Peer Review File

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Comment 1: Line 246: 'placed'

Reply 1: thank you for catching this

Changes in the text: fixed 'place' to 'placed'

Comment 2: Lines 235-253:

This may be the most interesting part of the discussion and I congratulate the authors on their thoughts on potential causes of the embolisms.

To me as someone who has placed over 500 iFUSE-Implants using the traditional route (laterally through the ilium into the sacrum) no complication similar to the ones described by the authors have occurred in all these years. This is in line with the fact that the two large RCTs published on iFUSE outcomes and safety, as well, observed no fat embolisms.

Therefore, please broaden your discussion and

a) Please refer to the only two large RCTs on iFUSE outcomes and safety (Dengler et al. J Bone Joint Surg Am. 2019 Mar 6;101(5):400-411 and Polly et al. Two-Year Outcomes from a Randomized Controlled Trial of Minimally Invasive Sacroiliac Joint Fusion vs. Non-Surgical Management for Sacroiliac Joint Dysfunction. Int J Spine Surg. 2016 Aug 23;10:28.) and state that those did not observe fat embolisms.

b) Please discuss in two or three sentences whether this may be different in your cases given that a different route of entry into the joint was chosen. For example, in your trajectory, the sacrum is opened completely including both cortices, potentially allowing for more "outflow" of fat from the bone marrow. In contrast, the traditional trajectory from the ilium into sacrum does not open the second cortex of the sacrum, given that the implant is placed without perforating the distal sacral cortex. Also, using your direction, bone marrow from the loose sacrum is pushed out, while via the traditional lateral approach, it is pushed into the sacrum. After all, the sacrum is much more porous and much richer in bone marrow than the ilium. Either way, would be interesting to read your thoughts on this in a few sentences.See below – comment 2 in regards to possible additional etiology of fat emboli in the two reported cases.

Reply 2: The reviewer brings up a very interesting point. We think there could be a few different aspects to this. On the one hand, the sacrum is less dense and theoretically houses more marrow/fat. Since our implants traversed the entire sacrum, it is possible we are displacing more fat. However this does not necessarily mean that intramedullary pressures are high enough to cause an emboli. On the other hand, since the ilium is more dense which could lead to higher pressure build-up during placement of an implant through the ilium and a higher risk of emboli during implant placement in the ilium. We feel that implant size is likely the most important factor, as a larger diameter implant will increase the volume of the implant and thus marrow/fat displacement to the power of 2. The two RCT's mentioned have been included. We also suggest that an additional irrigation step may help decrease risk of emboli since this has been shown in total joint arthroplasty.

Changes in the text:

Line 182-184: Two separate randomized-controlled clinical trials did not report a single incidence of fat emboli in their combined cohort of over 150 patients[21,22]

Line 224-245: The implant, either the 3D-printed triangular implant or the screw, may act similar to intra-medullary devices in terms of marrow disturbance. In the case of the triangular implant, it is placed by impacting the implant along a guide wire into a broached corridor in the bone. As is seen with intramedullary nails, implantation of the device may displace the bone marrow and fat out of the path of the device and into circulation[21]. Most importantly, the SIJ fusion implants are typically of a larger diameter than other pelvic fixation options such as iliac bolts. Any increase in the diameter of an implant placed through the sacrum will increase the volume of marrow displacement to the power of two (cylinder volume $= \pi r^2 h$). Thus, the larger SIJ fusion devices may inherently carry a higher risk of emboli. Additionally, in our technique the device is placed through the sacral ala into the posterior ilium, two regions of bone that have a relatively high ratio of bone marrow. Placing the implant in this area may thus run the risk of displacing fat and marrow globules into the venous circulation. When performed for primary SIJ fusion, the implant is placed from the ilium into the sacrum. In our cases, the implant was placed from sacrum into the ilium as part of our spino-pelvic fixation. While this may theoretically lead to an increased volume of the sacral marrow being disturbed in comparison to a primary SIJ fusion technique, there is currently no literature quantifying sacral volume replacement differences between the two techniques. This could be an interesting area of future research. Another consideration is given the higher density of cortical bone within the ilium, implant placement through the ilium could possibly lead to higher intramedullary pressures than placement through the sacrum, which we believe could increase risk of emboli at this location. If so, then implant placement via either direction previously discussed would carry a risk of emboli.

Line 257-258: Lastly, as is seen in total joint arthroplasty, an additional irrigation step of the implant corridor may help decrease risk of embolism[15].