

## Reply to the Letter to the Editor Regarding the Article: Augmented Reality Device for Preoperative Marking of Spine Surgery Can Improve the Accuracy of Level Identification

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### Keywords:

marking, augmented reality, mixed reality, wrong site surgery, head-mounted display

Spine Surg Relat Res 2023; 7(1): 118-119

[dx.doi.org/10.22603/ssrr.2022-0171](https://doi.org/10.22603/ssrr.2022-0171)

Thank you for the important comments on our paper entitled “Augmented Reality Device for Preoperative Marking of Spine Surgery can Improve the Accuracy of Level Identification”<sup>1)</sup>.

First, regarding the data on level misidentification rate, the chi-square test yielded  $p = 0.07$ . No statistically significant difference was observed.

One limitation of this study is the small number of cases, and we speculate that this is the reason for the lack of significant differences. When evaluating a new technology, evidence with statistical support is often limited because of the small number of cases initially. However, if we believe that anything remains the same without evidence, it will be difficult to improve the technology. This is because when a new technology is first applied in a field, we can speculate on its effectiveness, but we have no evidence. Wrong site surgery is a devastating complication of surgery that should not occur; however, it can occur even with the use of markings and X-rays. To reduce this complication as much as possible, it is currently effective to proceed with the surgery one by one with caution, and we believe that augmented reality (AR) technology is useful as one of the bundled approaches to prevent misidentification of spinal levels.

Next, we consider the verification of interrater reliability to be an important theme. Because the adjustment of a 3D polygon is made manually by human operators, the accuracy will possibly vary, depending on the experience of the evaluators. In addition, because 3D data is constructed from preoperative images, errors may appear due to differences between the alignment of the spine in the operating room

and that in the 3D data. The need for this correction in the operating room may also lead to differences among evaluators. Currently, we cannot provide statistical data on interrater reliability due to the small number of cases. However, we believe that interrater reliability should be verified in the future.

As mentioned in the paper, the time required to generate AR data is a disadvantage in terms of labor costs. However, there is no increase in radiation exposure by adopting this technique. As has been pointed out, fatigue caused by the head-mounted display (HMD) is a major problem, and it is not realistic to perform surgery while wearing the HMD all the time under the current circumstances. However, the world of AR using HMDs is constantly evolving, so technological innovations will continue to occur in the future. I suspect that systems will emerge that are light enough to reduce fatigue and display detailed polygons that are less stressful to the eyes.

At present, it is difficult to justify using this system only for marking, considering the cost and effort involved.

We believe that the true value of this system will be realized when it can be used for surgical planning as well. Particularly in cases where surgical techniques and diagnosis are difficult, it is extremely valuable to display detailed 3D images of the positional relationship between nerves and bones from preoperative images<sup>2,3)</sup>. Anyone who has looked at a spine model and considered surgical planning preoperatively will easily realize that if the model is a model of the patient themselves, the surgical planning will be more concrete.

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Received: October 14, 2022, Accepted: October 20, 2022, Advance Publication: December 12, 2022

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I agree that it is difficult to confirm spinal levels from the thoracic spine because there are no obvious bony landmarks compared with the cervical or lumbar spine, and the presence of the ribs and scapulas make it difficult to confirm spinal levels using X-ray. I believe that the more difficult it is to confirm the spinal levels of a patient with thoracic spine disease, the more effective it is to improve the accuracy of level confirmation using various methods, including AR.

**Conflicts of Interest:** The authors declare that there are no relevant conflicts of interest.

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