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### Appendix

These are typical examples of MTS load and displacement recordings from which measures of neutral zone and structural stiffness were identified. These graphs represent the overall motion associated with the loading applied by the MTS ram. The slopes of the recordings represent a composite structural stiffness that includes multiple joints: L4-5, L5-S1, and the SI joints.

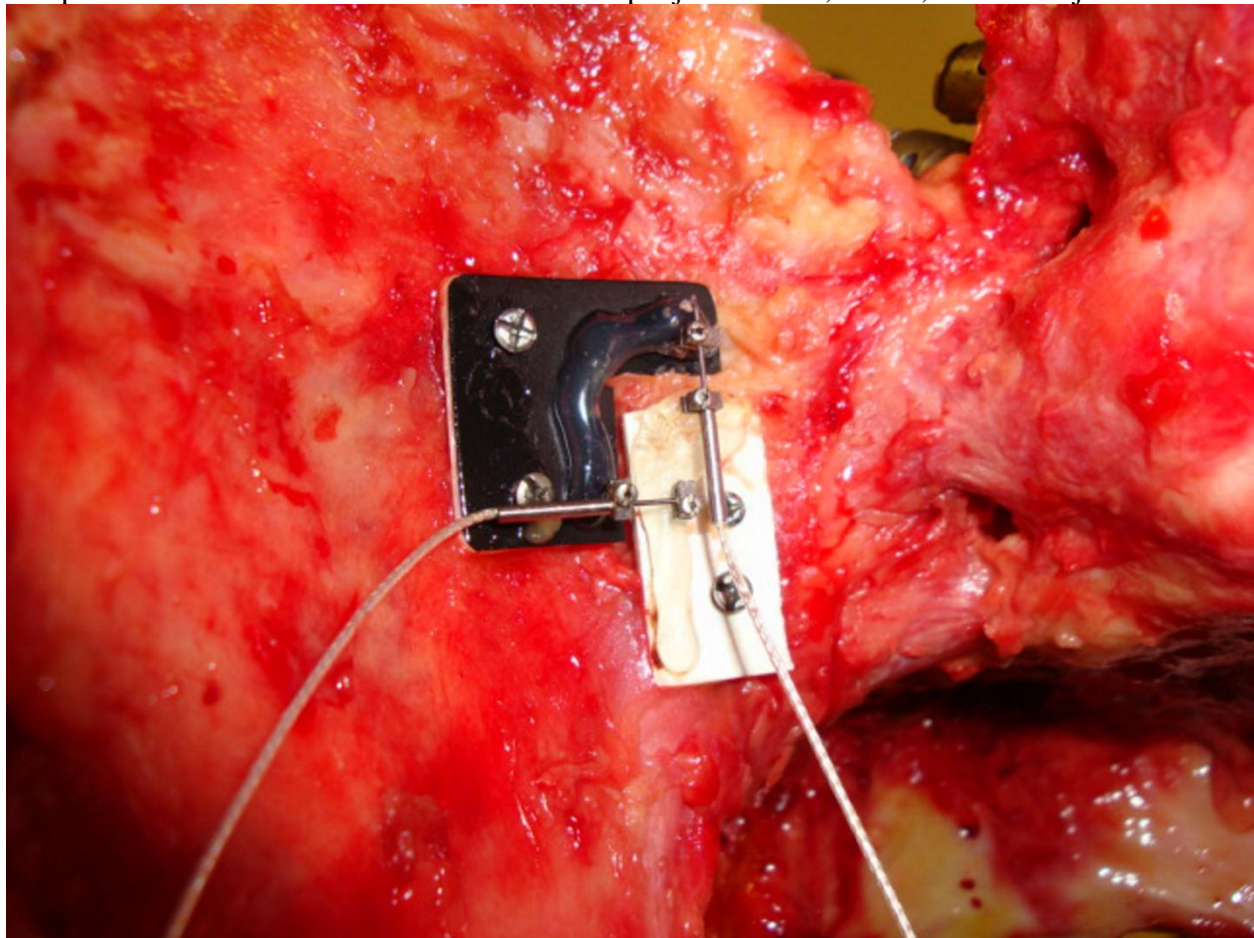


Fig. A1. The DVRTs were mounted on special brackets attached to each side of the SI joint's anterior surface, so that one was aligned along the direction of the apparent plane of motion of the joint (vertical) and the other perpendicular to that plane (horizontal). The horizontal measures were not large enough to report, but the vertical motions were measurable. Thus, we assumed that any horizontal movement did not cause a significant artifact of misorientation for the vertical measures.

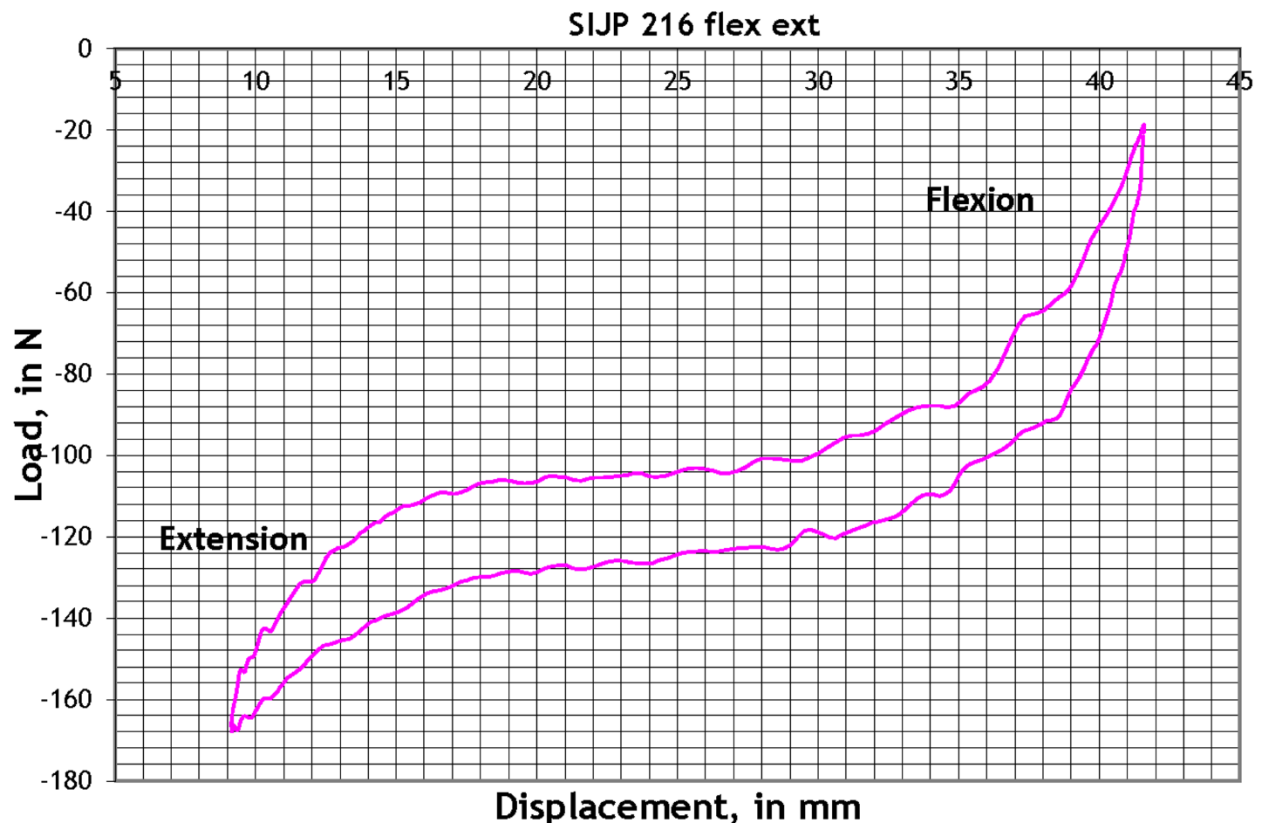


Fig. A2. Flexion-extension load cycle where the ram compression load created the extension and flexion moments at L4. The associated moments applied to the SI joint were not possible to measure.

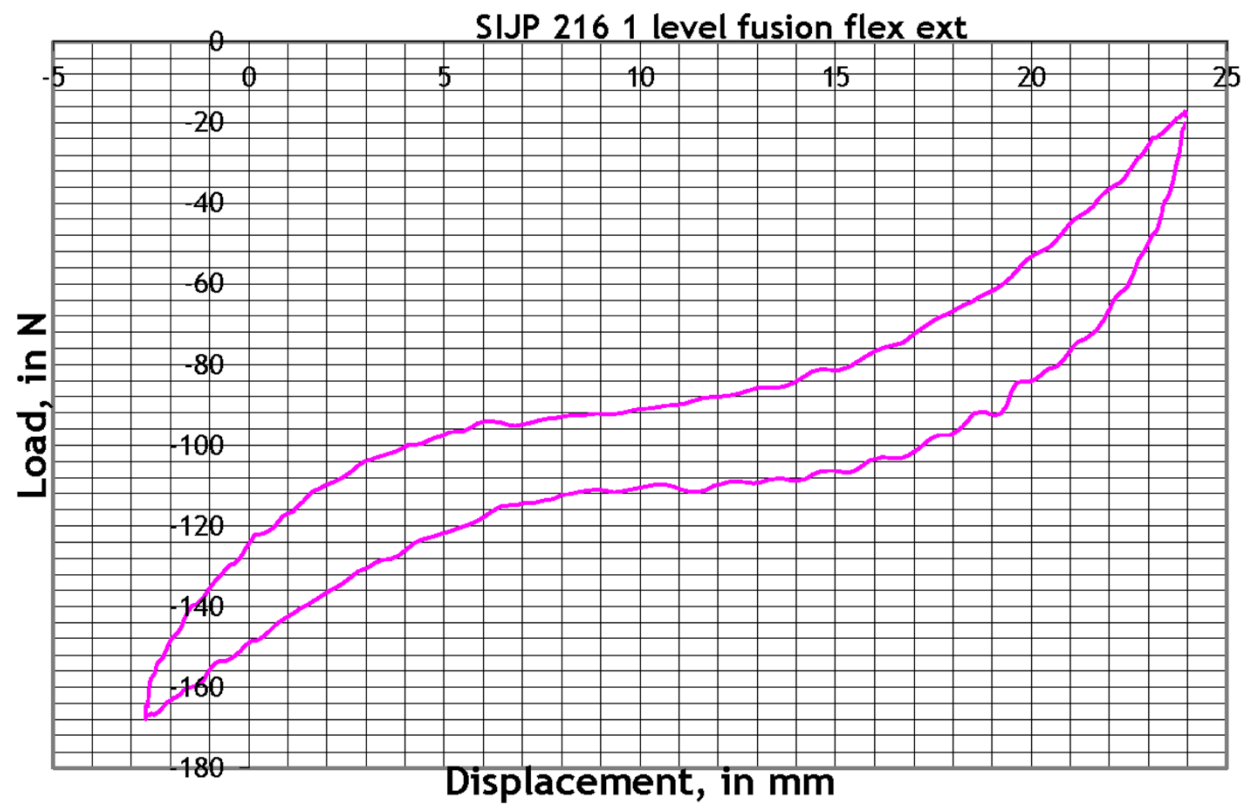


Fig. A3. The flexion-extension load cycle after fusion at the L4-5 level. Note the smaller neutral zone as the overall motion of the combined joints is compromised.

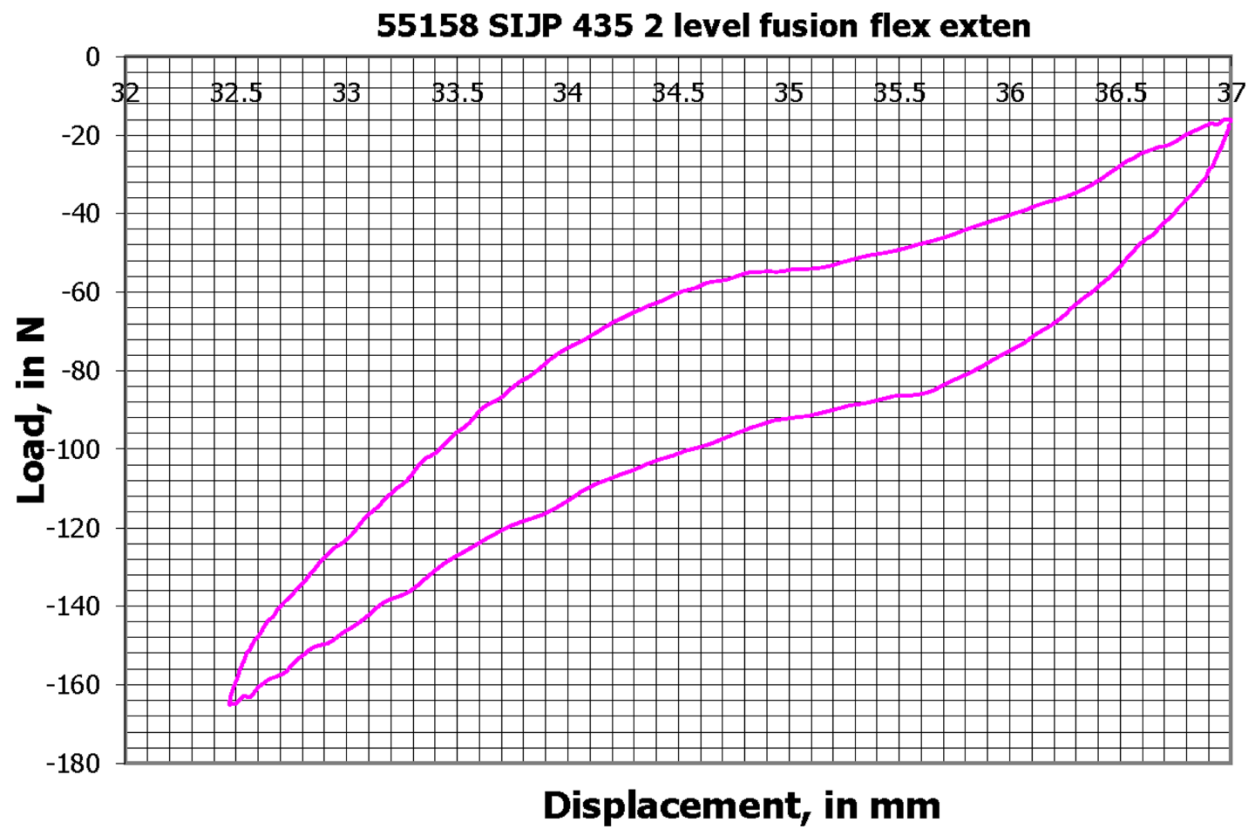


Fig. A4. The flexion-extension load cycle after fusion of L4-5 and L5-S1 shows almost no neutral zone.

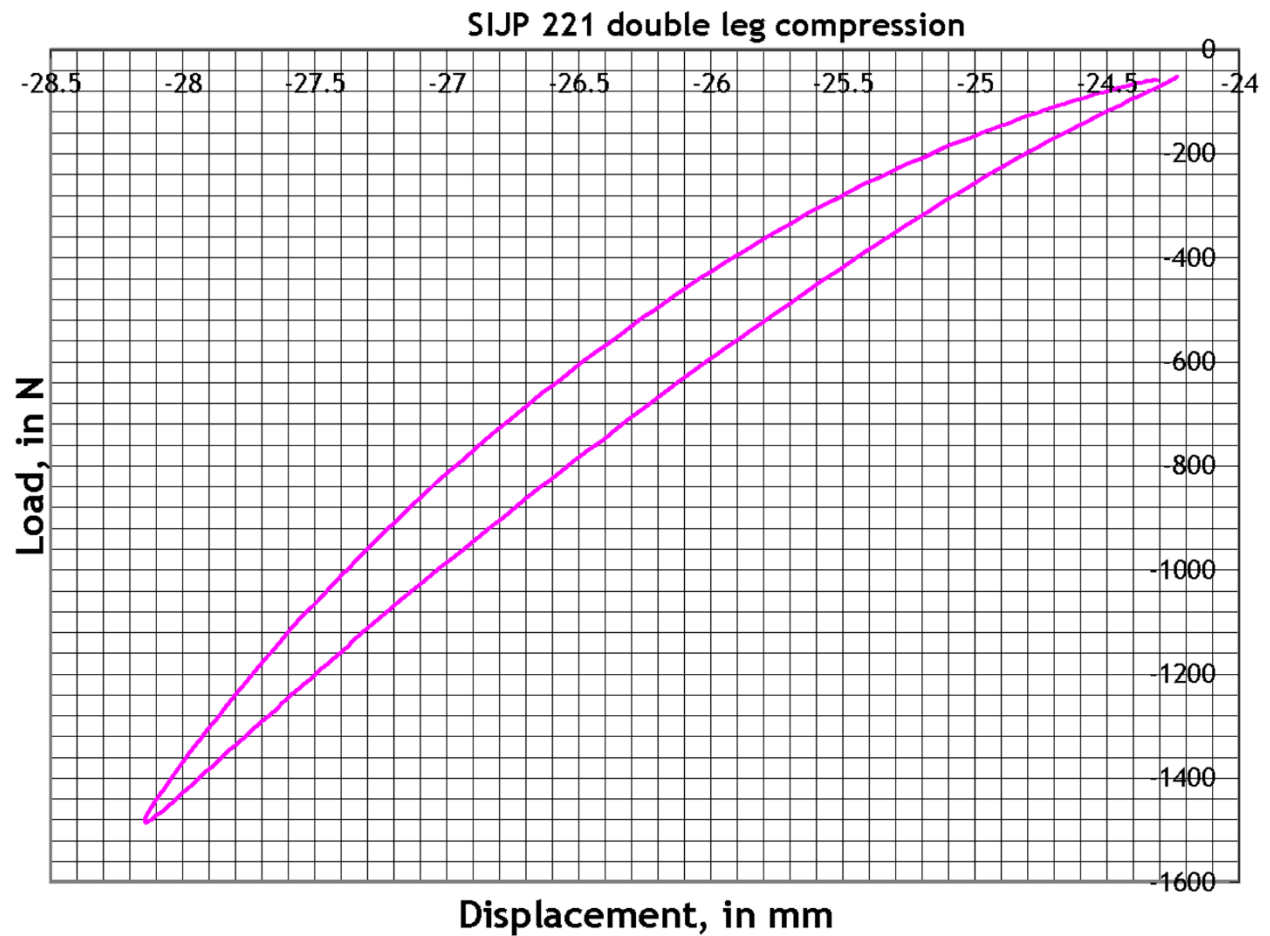


Fig. A5. The simulation of double-leg support loading has a phase of changing slope associated with joint movements, and neutral zone. The spinal joints did not visibly flex or extend.

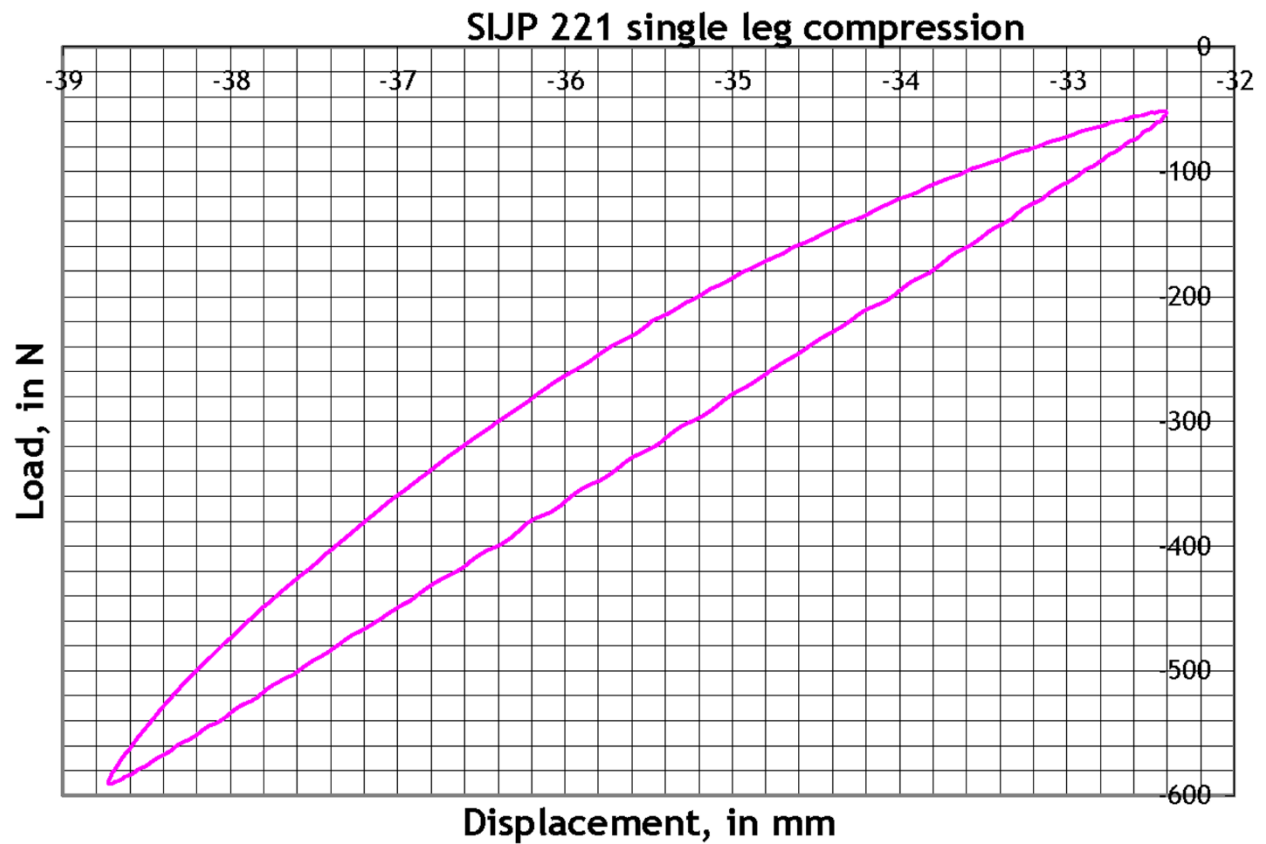


Fig. A6. The simulation of single-leg support loading also showed no visual evidence of a neutral zone or sagittal plane movement of the spinal joint.

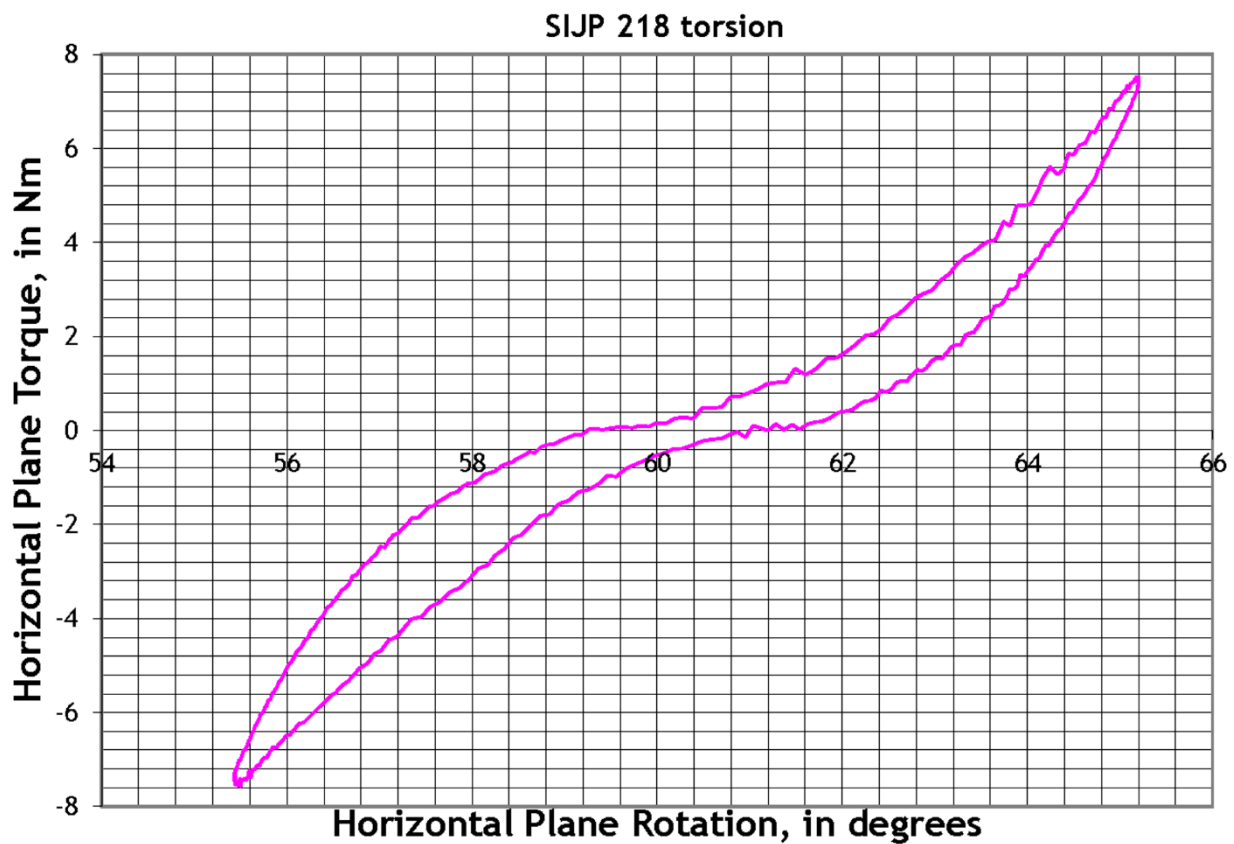


Fig. A7. Horizontal plane rotations show a neutral zone, which was a combination of rotations in the lumbar spine and pelvis.

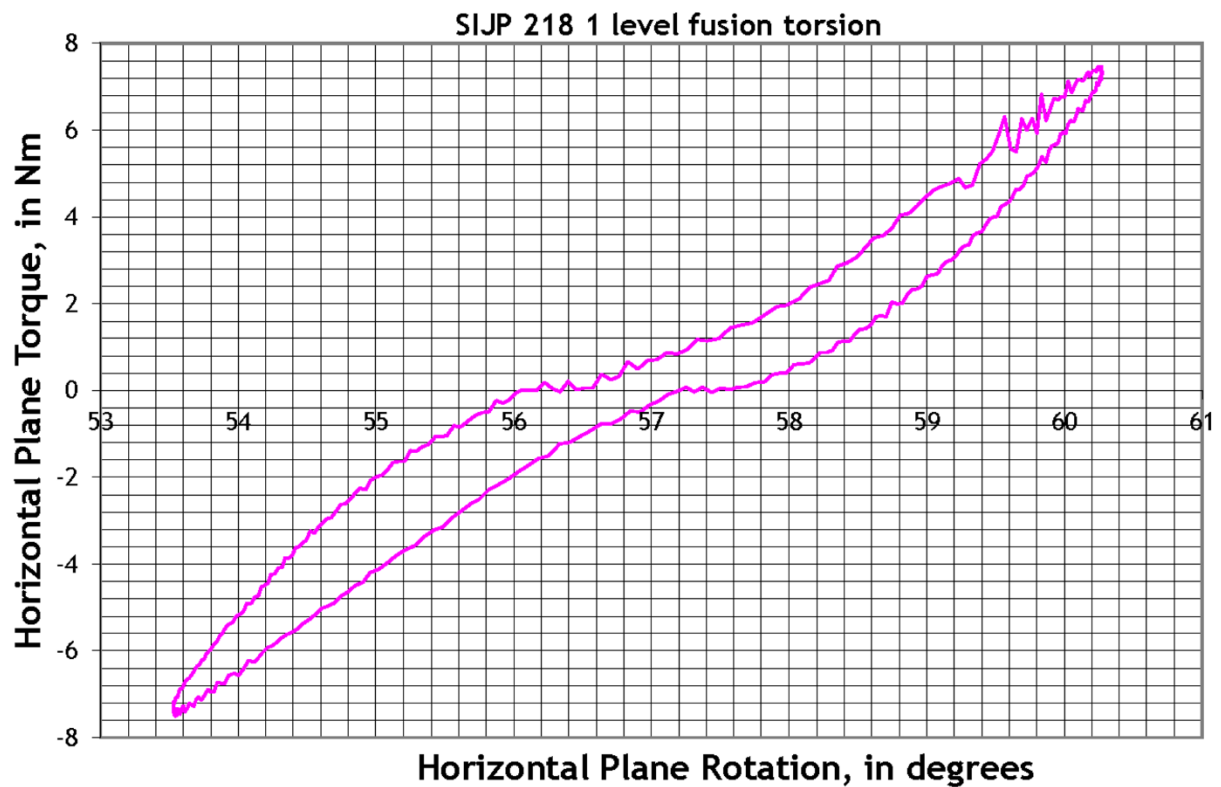


Fig. A8. Horizontal plane rotations after fusion of L4-5 show a shrinking neutral zone, implying that the neutral zone for all the combined joints probably is coming primarily from the spinal joints.



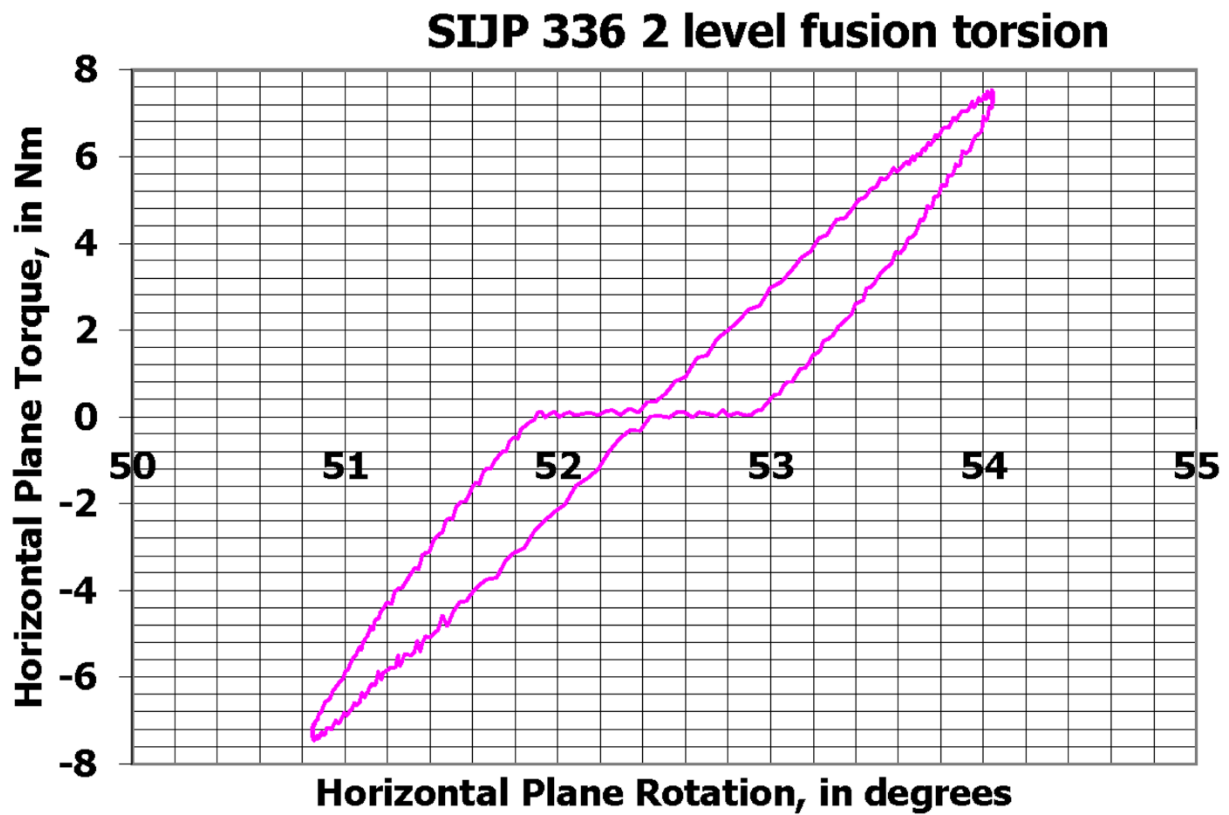


Fig. A9. Horizontal plane rotations after fusion of L4-5 and L5-S1 show a very small neutral zone, which may include some slack in the universal joint as it progresses from right to left rotation.