Author’s response to reviews

Title: Sagittal Spinopelvic Malalignment in Degenerative Scoliosis Patients: Isolated Correction of Symptomatic Levels and Clinical Decision-Making

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Author’s response to reviews:

Thank you for the insightful comments and the opportunity to submit a manuscript revision. The responses to the comments are below.

Reviewer reports: Reviewer #1: I enjoyed reading the manuscript. I have several concerns. 1. First of all, as the authors indicated, "(3) Our results can only be applied to a very specific cohort of DS patients - those who underwent a targeted decompression and fusion of only their neurologically symptomatic levels. This is a "selected" cohort comprised of patients with "moderate" scoliosis with a Cobb angle less than 40 degrees, coronal shift less than 2cm, and a SVA less than 10cm". In my opinion, generally, PI-LL mismatch is not a problem in this specific type of the DS patients, at least, in the short term.

Correct, PI-LL mismatch is not as great of a concern in this patient population. With that being said, the average pre-operative PI-LL mismatch in this group of patients was approximately 20 degrees, and was subsequently corrected to approximately 9 degrees after surgery.

2. Inclusion criteria Page 5, line 20: We excluded patients if they had undergone a previous fusion, concomitant osteotomy procedure, or had less than 12 months follow-up. Page 7, line 13: The mean follow-up was 29.2±19.1 months (range: 6-108 months).
We apologize for this mistake. The range should be listed as 12-108 months, this has been corrected in the manuscript.

3. The rate of the PI-LL mismatch on the plain lateral standing film over time was missing

Thank you for this comment. We have added the rate to the following sentence:

"We found that patients who were able to correct their PI-LL mismatch to 10° or less on their MRI had a significantly better chance of achieving that goal post-operatively, regardless of what their PI-LL mismatch was on standing lumbar radiographs (pre-op- 35.3%; immediate post-op- 62.5%; final-45.8%)."

4. PI-LL mismatch before surgery on extension film or MRI Page 12, line 15: In contrast, if patients were unable to obtain that mismatch pre-operatively, thereby demonstrating a less structural curve ?? more structural curve??

We apologize for this mistake. The statement should be a “more structural curve.” This has been corrected in the manuscript.

Page 12, line 15: patients achieved a PI-LL mismatch within 10° only 14.8 and 21.7% of the time post operatively, respectively. ?? On the Figure 3, 9.1% and 20.5%, respectively?

We apologize for this mistake. The figure is correct. The numbers should be 9.1% and 20.5% respectively, this has been corrected in the manuscript.

5. Page 13, line 8: This is perhaps because lumbar extension radiographs are looking at a dynamic position of the lumbar spine and that those patients who were able to achieve a PI LL mismatch within 10° on these films have a more flexible spine than those who could only achieve that mismatch on their MRI but not on their lumbar extension radiographs (n = 10). On the Figure 3, pre-op mismatch was 44 patients both on the Lumbar extension radiograph and MRI. I can't understand the meaning of n=10 in the line 11 and n=16 in the line 12 on the page 13.

We apologize for the confusion here. We have removed “n=10” and “n=16” from the manuscript. These values represented data from our previous draft before we performed additional measurements and re-analyzed the data.

6. Page 13, line 11: This additional flexibility could perhaps be responsible for the loss of LL over time in this group -- Is this the only speculation of the authors?
Great question. After discussion with the authors, that is our main speculation at this point. As stated in the manuscript now:

“This is perhaps because lumbar extension radiographs are looking at a dynamic position of the lumbar spine and that those patients who were able to achieve a PI-LL mismatch within 10° on these films have a more flexible spine than those who could only achieve that mismatch on their MRI but not on their lumbar extension radiographs. This additional flexibility could perhaps be responsible for the loss of LL over time in this group. Thus, we may be able to predict the radiographic success of sagittal plane correction with our technique by assessing pre-operative spinal flexibility.

" Reviewer #2: Respect for the sagittal plane has been broadly published and accessible for all surgeons. Yet, suboptimal outcomes and revision cases remain highly prevalent. Iatrogenic causes remain an important contributor to the prevalence of adult spinal deformity. One reason for the increased incidence of iatrogenic deformity relates to the lack of understanding of the basic concepts of spinopelvic alignment and the preservation of sagittal alignment when addressing focal or regional degenerative conditions. In addition to decompression and stabilization, maintenance of lumbar lordosis is crucial in avoiding the creation of flatback deformities. An attempt by the authors to address the issue of isolated correction and short fusion is commended. The manuscript has merits but some revisions are suggested that might help to improve the quality of the manuscript.

Abstract

Page 3 lines 16-18: Of patients who achieved PI-LL mismatch within 10° on their pre-operative extension lateral lumbar radiographs, 63% were able to achieve a PI-LL mismatch within 10° on their initial postoperative films. Comment: Sentence confusing. Suggest revising to: Of patients who achieved PI-LL mismatch within 17 10° on their pre-operative extension lateral lumbar radiographs, 63% were able to maintain a PI-LL mismatch within 10° on their initial postoperative films.

We apologize for the confusion, and agree that your recommended revision is clear. The sentence now reads:

“Of patients who achieved PI-LL mismatch within 10° on their pre-operative extension lateral lumbar radiographs, 63% were able to maintain a PI-LL mismatch within 10° on their initial postoperative films.”

Page 4, lines 14-18: Loss of LL is commonly observed in patients with symptomatic DS. A critical distinction for the surgeon to make with regards to which levels to fuse revolves around the etiology of the loss of LL and resulting positive sagittal imbalance commonly observed in these patients. The surgeon must decide whether this loss of LL is largely structural or whether it is more positional in nature given that stenosis is usually present in this setting. Comment: The etiology of Adult Spinal Deformity including degenerative scoliosis has not been completely
elucidated. If it is postulate that DS is caused by degeneration of the intervertebral discs and facet joints, and the process of degeneration follows the predicted loss of disc hydration and disc space height, followed by increased loads on the facets leading to facet degeneration, then degeneration of these elements may cause instability in the spinal column leading to rotation, lateral olisthesis, spondylolisthesis, eventually loss of lumbar lordosis and kyphosis. Axial, coronal, and sagittal deformities then follow the asymmetric degenerative processes. It could be argued that the loss of LL is a late stage phenomenon in the degenerative process, and as such patients who are younger and have flexible spines are still able to maintain a reasonable PI-LL difference and are able to maintain the PI-LL mismatch at least in the short term period after short fusion surgery. Authors should discuss their findings taking into consideration, the etiology of the disease, patient ages and symptomatology.

Thank you for this comment, you bring up an excellent point. We have included the following in the manuscript (at the end of the limitations paragraph):

"For the purposes of this study, we did not take into account the patients age, specific symptomatology, or etiology of disease. We recognize that the progression of degenerative scoliosis is multifactorial in which age and etiology play significant roles, the loss of lordosis and subsequent post-operative improvement could directly related to those factors. As such, we will focus our prospective research on evaluating these patients in the context of their age, specific symptoms, and etiology of presentation."

Methods Page 5, lines 13-15: Inclusion criteria entailed patients who failed conservative treatment for DS, presented with a loss of normal LL (positive sagittal imbalance) as observed on preoperative radiographs Comment: Positive sagittal imbalance does not automatically mean loss of lumbar lordosis. Loss of LL should be given in degrees or given as appropriate for age adjusted PI-LL mismatch values.

This is a very valid point. We have removed the "positive sagittal imbalance" as to not directly equate the loss of lumbar lordosis to the positive sagittal imbalance.


8) The new targets for the radiographic parameters provide more "patient-specific" alignment thresholds. Their data revealed that age should be considered when determining the ideal sagittal alignment for a given patient, with older patients requiring less rigorous alignment objectives. Authors should therefore discuss their findings in view of these updated recommendations.
Thank you for this point and reference, we agree that this is an important consideration. We have included the following in the discussion section: "Traditionally, a major goal of surgery has been to correct the LL to within 10° of the PI for improved health-related quality of life scores postoperatively. However, new research has indicated that the age of the patient should be taken into account when determining the correction to the “ideal” sagittal alignment, as older patients requiring less rigorous alignment objectives. These radiographic parameter targets based on age, may provide more "patient-specific" alignment thresholds. In this study, we assessed an overall goal of a PI-LL mismatch to within 10°, irregardless of the age of the patient. In the future, we plan to conduct a prospective study on this specific cohort, and will adjust target sagittal balance with the age of the patient in consideration."

Page 10, lines 12-17: Notably, this was accomplished without having to take into account the overall spinal deformity, avoiding longer fusions, interbody cages, and / or osteotomies (mean post-operative LL and PI-LL of 44° and 10°, respectively). These results indicate that the hypo-lordosis and positive sagittal balance commonly observed preoperatively in DS patients is not always entirely structural but rather positional and compensatory for the concomitant spinal stenosis. Comment: For non-fixed deformities with flexible curves, maintenance of LL, and age adjusted PI-LL mismatch, there is no need for long fusions, interbody cages or osteotomies for preserving sagittal alignment and balance postoperatively.

We agree with your comment. As that sentence may be an over statement, we have elected to remove the sentence: "Notably…and 10° respectively)"

Page 10, lines 19-21, and Page 1-2: Moreover, when compared to the LL on routine standing spinal radiographs (taken in the position of comfort), the LL on pre-operative standing lumbar extension radiographs and supine MRIs were found to be significantly greater with mean values of 15° and 9°, respectively. These findings further support the notion that the hypo-lordosis often seen in DS patients can be largely positional and not necessarily structural in nature. Comment: Generally, structural components of spinal deformities can change according to position. Structural deformities like scoliosis and kyphosis normally reduce in magnitude from standing radiographs to supine or bending radiographs both in adolescents and adults. Therefore increase of LL from standing radiographs to extension and MRI supine do not necessary mean that LL changes are just positional and not structural.

Correct, we agree with you statement. We are not claiming that the lumbar lordosis in the DS patients are not structural, and all positional, but rather that there may be a large positional factor (in addition to the structural factor) in the loss of lumbar lordosis. To that end, we have edited to sentence to read: “These findings further support the notion that the hypo-lordosis often seen in DS patients may have a positional component.”

Table 2: Measured radiographic parameters Pelvic Tilt Pre-Op 23.9 ± 9.5 [2.2 - 45.7] Immediately Post-op 27.0 ± 9.5 [10.2 - 46.6] 0.073 Comment: Pelvic Tilt increased post op in your study. It will be useful to discuss, this as one of the goals of surgical correction is to decrease PT in addition to reducing PI-LL mismatch.
Thank you for this comment. This is a good point. We have included this in the discussion: “Our cohort did have a small increase in PT postoperatively. That being said, it is hard to know how to interpret this given that the increase was not statistically significant. It is important to note, however, that pelvic retroversion is often found to be a compensatory mechanism in patients with a positive sagittal imbalance that allows them to maintain an upright posture. The goal of surgery should always be to decrease PT in sagittally imbalanced patients, particularly since it has been shown that patients with a larger postoperative PT, increased pelvic retroversion, were more likely to demonstrate residual pain, than patients with a smaller postoperative PT. (Lazennec JY, Ramare S, Arafati N, et al. Sagittal alignment in lumbosacral fusion: relations between radiological parameters and pain. Eur Spine J 2000;9:47–55.)”