurement of preoperative sagittal parameters: Konstam’s angle, SVA, and TK; B Identification of the site of osteotomy and the location of wedge-shaped resection. Detailed information about how to
determine the parameters of wedge-shaped resection has been added in the Discussion section(page 5, lines 91-96). C: Simulation of the osteotomy and evaluation of Surgimap-predicted postoperative parameters to determine whether VCD is sufficient for correction. (Materials and methods section, page 7, lines 142-146).

5. They should also explain how to address the caveats from previous literatures such as estimation of bleeding amount and buckling of the spinal cord.

Answer: Thanks for the comment. The main purpose of surgical planning for a spine deformity is to analyze the coronal and sagittal alignment and evaluate the effects of predicted surgical technique in order to choose the best procedure for a given patient. In the current study, Surgimap was used to measure pre- and postoperative spinal parameters and to simulate an osteotomy procedure. The geometrical changes of spinopelvic parameters help surgeons select the optimal osteotomy. It’s very helpful and useful method regarding the aspect. The amount of bleeding and spinal cord buckling are influenced by a number of factors, including patient coagulation function, duration of the operation, and the surgeon’s experience and skill. Thus, it is difficult to predict outcomes with any existing method and further research is needed. This information has been addressed in the revised version (pages 15-16, lines 320-331).

6. More specifically, under the Surgimap Spine, what are the other factors surgeons should take into consideration and how to parametrize them.

Answer: In my opinion, surgeons should be aware of the following points when using Surgimap. First, all angle and length parameters must be measured precisely, because a small error has a large effect on the outcome. Second, before measuring any length, image calibration must be performed. The surgeon draws a line on the image and then defines the realistic length of the line. Third, it is important to make sure that preoperative planning is consistent with surgery, so X-ray or CT should be performed intraoperatively to verify that the location of osteotomy is as planned with Surgimap. This information has been added in the revised version (page 16, lines 338-346).