Author’s response to reviews

Title: Is a Persistent Central Canal a Risk Factor for Neurological Injury in Patients Undergoing Surgical Correction of Scoliosis?

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Author’s response to reviews:

Reviewer #1: This retrospective study was conducted to examine the presence of a persistent central canal (PCC) within the spinal cord results in an increased risk of neurological injury during surgical deformity correction. The authors concluded that there is no evidence to suggest a PCC increases the risk.

This reviewer does have certain questions and criticisms which should be addressed by the authors prior to publications.

The authors defined a PCC utilizing MRI. Centrally located, intra-medullary cavity was defined as a PCC. This reviewer does think that the central canal is communicating with the 4th ventricle. Is there any difference between the central canal and a PSS?

Response: A central canal is defined in the opening of the discussion section (lines 196 – 199) as ‘The central canal is an ependymal lined structure in the spinal cord that extends inferiorly from the fourth ventricle to the conus medullaris. Anatomical studies suggest the central canal is only seen in fetal and new born spinal cords and undergoes age related stenosis such that it is obliterated in the vast majority of adults. It may persist however as shown in autopsy studies, and although reported to be seen in only 1.5% of MRI studies of the spinal cord it can normally be regarded as an incidental finding.’

In a PCC, a degree of age related stenosis has occurred such that the central canal no longer extends all the way from the fourth ventricle to the conus medullaris. However, a remnant remains within the spinal cord referred to as a PCC. The central canal can communicate with the 4th ventricle beyond infancy but this is uncommon and is usually associated with hydrocephalus.
which excludes it from being a PCC which is essentially idiopathic. The revised manuscript has been amended to clarify this.

The authors described that a PCC is an intra-medullary cavity of a maximum diameter of 4mm. Is the difference only a diameter of the canal or cavity? Why did the diameter define as 4mm? In addition, please make clear the difference between a syrinx associated with syringomyelia and a PCC. Were all PCCs in this series seen in the level of scoliosis?

Response: There is currently no widely accepted definition of a PCC in the literature and debate continues on the criteria for distinguishing between a PCC and syringomyelia. The 4mm diameter is based on the study by Petit-Lacour et al 2000 (Reference No. 10 in amended submission) which was the first study published describing the visibility of the central canal on MRI.

Syringomyelia tends to be used to refer to a CSF filled cavity within the spinal cord which is surrounded by a wall comprised of glial cells (which therefore implies it is related to a pathological process) and may present with abnormal neurological signs and symptoms. The term PCC is generally used to refer to an ependymal lined, CSF filled cavity within the spinal cord which is thought to represent an anatomical variant. They are usually asymptomatic and have no identifiable underlying cause. Whether the presence of a PCC poses a risk of an individual ultimately developing syringomyelia in the future at present remains uncertain and open to discussion. Much of the confusion arises from the fact that in practice, it is often not possible to distinguish between the two radiologically and therefore the umbrella term ‘syrinx’ is applied despite the fact this encompasses more than one entity. The manuscript has been amended to clarify this.

The PCC was found to be located either entirely or partially within the instrumented spinal levels in all patients within the PCC group. This has been added to the results section (lines 173-177) as well as an additional table (table 3) which demonstrates the anatomical level of the PCCs, the exact vertebral levels instrumented and % curve correction achieved.

Regarding the control group, the authors noted that the gender and age were matched in this study. How did the authors include these 44 patients? Did the authors use propensity score matching? This reviewer does think that the severity of scoliosis, correction levels and operation methods should be also matched in the present study.

Response: The 44 control group patients were matched on the basis of age and sex. These matched controls were selected at random using statistical software from a list of 1150 AIS
patients provided by the Neurophysiology department of the hospital who had also undergone surgical correction of AIS during the same study period as the 11 patients with a PCC between June 2004 – October 2011, none of whom had an underlying NAA evident on pre-operative MRI. Propensity score matching was not used. After being selected as matches the notes of each of these patients were then requested from medical records to be analysed.

The list of 1150 patients from which the matches were selected included details of operation date, age, sex but did not include severity of scoliosis and correction levels. Matching to include operation methods, severity of scoliosis and correction levels would have necessitated the notes of all 1150 potential matches being requested from medical records and analysed to extract this additional data which the authors did not feel was feasible.


Suitable for publication after revision.

Methods

Line 84-89: Please add the reference for your definition of PCC, especially for the 4mm max diameter and for the two vertebral levels extension (shorter cavities can be found more often).

Response: There is currently no universally accepted definition of a PCC in the literature and debate continues on the criteria for distinguishing between a PCC and syringomyelia. The 4mm diameter is based on the study by Petit-Lacour et al 2000 (Reference No. 10 in amended submission) which was the first study published describing the visibility of the central canal on MRI. The extension over at least two vertebral levels is based on a definition provided in the paper by Magge et al 2011 (Reference No. 11 in amended submission).

Why the motor evoked potentials were not used during scoliosis surgery?

Response: During the period covered by this study, The Neurophysiology department in our institution were not routinely performing MEPs for AIS cases. This is no longer the case and MEPs are currently being used for all scoliosis operations.

Results

Line 150: what kind of neurological deficit was present in this patient?
Response: Mildly diminished sensation in the S1 distribution of the right foot with no associated motor weakness. No definite cause for this was demonstrated on pre-operative MRI and nerve conduction studies. This has been clarified in the amended manuscript (lines 150-152)

Please provide one or more figures with a typical MRI image of PCC.

Response: Two figures (figures 4 and 5) have been provided with amended manuscript which illustrate typical appearance of PCC on MRI

Discussion

Please discuss the difference between the PCC and the hydromyelia.

Response: Hydromyelia is generally used to refer to an ependymal lined, CSF filled spinal cord cavity and most likely represents persistence into adulthood of a fetal configuration of the anatomy of the central canal of the spinal cord. The term can therefore be used interchangeably with PCC as they represent the same entity although it could be argued that calling it a persistent central canal is a more literal description This is included in the amended manuscript (lines 213-218).

Conclusions

The authors write "Our study indicates there is little evidence". In reality, their study "does not provide any evidence"

Line 273: replace "recommend" with "suggest", (the same in the Abstract)

Response: Manuscript amended as suggested

Legend for tables 1 and 2. Delete the words "The table summarising the". Explain abbreviations AIF, PIF, AR. Words deleted. Abbreviations included

Legend for figures 1 and 2. Delete the words "The chart summarising the". Explain abbreviations AIF, PIF, AR. Words deleted. Abbreviations included

Legend for figure 3. Another unprecise description. Should better be „Number of patients with normal (green), borderline (amber) or abnormal (red) SCM observed in the study (left) versus the control (right) group“
Reviewer #3: This a well designed study. The aim of this study is to determine whether there is any evidence to suggest that patients with a PCC are also at a higher risk of neurological injury during surgical scoliosis correction.

Only 11 patients with a PCC were identified who had undergone correction of adolescent idiopathic scoliosis (AIS). The incidence of abnormal intra-operative spinal cord monitoring (SCM) traces in this group were in turn compared against 44 randomly selected age and sex matched controls with no PCC who had also undergone surgical correction of AIS during the study period.

The comparison of the 2 groups showed no significant difference in the incidence of abnormal intra-operative SCM signal traces between the PCC group and the control.

The authors concluded "We therefore recommend that surgical correction of scoliosis in patients with a PCC can be carried safely with routine precautions.

Given the very small number of patients with PCC I would be very conscious to give a recommendation. In addition in order to reinforce the results I think it would worth adding some more info in regards to the PCC group. The location of the PCC and the type of AIS should be included. A patient with a PCC at the upper thoracic spine has less risk of neurological injury if the proximal thoracic curve is non-structural. In addition the magnitude of the curve and the percentage of curve correction is important to know.

Have any of the 11 patients with PCC required significant correction at the level of the PCC? I think this is the group of patients at risk.

The inclusion of the above would reinforce your conclusion and again I would recommend you add the data and make some comments of the discussion section.

Response: ‘Recommend’ altered to ‘suggest’ in conclusion (line 323 in amended manuscript). Details on the level of the PCC, the vertebral levels instrumented, magnitude of curve pre-operatively and percentage correction has been included in revised manuscript in table 3. The PCC was found to be located either entirely or partially within the instrumented spinal levels in all patients within the PCC group. This has been added to the results section (lines 175-176).

A satisfactory percentage curve correction was achieved in all eleven PCC patients. The absence of any abnormal SCM traces in any of the eleven patients in the PCC group therefore cannot be attributed to either the PCC being at an anatomically remote level to the level of instrumentation or be related to a minimal surgical correction. This is included in the amended manuscript (lines 260 – 265).