INTRODUCTION:
Spinal fusion and more recently total lumbar disc replacement (TDR) are common non-conservative treatments used for patients with degenerated disc and low back pain (LBP). Several finite element and in vitro studies have evaluated the biomechanics of the lumbar spine alone following single and multilevel fusion and/or disc replacement; however the literature on changes on biomechanics of sacroiliac joint (SIJ) following these surgical interventions is sparse. Some studies have shown that prevalence of sacroiliac joint involvement in post-fusion LBP ranges from 29 to 40% [1-2]; however, the exact frequency of sacroiliac dysfunction in a population suffering from LBP after lumbar fusion is unknown. Moreover contribution of single and multilevel total disc replacement on post operative back pain is not understood. Experimental techniques for measuring and comparing biomechanics of sacroiliac joint following various surgical interventions would be very technically demanding due to extremely small motions at the SIJ joint. Furthermore, it is impractical to quantify stresses across the joint. Thus, we used the finite element analysis do assess the changes in kinematics and average stress distribution across sacroiliac joint following bi-level lumbar disc replacement, bi-level fusion and fusion disc replacement (Hybrid).

RESULTS:
The percentage changes in average contact stress across sacroiliac joint is presented in Fig.2 for implanted models with respect to intact model. In flexion, the SIJ stress increased by 27%, 55% and 60% in bi-level disc, disc+fusion (Hybrid) and bi-level fusion versus intact respectively. In extension the implanted models had more increase in SIJ stress compared to intact with the percentage of increase of 167%, 270% and 280% respectively. In lateral bending the stresses didn’t change much and in axial rotation the SIJ stress decreased in all implanted models by approximately 25% compared to intact. The motion of SIJ joint increased in all implanted models in flexion and extension; however bi-level fusion and bi-level disc replacement models had maximum and minimum increase of motion compared to intact respectively. In lateral bending the motion decreased slightly in bi-level disc and remained similar to intact in the other implanted cases. In axial rotation all implanted models had significant reduction of motion at SI joint versus intact.

MATERIALS AND METHODS:
An experimentally validated, 3D ligamentous finite element (FE) model of the L3-S1 segment [3] was combined with a 3D ligamentous FE model of the pelvis [4] for the spine-pelvis segment model (Fig. 1A). The intact model was first modified to simulate bi-level fusion across L4-S1 by means of titanium rod and pedicle screw fixation system (Fig. 1B). The second model was created after complete removal of nucleus pulposus at L3-L4 for placement of Charite disc (DePuy Spine, Raynham, MA) plus fusion at L5-S1 (Fig. 1C). The third implanted model included bi-level disc replacement across L4-S1 segment (Fig. 1D). The intact and implanted models were subjected to a 400 N follower preload plus a 10 Nm moment to simulate flexion (Flex), extension (Ext), lateral bending (LB) and axial rotation (AR). Pelvis was fixed in all degrees of freedom. A frictionless contact pattern was defined between all articulating surfaces of the model.

Fig. 1: FE models of spine-pelvis: A) Intact B) Bi-level (L4-S1) fusion C) L4-L5 Charite+L5-S1 fusion D) Bi-level (L4-S1) Charite.

CONCLUSION:
The Charite artificial disc replacement at the level of L4-L5 has a minimal increase in motion and stresses across SIJ articular surfaces in all modes except extension. In extension, the TDR led to a substantial increase in motion and stresses (although smaller than fusion) and is in line with previous experimental studies which revealed increased overload of the posterior spinal structures after DTR procedure. Lumbar fusion procedures have a considerable impact on SIJ overload after surgery in all loading modes, therefore clinicians should be aware of the higher risk of Sacroiliac Joint Syndrome in this patient group, as compared to TDR group.

REFERENCES: