Author’s response to reviews

Title: Three dimensional reconstructions of Lenke 1A Curves

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Author’s response to reviews:

Dear Dr.Grivas,

Please find our responses to the comments from the reviewers below. We thank you for this opportunity to present our work, and hope you will find the paper acceptable for publication.

Yours sincerely

Dr Jean-Claude Bernard

Reviewer reports:

Reviewer #1:

I enjoyed reading the manuscript.

Lenke type 1 curve includes pure single thoracic curve or double thoracic curve with smaller upper T curve, which is less than 25 degrees in the bending film (nonstructural). These two kinds of Lenke type 1 curve may have different number of the plane or different direction of the rotation of the plane #3. So the results of this study are conceivable to me.
My questions are:

1) In order to distinguish Lenke type 1 from type 2, bending radiograph is necessary to determine whether the upper T curve is structural or nonstructural. Did the authors take bending radiographs?

- Response: no, we did not use bending radiographs to determine whether the upper curve was structural or not, because it is difficult in daily practice to multiply radiographs for these patients in the growth period, as they are already very often exposed. We use clinical examination for that, by measuring the upper bump in standing position and comparing it to the one measured in ventral decubitus: if the upper bump disappears in lying position, it means that the curve is not structural.

2) Line 170, "In practice, for orthopaedic conservative treatment, the first objective with the brace will be to guide this scoliosis from 4 planes to 3 planes". I can't understand this opinion. Why is it necessary to reduce the number of the plane?

- Response: when the torsion is very important in the dorsal area, the curve is divided in two planes, that is to say that there are 4 planes for the whole spine, whereas there should be only 3 in asymptomatic subjects. When we intend to guide the scoliosis with the orthopaedic treatment from 4 planes to 3 planes, we mean that we intend to reduce rotation of the dorsal area.

Reviewer #2:

The concept of Berthonnaud is personal and interesting. The wired model has the advantage of being fast acquisition. However, it is much less accurate than 3D EOS reconstruction which provides the specific rotation for each vertebral segment.

The 3 initial regional plans are defined from the 3 physiological sagittal curves and their inflection point. In case of scoliosis these sagittal planes will rotate like the rudder of a submarine whose axis could tilt thus changing the trajectory in a horizontal plane but also in depth. The regional plane obtained from this wired representation depends on two arbitrary criteria: the proximity of the points with respect to the unknown plane and the continuity of projection of these points in this plane. Now we know by EOS 3D that each vertebral segment has a specific rotation. The image of the rotation of the plane is therefore an approximation which may be useful, but does not correspond to the reality. A 3-D shape of the vertebral body line, and even a part of it cannot be adequately represented by a 2-D plane.
Response: thanks for this opinion. We totally agree that EOS is the most appropriate tool to provide an accurate reconstruction with the specific rotation of each vertebral segment. But thinking about brace conception, we need to consider groups of vertebrae, because of the technical aspects of brace pads. That’s why the image of the rotation of the plane is useful, even if this is an approximation. The top view provides the ideal orientation of the force that should be applied through the brace, on each plane.

"matching" could be better than "including"

Response: ok, this has been now changed in the text.

A conclusion should demonstrates to the reader that you accomplished what you set out to do. You only demonstrate that using an arbitrary regional plane representation of a 3D shape you get 2 types of Lenke 1A scoliosis. In may 2010 you published in Scoliosis the Interest of the three dimensional analysis in brace treatment of idiopathic scoliosis. Prospective study. You wrote: "No significative difference was found between the two groups for the correction of frontal, sagittal plane, or for the plane of maximum deformation." In a later work it appears that a difference is noted in the thoracic kyphosis. Is there an international reference?

Response: ok, thanks for this remark regarding our conclusion in the abstract, we have now changed it. Regarding our previous work about the 3D analysis in brace treatment of idiopathic scoliosis, we did not publish further about it, so we don’t have any international reference to communicate. We have to say that we changed our ways: we used to consider the plane of maximum deformation, as many people do, but we use now the regional planes to avoid approximations, especially as it makes more sense for clinical and orthotic practice.

Please add: IN OUR MODELING, the 3D spinal curve is compound...

Response: ok, it is now added.

The geometric structure of a 3D spinal curve CAN BE characterized by the size and orientation of regional planes...

Response: ok, done.
The heterogeneity of Lenke 1A has already been demonstrated by Atmaca: Spine J. 2014 Oct 1;14(10):2425-33. Axial plane analysis of Lenke 1A adolescent idiopathic scoliosis as an aid to identify curve characteristics. "Addition of axial plane analysis to conventional coronal and sagittal evaluations in patients with Lenke 1A curves may reveal inherent structural differences that are not apparent in single planar radiographic assessments and may necessitate a different surgical strategy."

Response: yes, you are right. We have now modified our introduction and we expose that the objective of this study was to show if the use of regional planes analysis could determine if all Lenke 1A curves would result in the same 3D representation. And we have also added a paragraph in the discussion to mention that our conclusions are in line with Atmaca’s ones.

3D thoracic angulation integrates a part of the 45° of physiological kyphosis at the frontal Cobb angulation. What is pathological remains the frontal Cobb angulation which physiologically should be at 0°.

Response: yes, this is of course an important point, and Cobb angles in regional planes should not be interpreted in the same manner than Cobb angles in frontal planes. But we tend to harmonize sagittal curves by correcting planes rotation, not by trying to reduce Cobb angle. It is well-known that one can have a Cobb angle close to zero and still present some rotation of the plane.

The arguments in favor of this clinical orientation are not obvious. FIG. 1 perfectly illustrates the ambiguity of the representation with a curvature of -54.4° at the lumbar level (plane 1) which results from the mix between the physiological lordosis of 50° and the frontal Cobb of 15°. A double curvature is usually more stable than a single curvature. In FIG 2 The cervical (plane 4) and cervico-thoracic (plane 3) rotation is identical and compensates the rotation of the thoracic plane 2. The plane 3 is in kyphosis, the plane 4 in lordosis, which explains the additional plane. The representation of the computer does not seem pathological.

Response: yes, what you underline is totally true, and consistent with our precedent remarks. Fig. 1 shows an example with very few rotation of the lumbar plane, and in that case, Cobb angle measured on the regional plane is very similar to the angle of physiologic lordosis. Concerning you remark about what seems pathological or not, we can argue for pathological aspects: if we have 4 planes and not 3, and if there is some rotation of the planes. Besides that, the conception of brace will be more complicated if the sense of rotation is different between the planes.
177-179 EOS 3D shows that rotation and inflexion do not evolve in parallel and are opposed even in so-called paradoxal curvatures.

- Response: yes, EOS already shows that so-called paradoxal curvatures could be curvatures by themselves; this can be clearly confirmed when we find some rotation between the two planes.

1204-207 Taking into account the prospective study started more than 7 years ago, it should be possible to say whether "orthospine" is useful or not for bracing scoliosis. On the other hand, this work seems very useful for the classification of scoliosis.

- Response: thanks for this positive comments. We have indeed more than an idea whether Orthospine is useful or not for bracing scoliosis. We just did not want to write it so clear, as we still haven’t published any results. But we have now added a little paragraph to our conclusion. This has completely changed our daily clinical practice, with a real concern about the orientation and the importance of forces that should be applied through brace’s pads. The top view allows a representation of scoliosis closer to reality and helps to define the ideal brace to correct it.

This regional planes analysis considers each curvature with its rotation, and this is the importance of rotation that helps us to decide and prioritize the to-be-treated curvatures. This is also very helpful to understand why some scoliosis remain stable after brace removal (because the planes rotation is well corrected) whereas others can still become worth, as the planes rotation is not corrected, even if the Cobb angle is corrected on frontal radiographs.