



Biomechanical Considerations for the SI Joint


Castellvi Spine
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Disclosure

Research Funding

- Aesculap
- Alphatec Spine
- Globus
- K2M
- Medtronic
- OrthoKinematics
- Ratchiotek
- Stryker Spine



Porsche 911 Cooling System

Type 993 and previous (1963-1997) Type 996 (1998-2005)



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Change is Good...

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Spine Biomechanical Testing

- Method of *Comparative Testing*
 - Flexion extension and lateral bending (pure moment testing – *flexibility protocol*)
 - Axial torsion and axial compression (are also important)

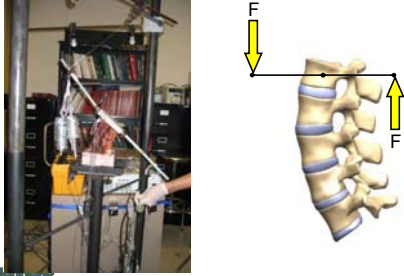
Panjabi, 1988

“Pure Moment” Testing

What bending moment does each intervertebral level see?

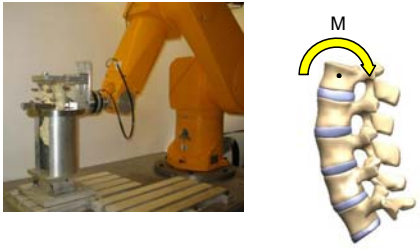
Modified without permission from Panjabi, 1988

Bending Moment: Force Couple
University of Toledo (Prof Goel)



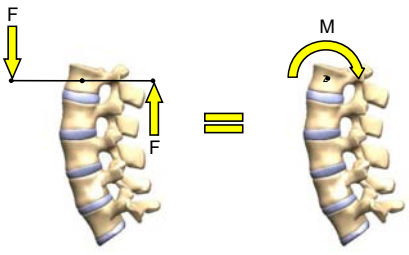
Allegheny Health Network

University of Pittsburgh
Department of Orthopedic Surgery



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Equivalent Pure Moment Test Protocols



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Sacroiliac Joint Fusion



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SI Joint Fusion

- Minimally Invasive iFuse Implant System®
- Vs. Open SI Fusion:
 - Smaller incision
 - Reduced blood loss
 - Short procedure ~ 1 hour
 - No need for bone grafting




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iFuse Implant System®



Why the unique triangular design?

- Cannulated screw may loosen^{36,37,38}

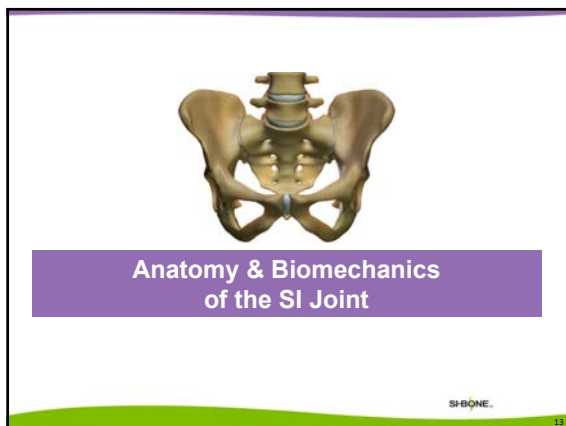


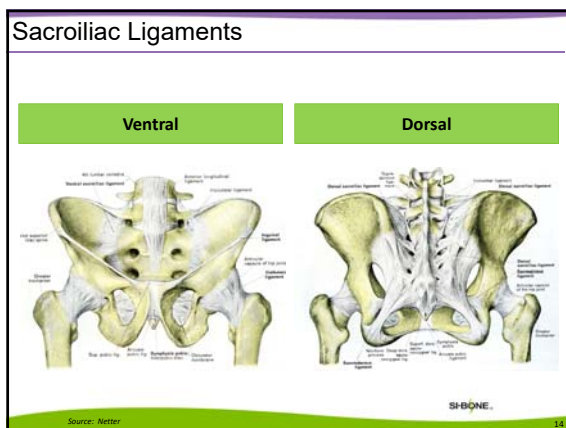
Design: Triangle vs. Round

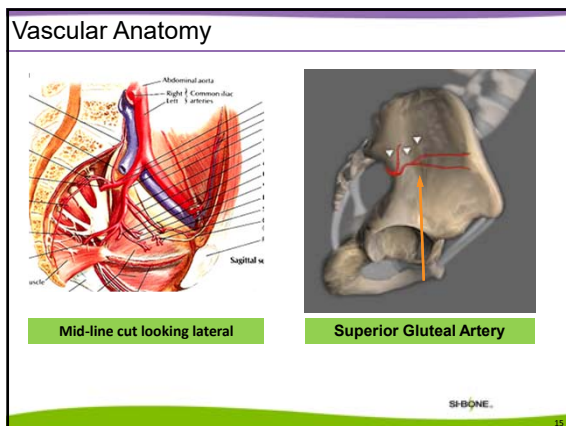
- Porous titanium plasma coating allows for biologic fixation
- Larger surface area designed to stabilize and fuse the heavily loaded SI joint
- 3X stronger than screw³⁹



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SI Joint Motion


Multi-planar motion

- Simultaneously rotate and translate through 3 axes of motion

Motions (<4° in any plane)

- Nutation/Counternutation**
 - Primary motion
 - Males: 1 - 2°
 - Females: 2 - 4°

Sacral Translation¹³
(A-P motion) up to 1.6mm


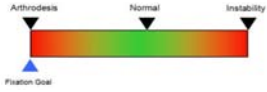


SH-BONE.



13. Shotton 1989 16

Biomechanical Goal of Rigid Fixation

- Fixation design rational
 - Provides immediate stabilization and fixation
 - Adjunct to fusion, i.e. "stiffens" FSU
- Clinical relevance
 - Reduce instability of pathologic FSU (< ROM)
 - correlated clinical outcomes to stiffness
- Metric
 - ROM



Good Idea?









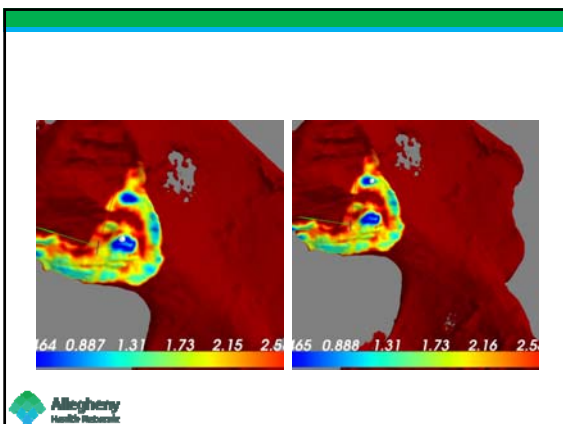
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Comparison Treatments

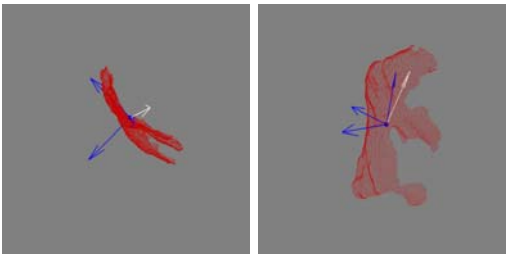
1. Intact
2. Intact (Resection)
3. Destabilized
4. Instrumented SI





Biomechanical Metric	Significant Mode of Loading	Clinical Relevance
ROM	 Flexion-Extension	Standard comparison technique for fixation constructs
Anterior Column Load Sharing	 Axial Compression	Graft and construct load sharing capability
Facet Translation Analysis	 Facet Interaction	Facet interaction: articulation and joint separation
Interpedicular Displacement	 Interpedicular Displacement	Posterior column effects
Finite Helical Screw Axis	 Finite Helical Screw Axis	Rotation from time frame A-B: independent axis measurement




Defining SI Joint Orientation



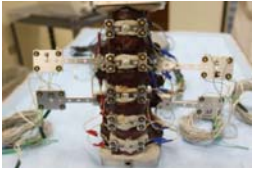


Biomechanical Study Design

Flexibility Protocol

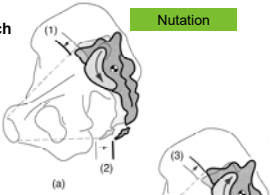


Instrumented Lumbar Spine

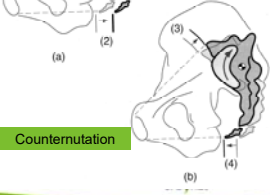


Motion of the SI joint

- **Primary motion is nutation, which is a nodding type of motion**
 - 1-2 degrees for males
 - 2-4 degrees for females
- **Center of Rotation is the S1 neuroforamen¹⁴**



(a)



(b)

14. Frost et al. 2006 24

Conclusion

- Adjacent levels changes (L5-S1)
 - Not able to detect changes in pure moment testing
- Due to relatively *small magnitudes* of gross joint motion
 - Should we define as instability?
 - May still have implications for the presence of pain in spite of a small ROM
- Specific biomechanical considerations
 - Consider plane of loading for the joint
 - Many models utilize single leg stance

