Peer Review File

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Comment 1: Page 3, line 76 to 87 should be written in “discussion” section. It is curious as a scientific paper that this paper does not contain “discussion” section.

Comment 2: You should make a “discussion” section and the limitation of your study should be mentioned in the section.

Reply to comment 1 and 2: Thank you very much for this suggestion, we agree a strong discussion section will add to the paper. The vast majority of lines 76-87 on page 3 were moved to the newly created discussion section as you recommended. The discussion section is seen underlined/bolded below, and includes our previously stated limitations within this section.

Changes in the text to comment 1 and 2: Our new discussion section is underlined and bolded below. It can be seen on pages 7-9 and lines 179-224.

The sacroiliac joint is a common source of significant pain and discomfort in the lower back or legs[1,2]. While a good history, physical examination, and radiographs are important in the workup, SIJ injection is the gold standard for diagnosis. Some etiologies of SIJD include fracture, soft tissue injury, sacroiliitis due to osteoarthritis or spondyloarthropathies, infection, scoliosis, and malignancy. Conservative treatment regimens for SIJD include physical therapy, manipulation of the joint, and anti-inflammatory medications. More invasive options include steroid injections and radiofrequency denervation. If conservative measures fail, surgical intervention is warranted. We generally aim for an 80% symptom improvement rate after steroid injection prior to surgical consideration.

MIS SIJ fusion is becoming more popular with the increased availability of intraoperative image-guided navigation and robotic systems. It is the authors preference to perform all of our SIJ fusion procedures, both routine or complex, using intraoperative robotic navigation. We would like to emphasize that SIJ fusions do not have to be done with robotic navigation. However, in our experience, when performing SIJ fusion using our described technique, we have found that utilizing this technology has improved our operative time, blood loss, accuracy, and ultimately patient outcomes.

Lastly, cost considerations should be taken into account when discussing robotic navigation technologies. The initial cost for robotic systems can vary widely, with prices ranging from $550,000-$2 million, with annual maintenance fees around 10% of this initial cost[14,15]. Despite these high initial costs, the literature shows that robotic systems are typically cost-effective in the long term due to the fact that operative times, revision surgeries, length of stay in hospital, and infections are typically reduced by utilization of this technology[14,15]. In a study comparing results of robotic vs non-robotic thoracolumbar fusions in 557 patients, Menger et. al demonstrated a 1-year cost-savings of $608,546 by using robotic navigation, attributed to the above reasons[15].

Limitations

Although using intraoperative navigation and robotic instrumentation for placement of sacroiliac screws is not a necessity, it has the potential to be a valuable tool for the spine surgeon and patients. Further research is needed to elucidate the outcomes of robotic vs non-robotic instrumented SI screws, but in the authors' experience, it has been a useful and effective tool, reducing our operative time, blood loss, fluoroscopic use, and screw accuracy. Additionally, utilization of the robot is likely to be cost-effective in the long-term.

We would again like to emphasize that these technologies are not meant to replace knowledge of operative anatomy or steps. The surgeon should not become complacent or overly-confident when using navigation or robotics. Anatomical landmarks and knowledge should be continuously used throughout to verify accuracy and provide safeguard against possible malfunction or inaccuracy of these systems.

Conclusion

Robotics and navigation in spine surgery are exciting and growing technologies that have the potential to offer the surgeon many new perioperative advantages. The described technique for robotic navigated SIJ fusion provided in this paper is meant to serve as a guide to help the efficiency and safety of others using this technology. We have found our method to be reproducible, safe, and beneficial to our patients.

Comment 3: Do you let the patient choose whether to have robotic surgery or not?

Reply to comment 3: Thank you for this question. This raises an important point that we agree should be addressed in the paper. We now perform all of our SIJ fusions using robotic navigation. We use this for both routine or complex cases. The reason for this is because similar to prior studies for other robotic surgeries, we have seen better outcomes in terms of operative time, blood loss, infection, accuracy, etc. We believe that utilizing this gives our patients the best potential outcomes. We have now included this in the discussion section.

In text changes to comment 3: Discussion section page 8, lines 189-195. Changes bolded and underlined below

MIS SIJ fusion is becoming more popular with the increased availability of intraoperative image-guided navigation and robotic systems. It is the authors preference to perform all of our SIJ fusion procedures, both routine or complex, using intraoperative robotic navigation. We would like to emphasize that SIJ fusions do not have to be done with robotic navigation. However, in our experience, when performing SIJ fusion using our described technique, we have found that utilizing this technology has improved our operative time, blood loss, accuracy, and ultimately patient outcomes.

Comment 4: How much more expensive is robotic surgery than regular surgery?

Reply to comment 4: Thank you for this question. This raises an important point that we believe should be addressed for those considering using this technology. We have addressed this question by providing monetary figures for initial costs of purchasing robots, maintenance fees,

as well as long term cost-savings data based on existing literature. This can now be seen in the discussion section.

In text changes to comment 4: Discussion section, page 8, lines 196-204. Bolded and underlined below

Lastly, cost considerations should be taken into account when discussing robotic navigation technologies. The initial cost for robotic systems can vary widely, with prices ranging from $550,000-$2 million, with annual maintenance fees around 10% of this initial cost[14,15]. Despite these high initial costs, the literature shows that robotic systems are typically cost-effective in the long term due to the fact that operative times, revision surgeries, length of stay in hospital, and infections are typically reduced by utilization of this technology[14,15]. In a study comparing results of robotic vs non-robotic thoracolumbar fusions in 557 patients, Menger et. al demonstrated a 1-year cost-savings of $608,546 by using robotic navigation, attributed to the above reasons[15].

Comment 5: Regarding case examples, cases should be presented that show the advantages of robotic surgery. It seems that your two cases would show good outcome without the robotic surgery

Response to comment 5: Thank you for raising this important point. In regards to our case examples, the goal of our paper is to describe the technique for performing robotic navigated SI fusion for those interested in performing this type of surgery. We do not compare robotic vs non-robotic cases or outcomes, although we do believe that this is an important future direction/study, and we have made this clearer in our limitations sections. Additionally, we are of the belief that SIJ fusions do not have to be done with robotic navigation, however we do believe it offers us many advantages, which is why we choose to utilize it for even routine cases. We make this clear in our discussion section as seen below. Our case examples are merely meant to show readers how we utilized the technology, not to suggest that those particular cases, or any, have to be done with this technology.

In text changes to comment 5: Discussion section, page 8, lines 190-195. Limitations section, page 8-9, lines 207-212

It is the authors preference to perform all of our SIJ fusion procedures, both routine or complex, using intraoperative robotic navigation. We would like to emphasize that SIJ fusions do not have to be done with robotic navigation. However, in our experience, when performing SIJ fusion using our described technique, we have found that utilizing this technology has improved our operative time, blood loss, accuracy, and ultimately patient outcomes

Although using intraoperative navigation and robotic instrumentation for placement of sacroiliac screws is not a necessity, it has the potential to be a valuable tool for the spine surgeon and patients. Further research is needed to elucidate the outcomes of robotic vs non-robotic instrumented SI screws, but in the authors' experience, it has been a useful and effective tool,

reducing our operative time, blood loss, fluoroscopic use, and screw accuracy. Additionally, utilization of the robot is likely to be cost-effective in the long-term

Comment 6: Regarding figure 3, the bottom half has no meanings. In this Figure, you are going to place an implant on the left side using navigation system. An implant has already inserted in the sacroiliac joint on the other side, which is confusing for readers. It is preferable to change a picture without implant.

Response to comment 6: Thank you for these comments. We agree, the prior picture could be confusing given the patient previous contralateral surgery. A new picture was provided for figure 3 in a patient without previous surgery and can now be seen in the figures section.

In text changes to comment 6: Figure legend. Figure 3. Bolded and underlined changes below

Figure 3. Demonstration of intraoperative templating on the robotic navigation station. Screw trajectory and size can be seen and adjusted in sagittal, coronal and bird's eye views on the touchscreen interface

Comment 7: Figures 4B and 4C are also confusing because of a implant in the contralateral side

Response to comment 7: Thank you for this comment. We agree that the patient having contralateral surgery in that figure could be confusing. We combined figure 4b and 4c into one picture as it shows everything we are trying to demonstrate and is in a patient without prior contralateral surgery. This can now be seen as figure 4B in the figure section. Additionally, the figure legend for figure 4 was updated to reflect this and can be seen below.

In text changes to comment 7: Figure legend update underlined below

Figure 4. Intraoperative photographs demonstrating utilization of robotic navigation. (A) The robotic arm has positioned itself at incision location based off of templating. As seen, this lines up precisely with preoperative marking of anticipated incision location based off of fluoroscopy. (B) Demonstration of the robotic navigation arm and instrumentation being used intraoperatively. The surgeon is seen using the robotic specific instrumentation to place the templated screw path with the assistance of the robotic arm. The navigation screen is well-positioned so the surgeon can see this at all times to verify correct drill and screw paths. The surgical level and side, as well as screw size are shown on the screen. The screw position can be seen on multiple views as it is placed into the patient. The bottom right-hand screen analyzes the deflection of the screw to indicate if too much deviation or torque is being applied.