



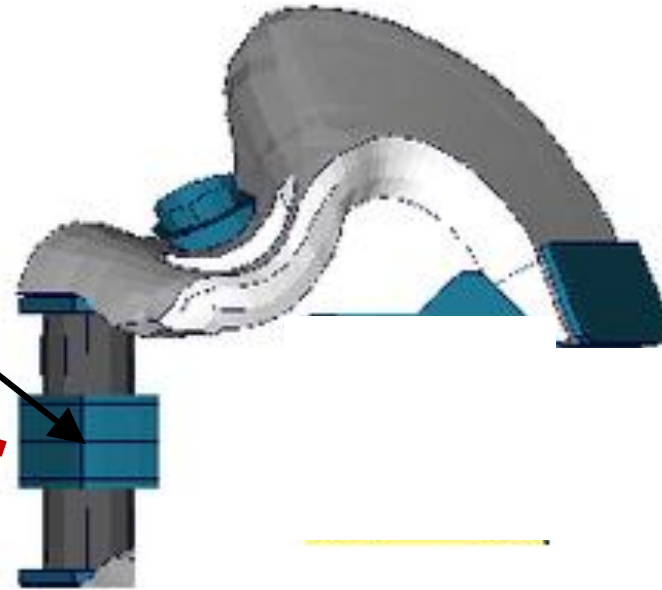
WorldSID Pelvic Injury Criterion. September 2012 update.



Pelvic Fracture Prediction with WorldSID



Pubic symphysis
load cell (1-axis)



Inferior view of the WorldSID left hemi-pelvis

WorldSID Pelvic Injury Criteria

(Petitjean et al. 2009)

		AIS 2+	AIS 3+
Pelvis	Peak pubic force Y Pelvis acceleration (3 ms)	<u>Fracture:</u> Acetabulum Ilium Ischium Pubic ramus	<u>Fracture:</u> Acetabulum (w/dislocation) Femoral neck Femoral head Sacrum <u>Disjunction:</u> Sacroiliac

Injury Risk Functions – Petitjean et al. (2009)

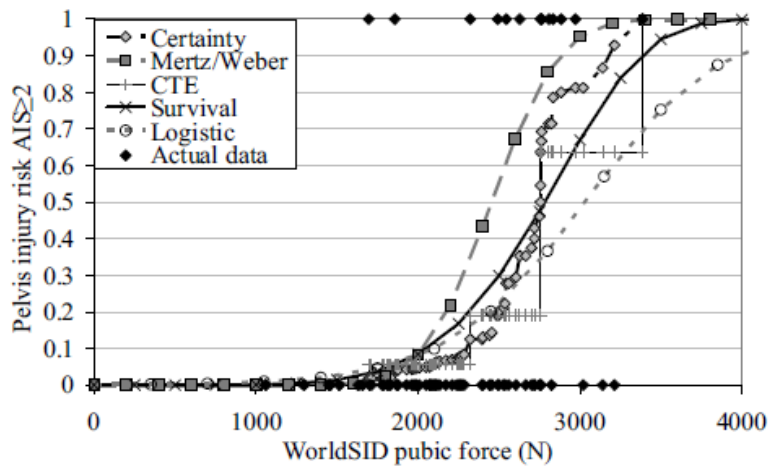


FIGURE 19. Risk of AIS ≥ 2 pelvis injury as a function of maximum pubic force for WorldSID.

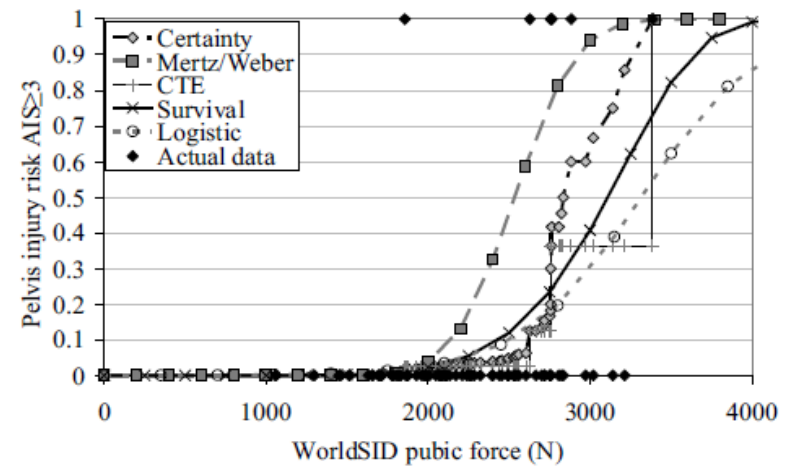
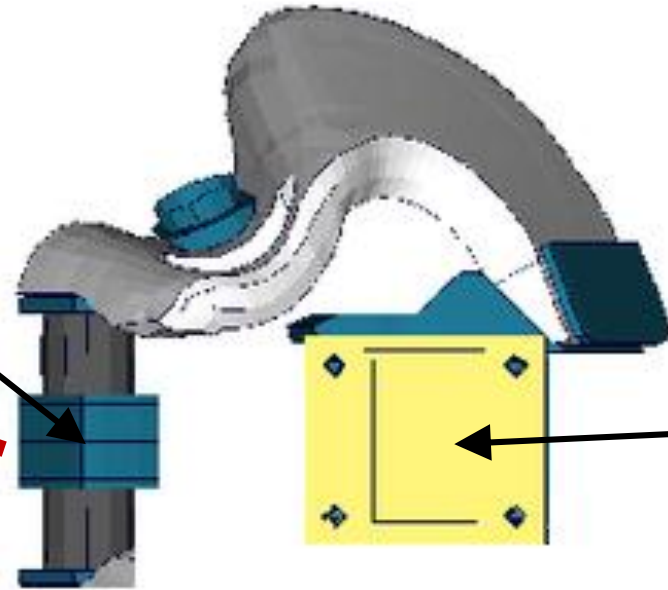


FIGURE 20. Risk of AIS ≥ 3 pelvis injury as a function of maximum pubic force for WorldSID.

Addition of Sacro-Iliac Load Cell



Pubic symphysis
load cell (1-axis)



SI load cell
(6-axis)

Inferior view of the WorldSID left hemi-pelvis

WorldSID Pelvic Injury Criteria

(Petitjean et al. 2009)

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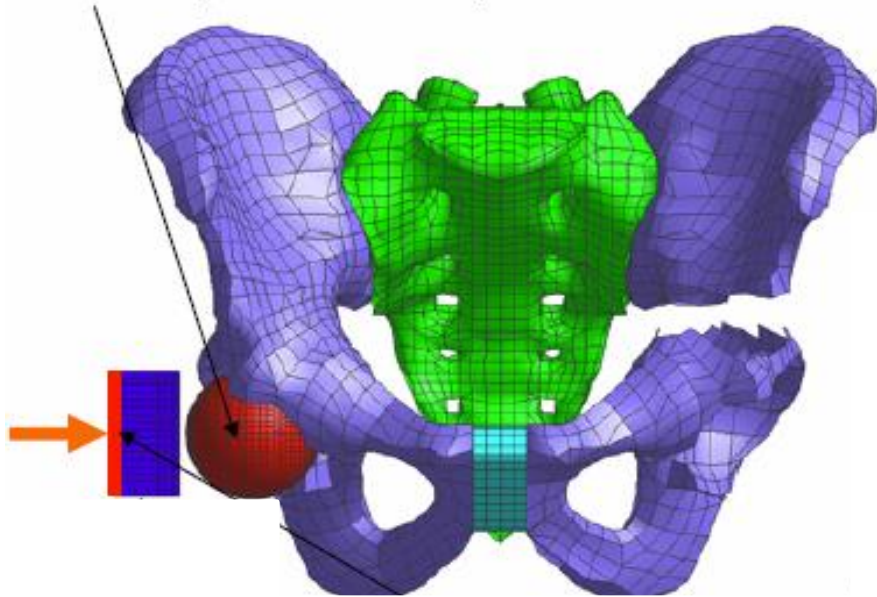
Research Questions

- What is injury distribution in the field?
- How is load distributed within pelvis during a lateral impact?
Does WorldSID match the human?
- Can SI load enhance injury prediction over PS load?
- Does this enhancement depend on injury location?

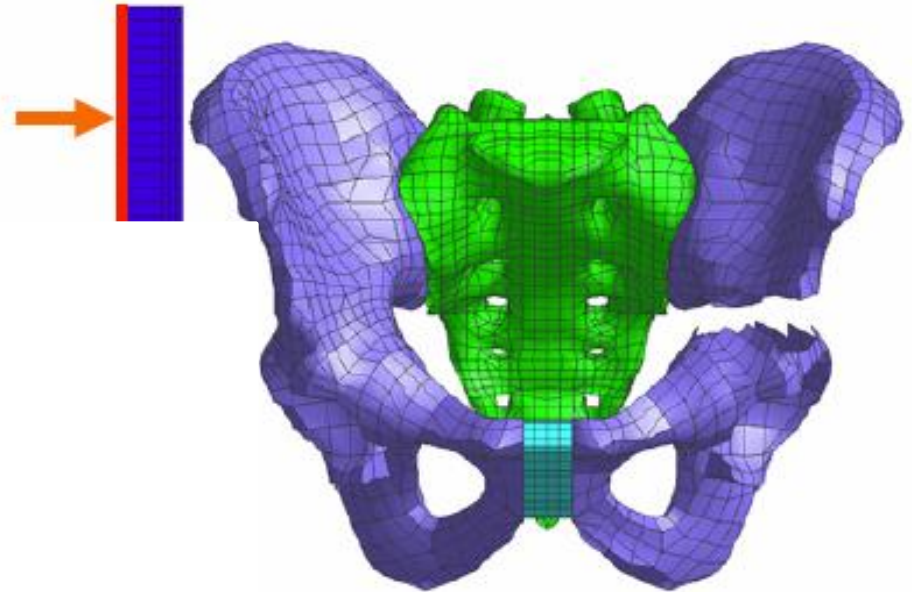
Experiments to Determine Load Distribution (Salzar et al. 2009)

Acetabulum Loading

Rigid ball (same diameter as that used by Guillemot et al.)

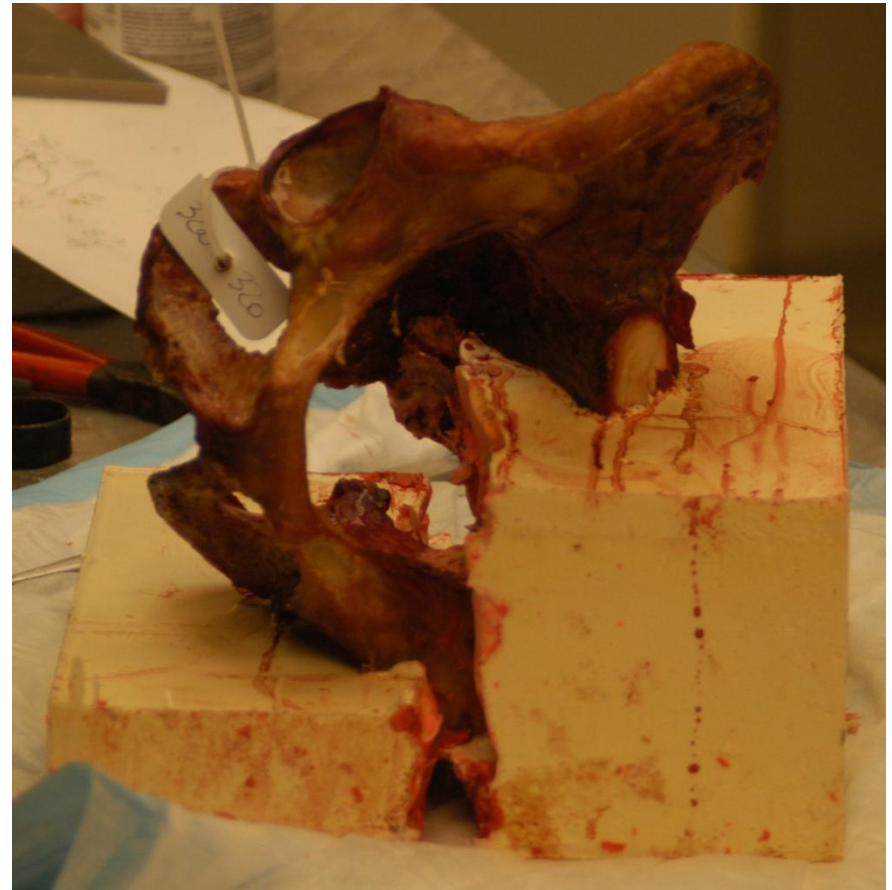


Iliac Loading

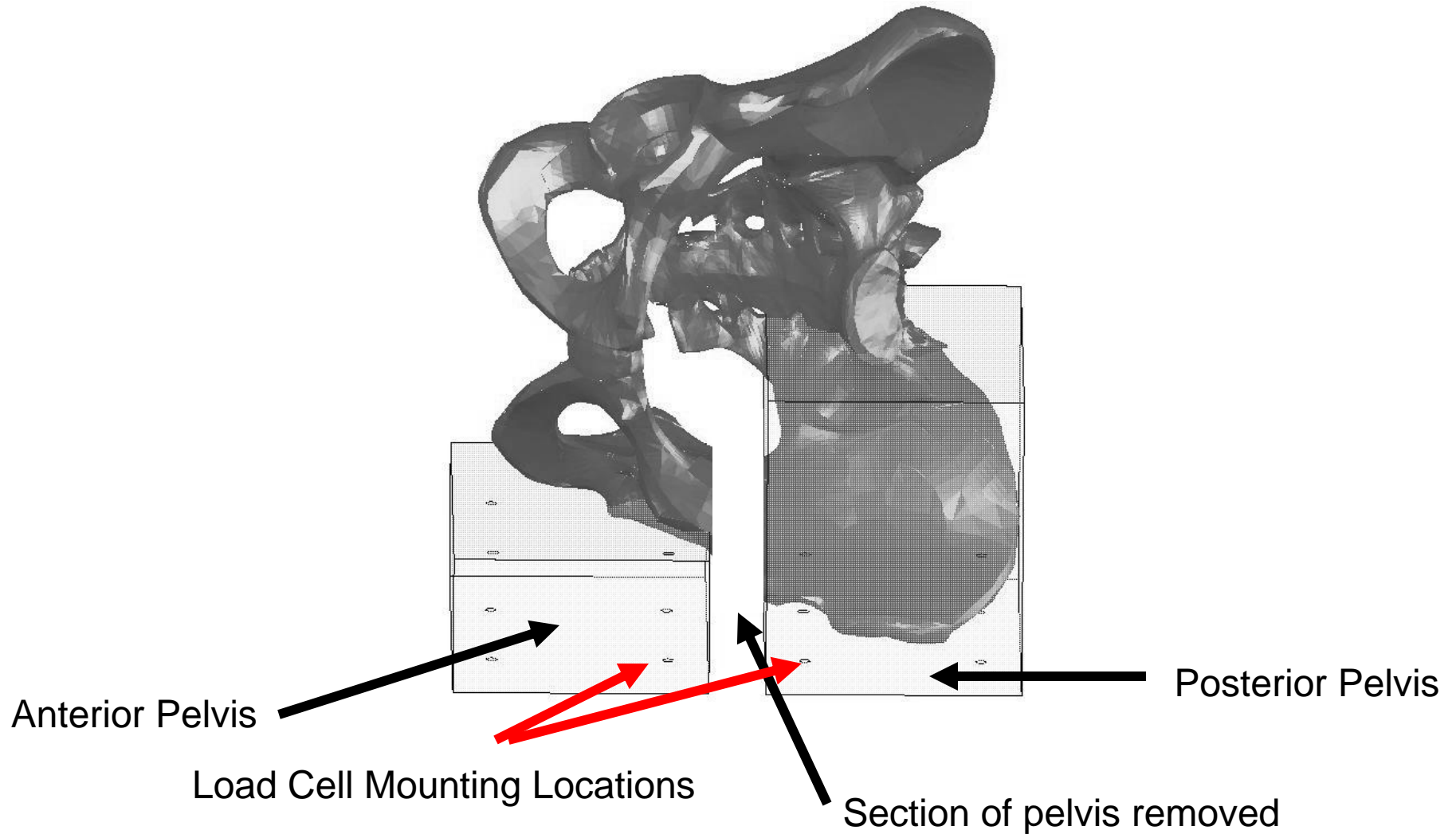


Specimen Preparation

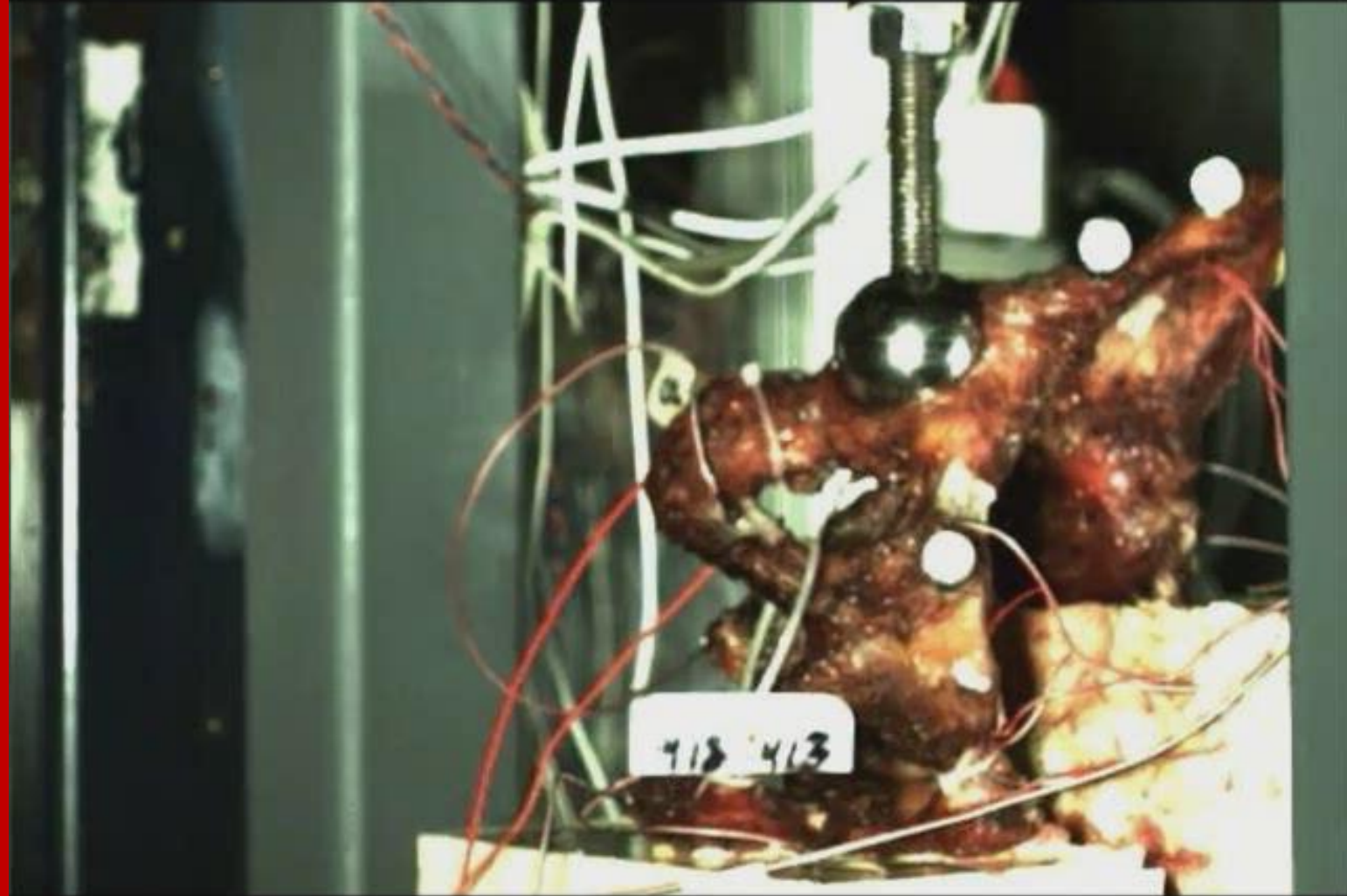
- Pelvis cut along line defined by the mid distance of the two anterior iliac spines and the top of the greater sciatic notch.



Potted and Sectioned Pelvis

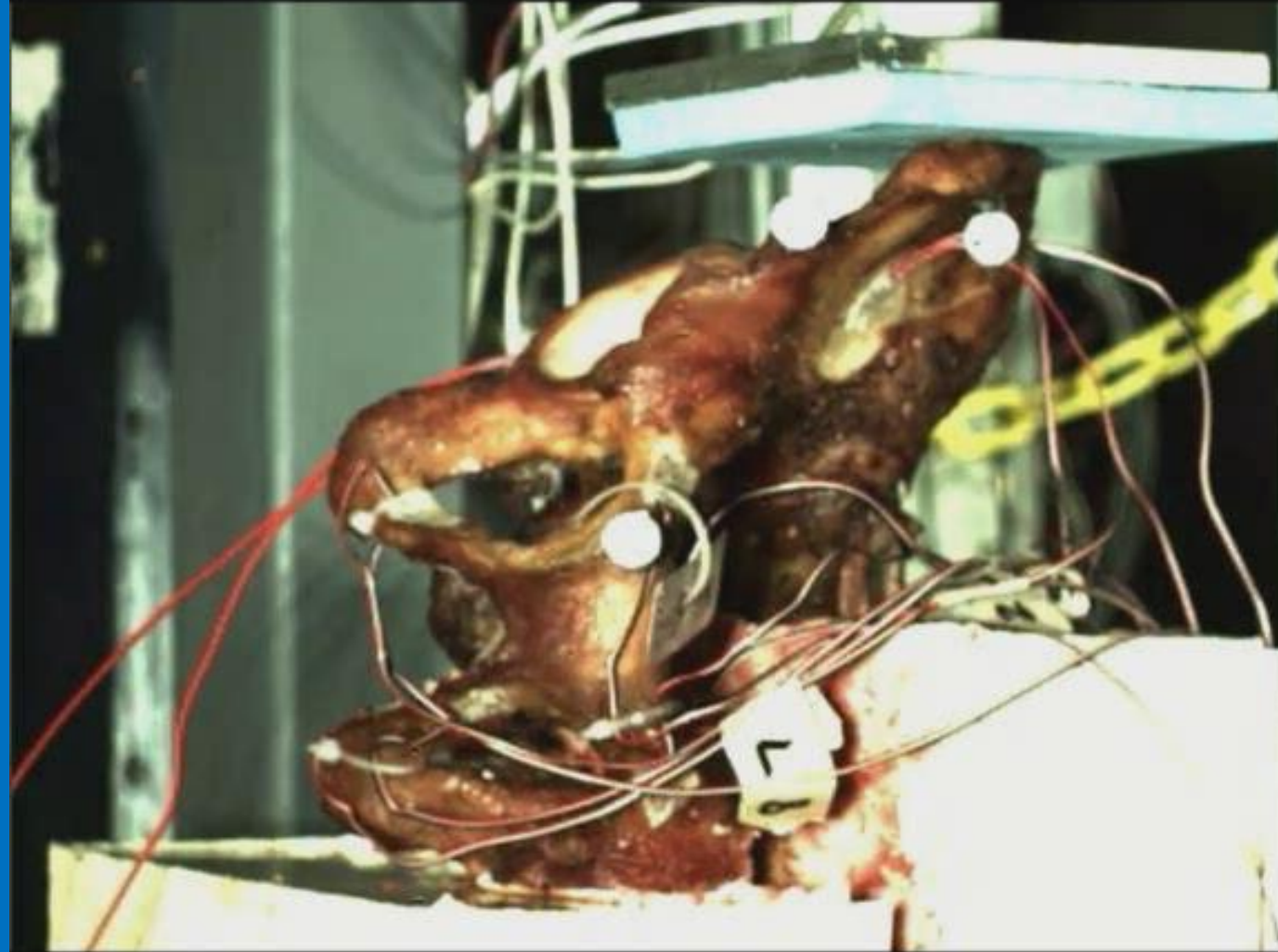


High-Rate Acetabulum Impact



Test 1_9

High-Rate Iliac Wing Impact



Test 1_14

Injury Outcomes

Test ID	Anterior injuries (AIS 98)	Posterior injuries (AIS 98)
1.1-a	Non-displaced Fx parallel to the PS, right side, including both ilio and ischio PR (8.5.26.00.2)	Vertical Fx of the body of the sacrum, along the post centreline (potting). (8.5.26.00.2)
1.2-a	Partial disruption of the PS. (8.5.30.0t0.3)	Ant dislocation of the right SIJ. Non-displaced Fx of the body of the sacrum, along the post centreline (8.5.28.00.3;8.5.26.00.2)
1.3-i	Non-displaced Fx parallel to the PS, right side (8.5.26.00.2)	Minor post inferior dislocation of the right SIJ (8.5.28.00.3)
1.4-i	Complete disruption of the PS, from centre to left (8.5.30.00.3)	Complete dislocation of the right SIJ (8.5.28.00.3)
1.5-a	Non-displaced Fx of the right ilio PR, 2 non-displaced FXs (superior and inferior) of the right ischio PR (8.5.26.00.2)	Fx descending from the top of S1, along the sacral holes (postage-stamp Fx) (8.5.26.00.2)
1.6-a	Displaced Fx of right ilio PR, right ischio PR; Fx of the left ilio PR down to the pubic angle. (8.5.26.04.3)	Non-displaced Fx through the right sacral holes, from the right 2/3 of the top of S1, descending through the holes 1 to 4; postage-stamp Fx. (8.5.26.00.2)
1.7-a	Vertical displaced Fx of both right ilio and ischio rami, parallel to the PS, multiple fragments. (8.5.26.04.3)	Non-displaced Fx through right sacrum ala, superior part. (8.5.26.00.2)
1.8-a	Complex displaced Fx of the acetabulum, along the fusion line of the 3 bones (ilium-ischium-pubis), extended postily toward the greater sciatic notch, and antily through the right ilio PR. Double Fx of the right ischio PR (T-Fx of Letournel). (8.5.26.04.3)	No injury
1.9-a	Complex vertical Fx of both ilio and ischio rami Fx, down along the PS, then going along the axis of the ischio PR, with multiple fragments. (8.5.26.04.3)	Vertical Fx of the body of the sacrum, along the centreline (potting), from the top of S1 to the third right sacral post hole (8.5.26.00.2)
1.10-a	Non-displaced Fx of the right ilio PR, 2 non-displaced FXs (superior and inferior) of the right ischio PR. (8.5.26.00.2)	Non-displaced Fx of the body of the sacrum, along to the post centreline, close to the potting incomplete post Fx of the sacrum, right side, parallel to the SIJ, including the right articular process. (8.5.26.00.2; 8.5.26.00.2)
1.11-i	Partial disruption of the PS, mostly the 3/4 inferior part. (8.5.30.00.3)	Partial dislocation of the post-inferior part of the right SIJ; no Fx there. (8.5.28.00.3)
1.12-i	Slight laxity	Slight laxity of right SIJ
1.13-i	No Fx; minor disruption/tear	Fx at the post-inferior side of the right SIJ (through an osseous bridge). (8.5.26.00.2)
1.14-i	Laxity w/o Fx	Minor post dislocation of the right SIJ (8.5.28.00.3)
1.15-i	No injury	Non-displaced complete Fx of the right side of the sacrum, parallel to the SIJ. (8.5.26.00.2)
1.16-i	Disruption of the PS, 3/4 inferior of the surface of the cartilage is detached from the right iliac bone. (8.5.30.00.3)	Partial dislocation of the right SIJ, post side, close to the sup and inf post iliac spines. Post osseous bridge of the right SIJ.(8.5.28.00.3)

Iliac Acetabulum Wing

Acetabulum

Iliac Wing

Quasistatic

Dynamic

Injury Outcomes

Test ID	Anterior injuries (AIS 98)	Posterior injuries (AIS 98)
1.1-a	Non-displaced Fx parallel to the PS, right side, including both ilio and ischio PR (8.5.26.00.2)	Vertical Fx of the body of the sacrum, along the post centreline (potting). (8.5.26.00.2)
1.2-a	Partial disruption of the PS. (8.5.30.0t0.3)	Ant dislocation of the right SIJ. Non-displaced Fx of the body of the sacrum, along the post centreline (8.5.28.00.3;8.5.26.00.2)
1.3-i	Non-displaced Fx parallel to the PS, right side (8.5.26.00.2)	Minor post anterior dislocation of the right SIJ (8.5.28.00.3)
1.4-i	Complete disruption of the PS, from centre to left (8.5.30.00.3)	Complete dislocation of the right SIJ (8.5.28.00.3)
1.5-a	Non-displaced Fx of the right ilio PR, 2 non-displaced FXs (superior and inferior) of the right ischio PR (8.5.26.00.2)	Fx descending from the top of S1, along the sacral holes (postage-stamp Fx) (8.5.26.00.2)
1.6-a	Displaced Fx of right ilio PR, right ischio PR; Fx of the left ilio PR down to the pubic angle. (8.5.26.04.3)	Non-displaced Fx through the right sacral holes, from the right 2/3 of the top of S1, descending through the holes 1 to 4; postage-stamp Fx. (8.5.26.00.2)
1.7-a	Vertical displaced Fx of both right ilio and ischio rami, paral	Non-displaced Fx through right sacrum ala, superior part. (8.5.26.00.2)
1.8-a	Comple line c toward ilio F Letoi	No injury
1.9-a	Comple rami Fx, down along the PS, then going along the axis of the ischio PR, with multiple fragments. (8.5.26.04.3)	Vertical Fx of the body of the sacrum, along the centreline (potting), from the top of S1 to the third right sacral post hole (8.5.26.00.2)
1.10-a	Non-displaced Fx of the right ilio PR, 2 non-displaced FXs (superior and inferior) of the right ischio PR. (8.5.26.00.2)	Non-displaced Fx of the body of the sacrum, along to the post centreline, close to the potting incomplete post Fx of the sacrum, right side, parallel to the SIJ, including the right articular process. (8.5.26.00.2; 8.5.26.00.2)
1.11-i	Partial disruption of the PS, mostly the 3/4 inferior part. (8.5.30.00.3)	Partial dislocation of the post-inferior part of the right SIJ; no Fx there. (8.5.28.00.3)
1.12-i	Slight laxity	Slight laxity of right SIJ
1.13-i	No Fx; minor disruption/tear	Fx at the post osseous b
1.14-i	Laxity w/o Fx	Minor post c
1.15-i	No injury	Non-displaced complete Fx of the right side of the sacrum, parallel to the SIJ. (8.5.26.00.2)
1.16-i	Disruption of the PS, 3/4 inferior of the surface of the cartilage is detached from the right iliac bone. (8.5.30.00.3)	Partial dislocation of the right SIJ, post side, close to the sup and inf post iliac spines. Post osseous bridge of the right SIJ.(8.5.28.00.3)

Iliac Acetabulum Wing

Acetabulum

Iliac Wing

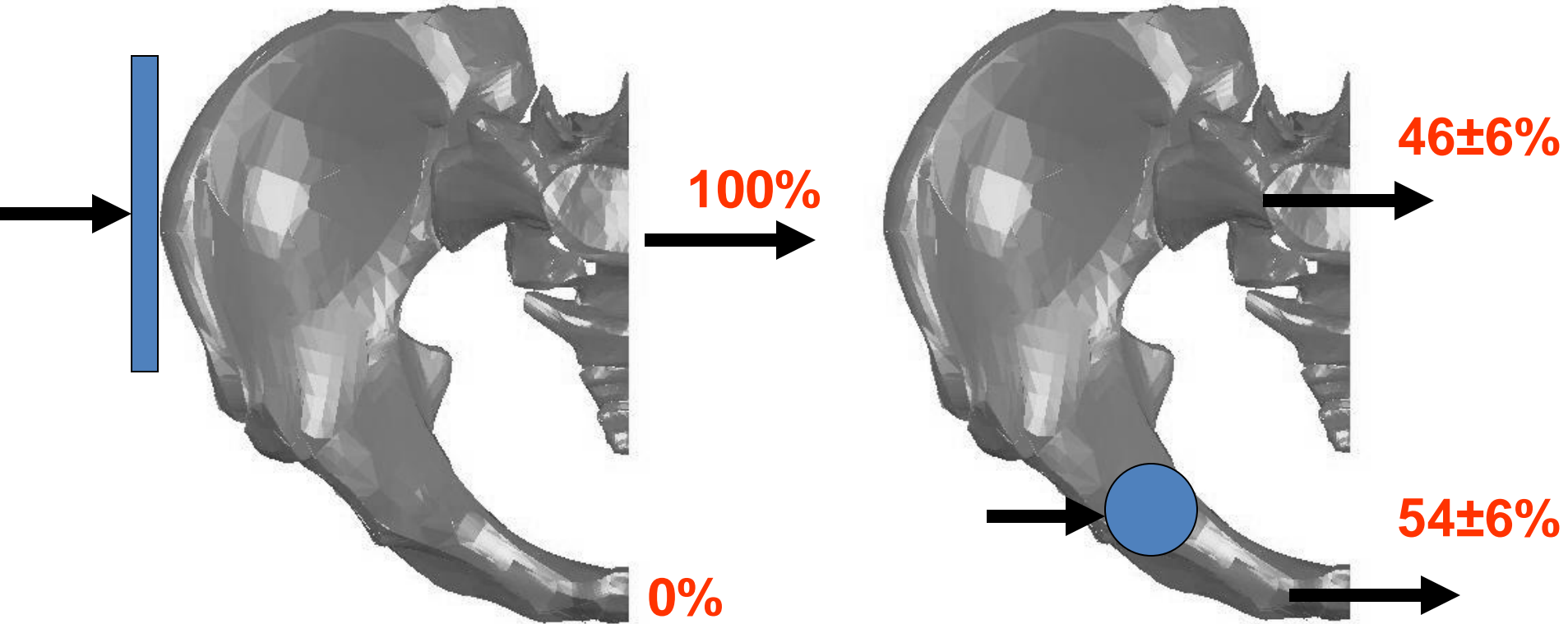
5/8 posterior tests caused PS disruption or anterior fx

7/8 anterior tests caused sacral fx

Quasistatic

Dynamic

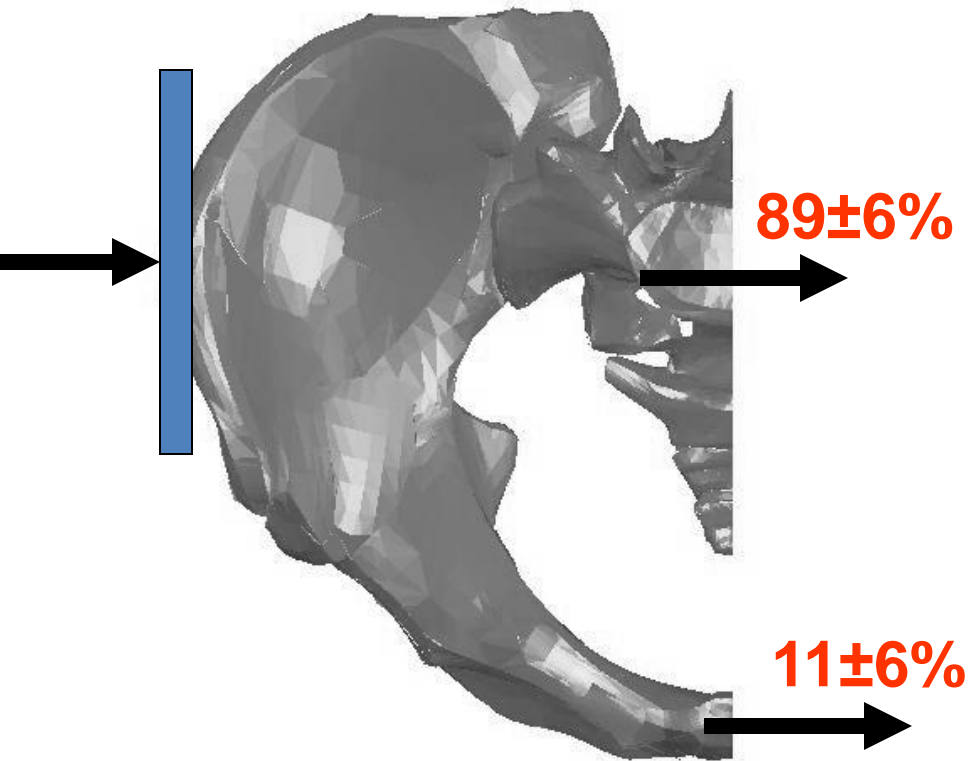
Quasi-static Load Distribution



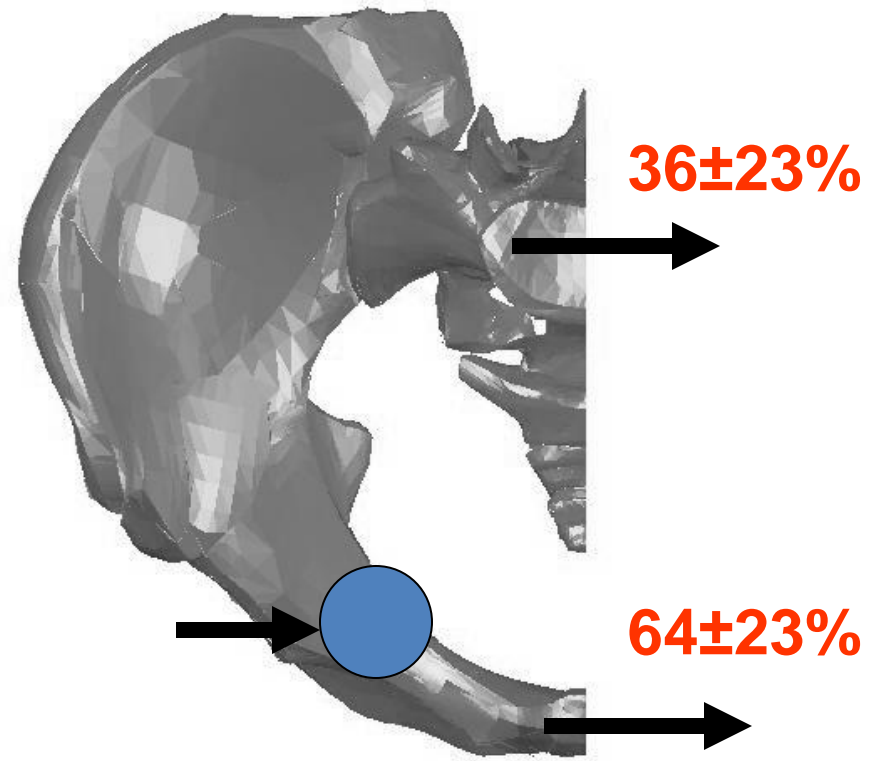
Iliac Wing Loading

Acetabulum Loading

Dynamic Load Distribution



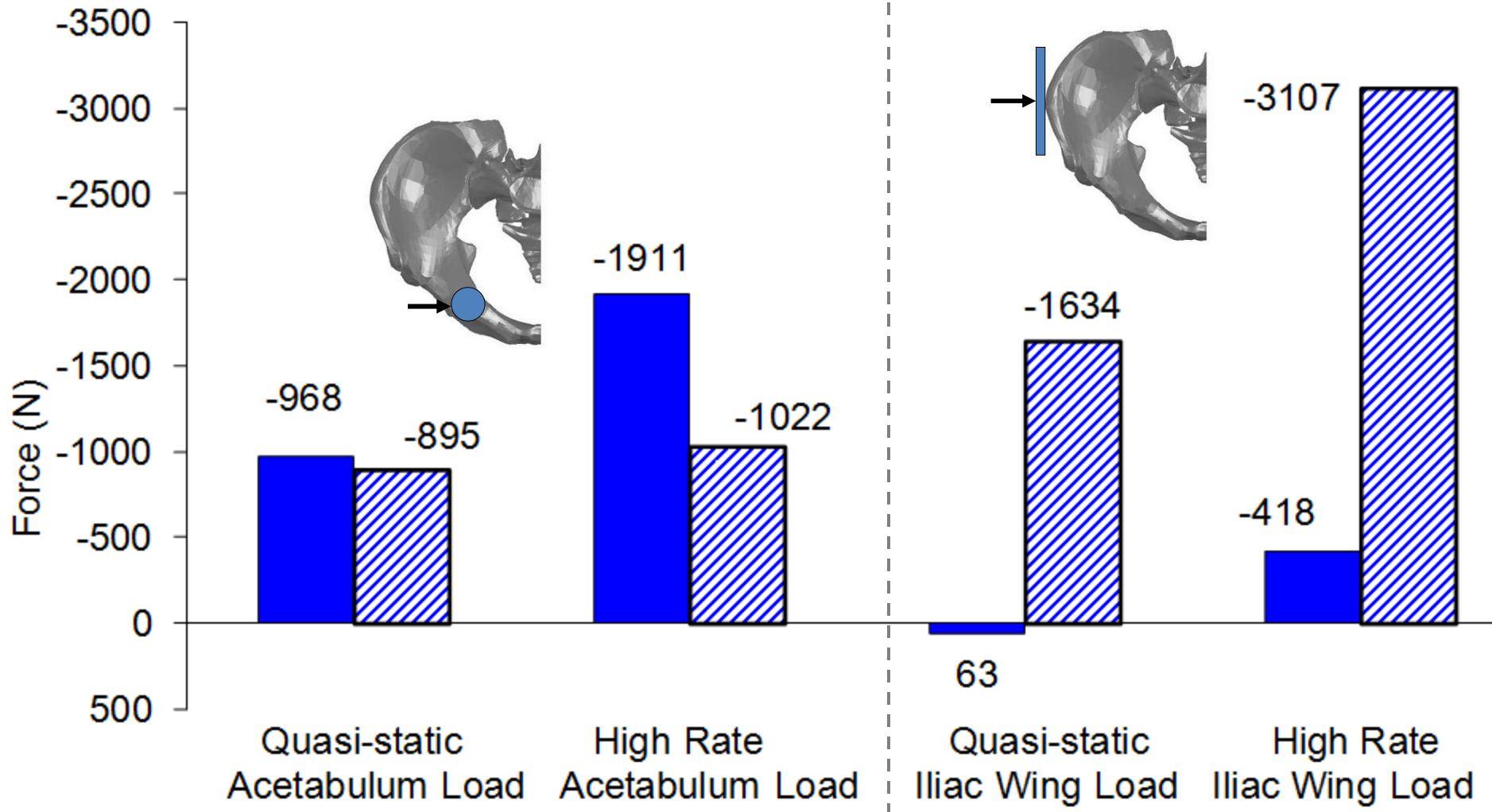
Iliac Wing Loading



Acetabulum Loading

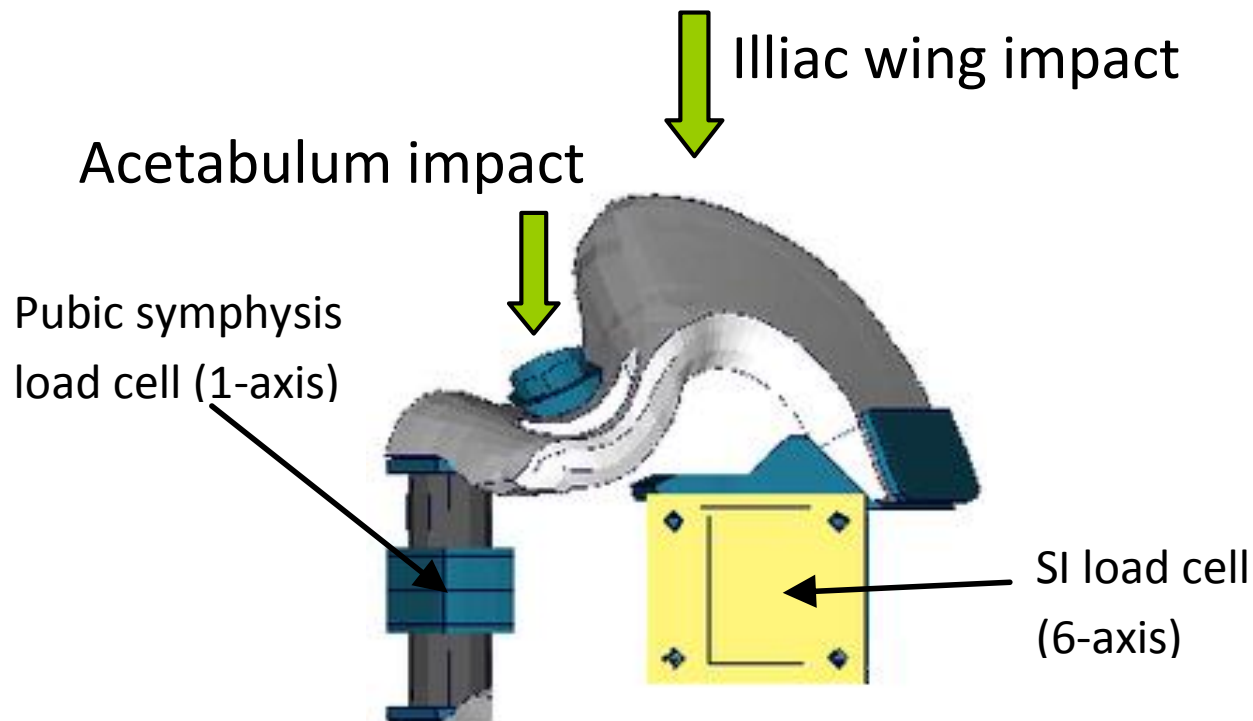
Force at Fracture

- Anterior Pelvis
- ▨ Posterior Pelvis



Proposed Project – Research Questions

- How is load distributed within pelvis during a lateral impact? Does WorldSID match the human?

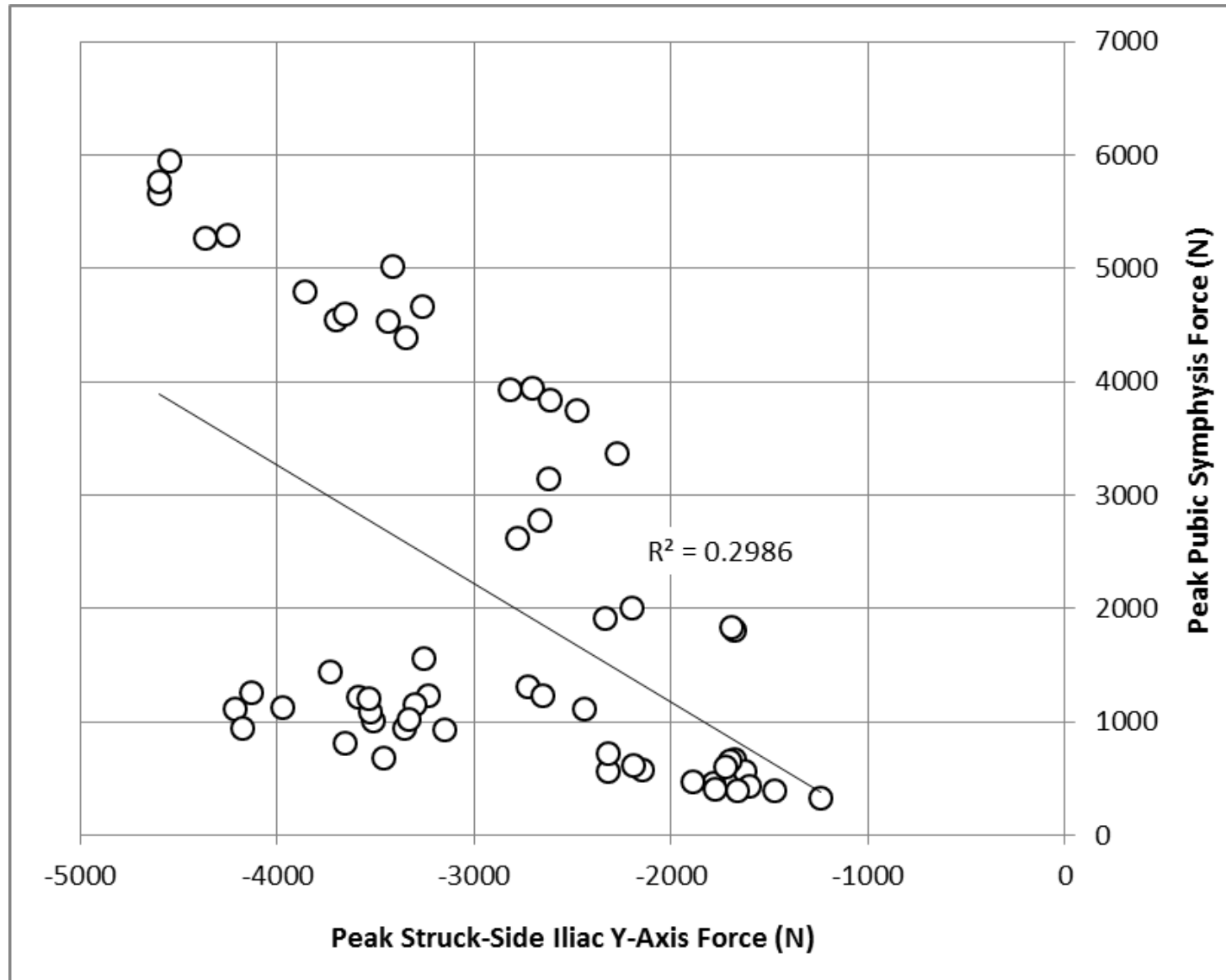


Inferior view of the WorldSID left hemi-pelvis

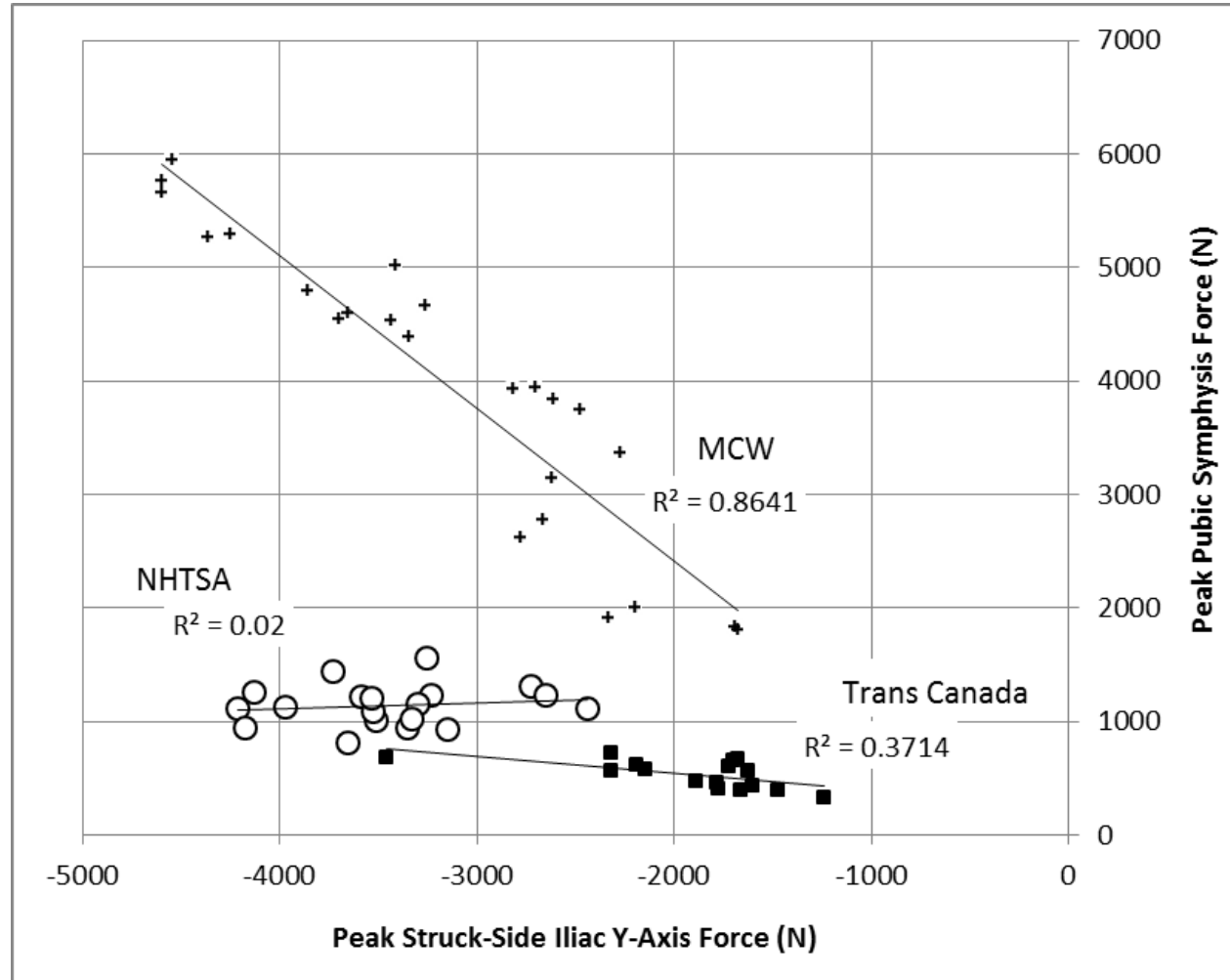
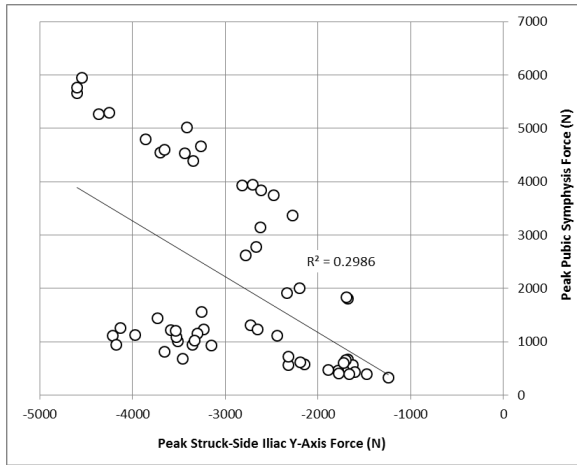
SI vs PS loads in sled and in-vehicle impacts

- 3 datasets:
 - MCW sled tests (Heidelberg-type sled)
 - Transport Canada (TC) (in-vehicle)
 - NHTSA (FMVSS 214, pole oblique)
- Correlation between the peaks of the two pelvic forces (SI and PS)?

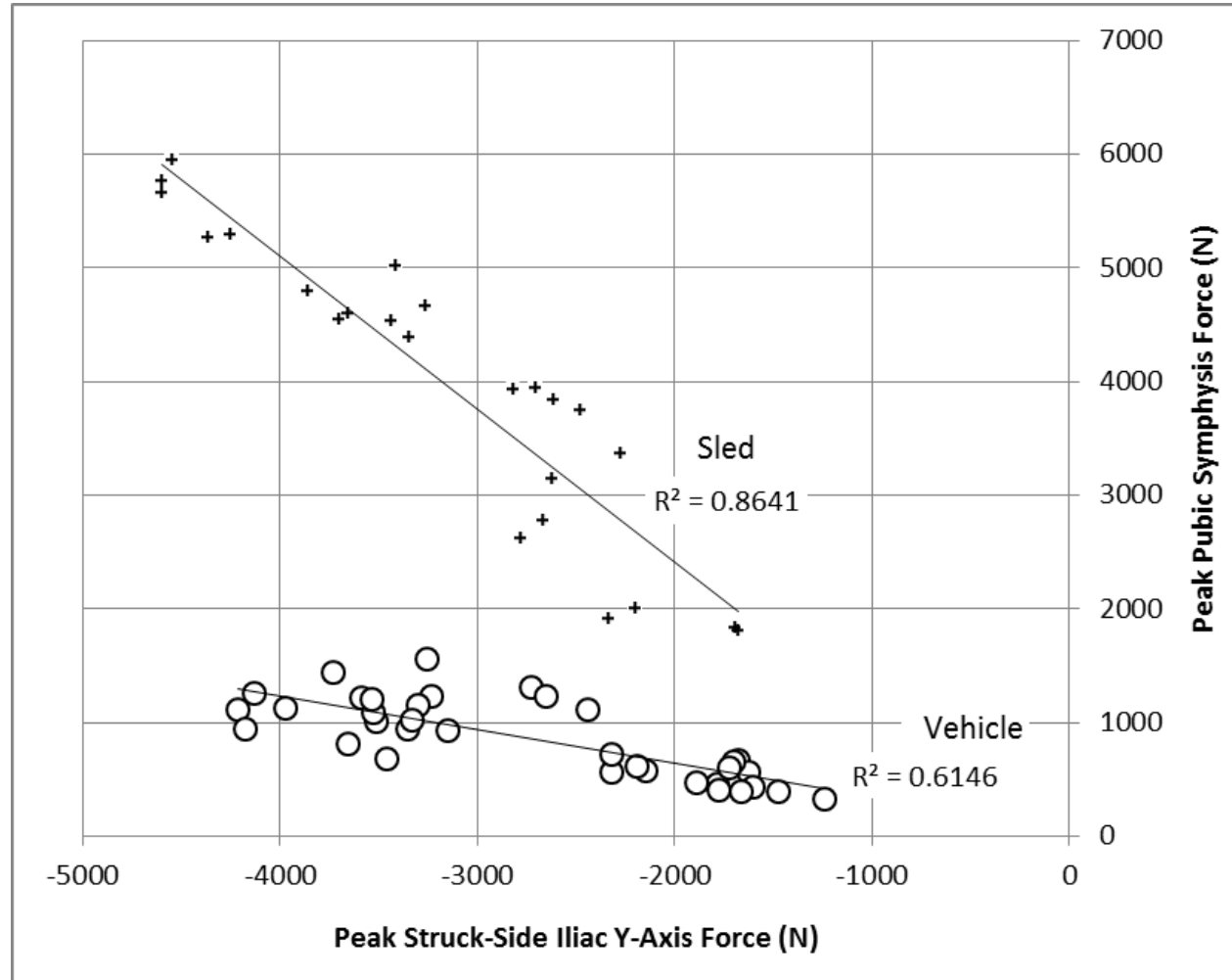
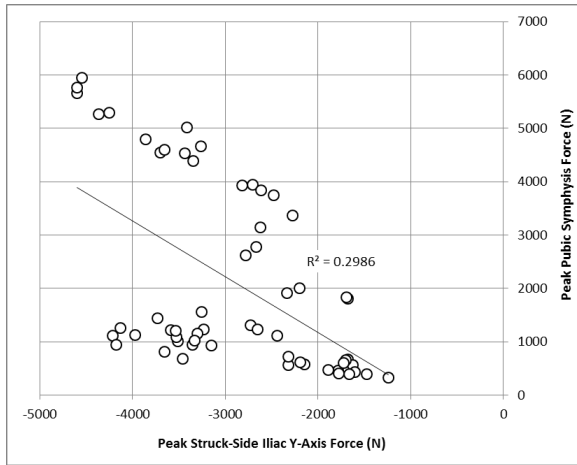
SI vs PS loads in sled and in-vehicle impacts



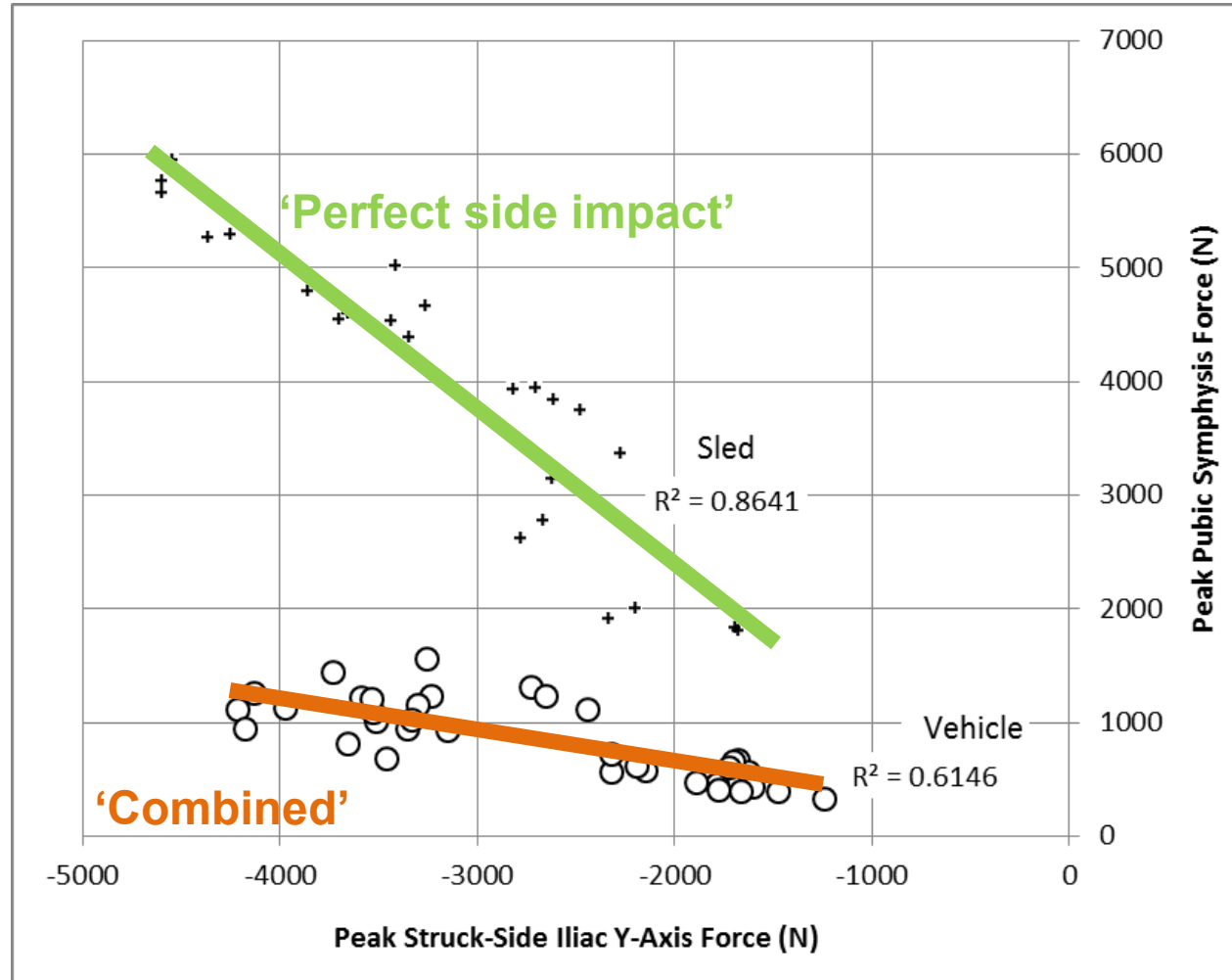
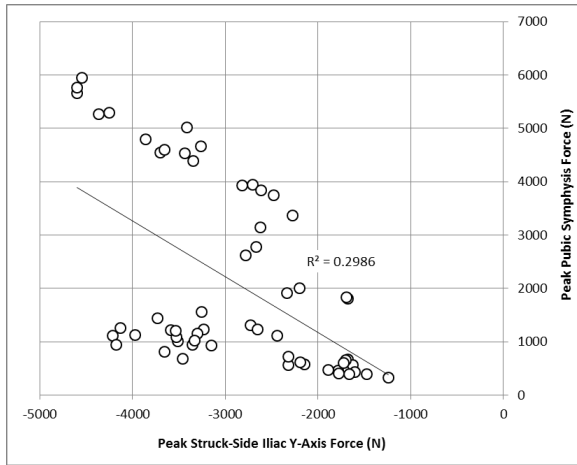
SI vs PS loads in sled and in-vehicle impacts



SI vs PS loads in sled and in-vehicle impacts



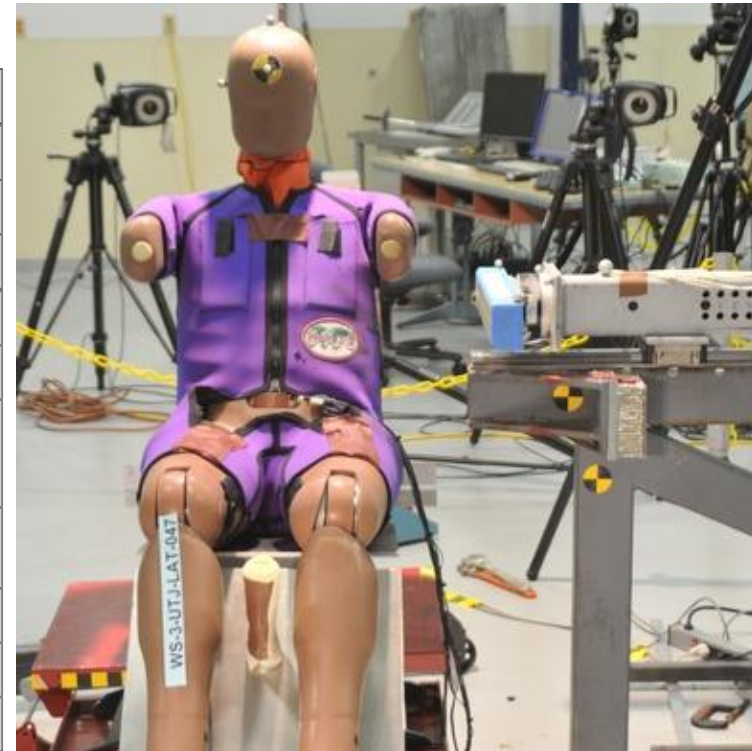
SI vs PS loads in sled and in-vehicle impacts



Proposed Project – Research Questions

- Can SI load enhance injury prediction over PS load?
- Does this enhancement depend on injury location?

Test Series	Description of Pelvis Impactor Tests
WSU	90° and 270° impacts to the greater trochanter at 4.0 to 10.1 m/s by a 23.4-kg rigid impactor with a flat, circular impact face (152.4-mm diameter)
ONSER	90° impact to the greater trochanter at 5.83 to 13.7 m/s by a 17.3-kg rigid impactor with a spherical (175-mm radius of curvature), circular impact face (120-mm diameter)
	90° impact to the greater trochanter at 12.6 to 15.0 m/s by a 17.3-kg impactor with a spherical (175-mm radius of curvature), circular impact face (120-mm diameter) covered with APR pad
UMTRI	90° impact to the femur 80 mm anterior to the greater trochanter at 6.0 or 7.2 m/s by a 25-kg rigid impactor with a flat, circular impact face (152.4-mm diameter)
	90° impact to the femur 80 mm anterior to the greater trochanter at 5.5 to 5.9 m/s by a 56-kg rigid impactor with a flat, circular impact face (152.4-mm diameter)
	90° impact to the femur 80 mm anterior to the greater trochanter at 9.2 or 26 m/s by a 20-kg impactor with a flat, circular impact face (152.4-mm diameter) covered with 25 mm Ensolite plus 25 mm Styrofoam, 50 mm foam plus 25 mm AL Ensolite, 25 mm Styrofoam, or 75 mm AL Ensolite plus 25 mm Styrofoam
	90° impact to the femur 80 mm anterior to the greater trochanter at 7.0 or 9.5 m/s by a 25-kg impactor with a flat, circular impact face (152.4-mm diameter) covered with 25 mm Ensolite plus 130 mm Styrofoam, 5 mm Ensolite, 25 mm Ensolite plus 25 mm Styrofoam, or 150 mm APR pad
INRETS	90° impact to the greater trochanter at 10.0 to 13.7 m/s by a 12-kg rigid impactor with a flat, square impact face (200 mm by 200 mm)
	90° impact to the greater trochanter at 9.47 to 11.8 m/s by a 16-kg rigid impactor with a flat, square impact face (200 mm by 200 mm)
	90° or 270° impact to the greater trochanter at 3.22 to 6.77 m/s by a 23.4-kg rigid impactor with a flat, rectangular impact face (200 mm wide by 100 mm high)



Proposed Project – Research Questions

- Can SI load enhance injury prediction over PS load?
- Does this enhancement depend on injury location?
 - Matched WS/PMHS impactor tests (n=?)
 - Range of injury outcomes
 - Predictor variables
 - PS force, SI force, combined model
 - “Posteriorly injured” cohort
 - “Anteriorly injured” cohort
 - Combined cohort
- Completion date: May 2013

