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New Advance in Biomechanical Research: Headform with Articulated Mandible

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Do mouthguards prevent concussion?

- Stenger *et al* (JADA 1964): 5 American college football players, X-rays showed distraction of mandibular condyles from fossae with a mouthguard worn
- McCrory (BJSM 2001): “neuro-mythology”, “no convincing evidence”
- Proponents: mouthguard manufacturers and dental practitioners
- NFL MTBI committee objective investigation

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Football jaw impact

Face mask
↓
Chin strap
↓
Mandible



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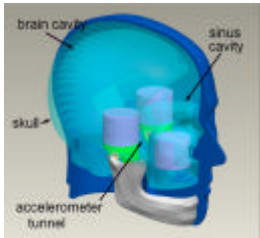
Objective: Headform to assess mouthguards

- Force-sensing jaw
NFL re-enactments: load path from chinstrap and facemask
- Biomechanics
WSU cadaver tests – Matt Craig (Ph.D. graduate)
Impact force vs. chin displacement
- Design
Based on existing Hybrid-3 headform
Articulating mandible
Force sensing, biofidelic, robust

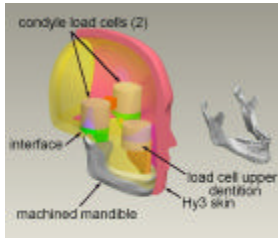
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Headform Platform

NOCSAE (med)



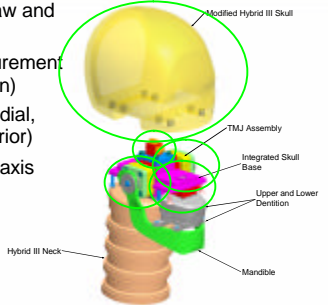
Hybrid III (50th%)



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Concept

- Remove Hybrid III jaw and skull floor
- Triaxial force measurement (TMJ, upper dentition)
- Jaw articulation (medial, lateral, anterior, inferior)
- Head kinematics (3-axis accelerometer)



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Mandible Anthropometry

- Geometry
 - HUMOS (human model for safety) car occupant model
 - Dragulescu et al (2002) Modeling and Dynamic Study of Human Mandible
- TMJ location
 - HyIII bony landmarks, anatomy texts
- General profile
 - NOCSAE headform, UMTRI skeletal model

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Dentition

- 50th% dentition model does not exist
- Digitized dental model of *ideal dentition*
- CNC machined from stainless steel
- Verified to fit adult mouthguards



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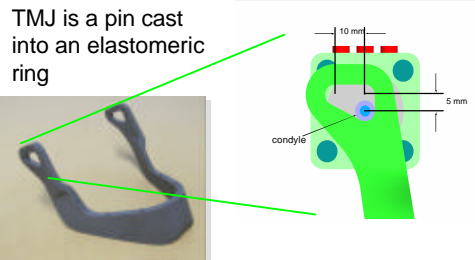
TMJ: Range of Motion

- Neutral pos'n (clenched teeth), condylar process supported posteriorly and superiorly
- 10-12 mm anterior, 5-6 mm inferior, 0.75 mm medial and lateral (Sturdevant 4th edition)
- At rest, jaw descends 3.5-4.8 mm without hinging: necessary space for mouthguard
- Prototype jaw rigid: all motion is at condyle

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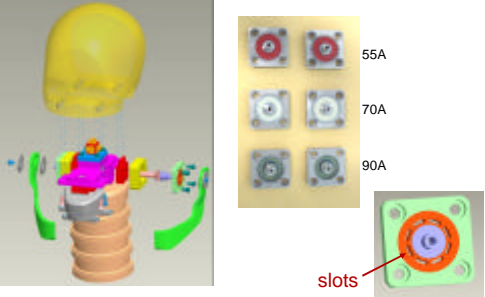
TMJ: Design

- Triangular slot
- TMJ is a pin cast into an elastomeric ring



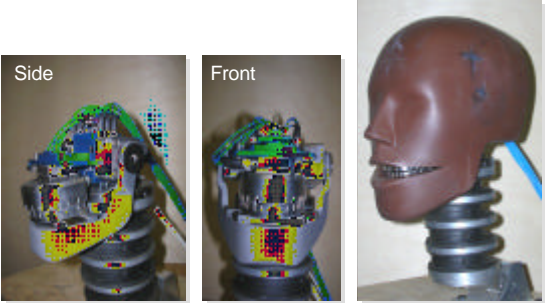
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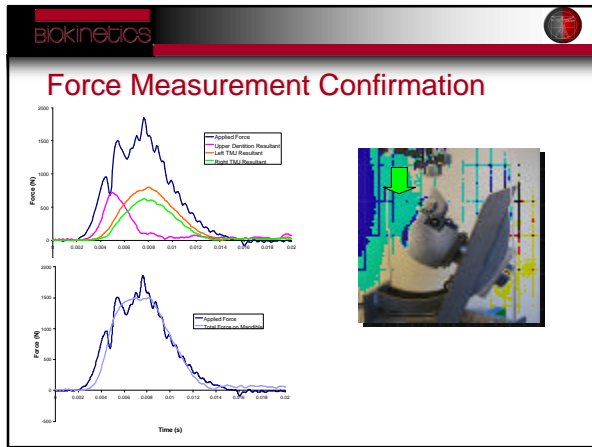
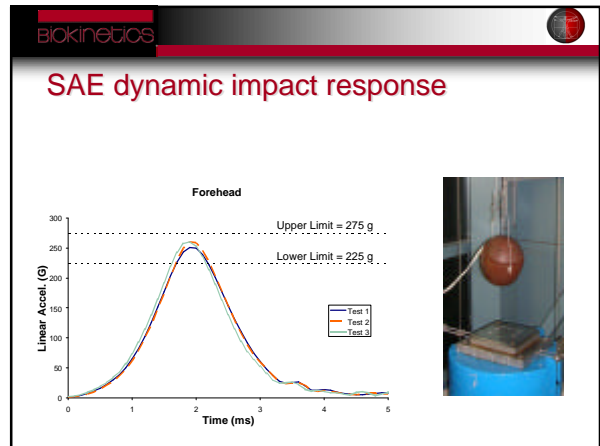
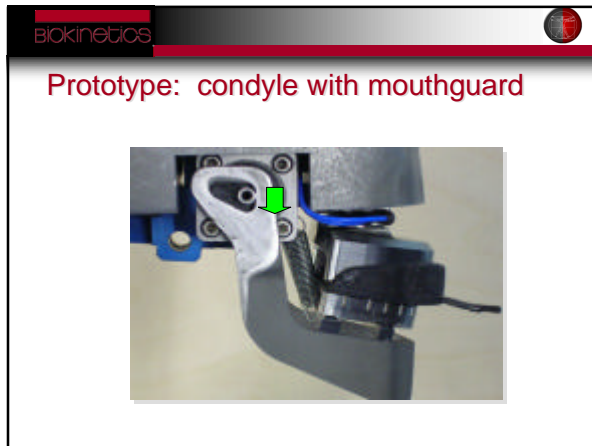
TMJ bumper design



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Prototype

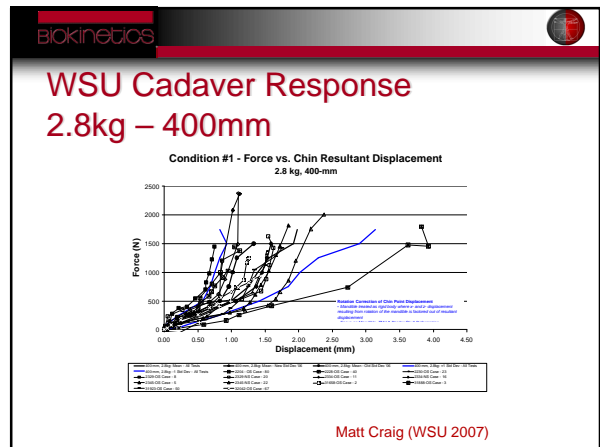
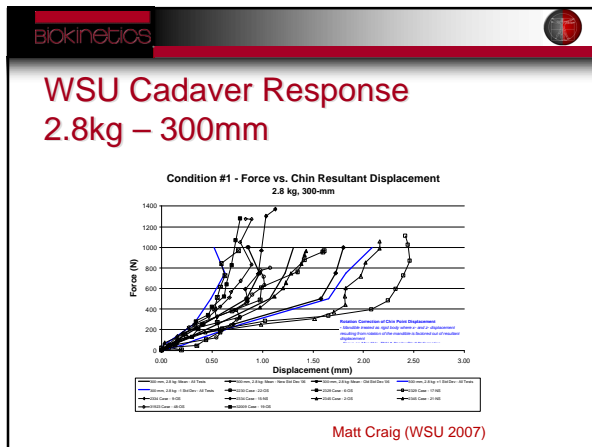


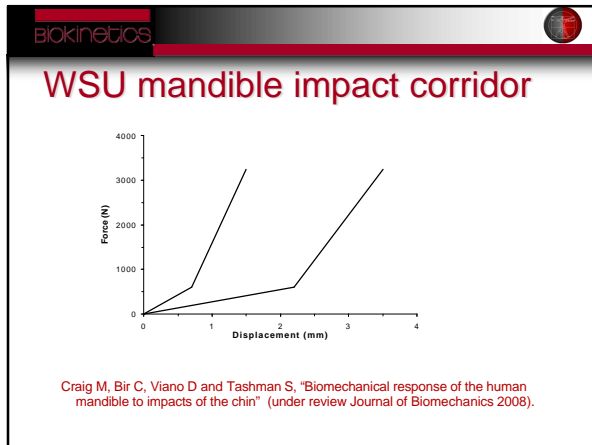
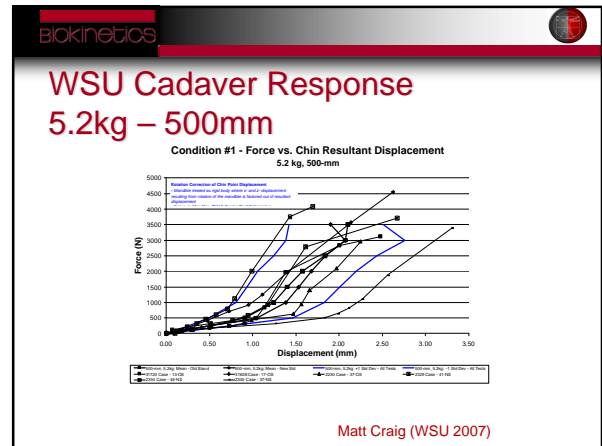
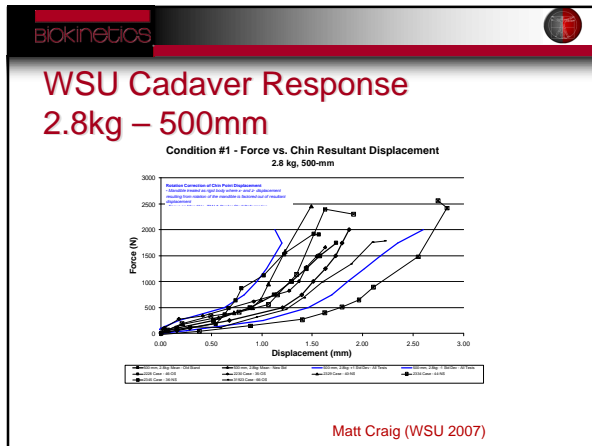


Validation Testing

- M. Craig's (WSU) cadaver research
- Falling mass
 - 2.8kg (300,400,500mm)
 - 5.2 kg (500mm)
- Force, chin displacement, condyle displacement
- Oriented chin-condyle vertical

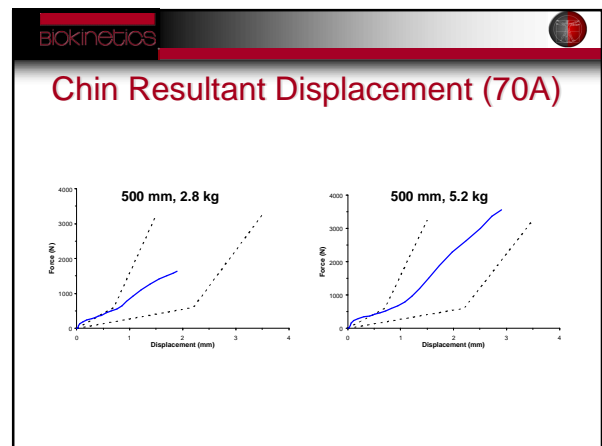
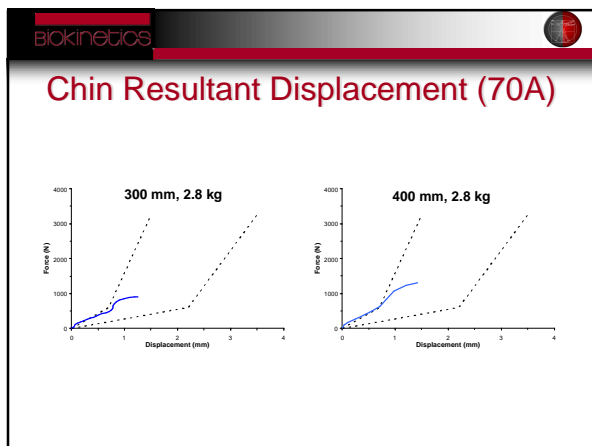
Courtesy of Matt Craig (WSU 2005)





Headform Validation


- Development tests @ Biokinetics
- Final tests @ WSU (July 2007)



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Ongoing work

- Headform sensitivity, durability, data quality
- Mouthguard effectiveness



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Ongoing work: mouthguards

			
Basic	Bimaxillary	Lower dentition	Custom laminated

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Future Considerations...

- Mouthguard models
 - Do they reduce TMJ force?
 - Do they affect head acceleration?
 - Boil-and-bite versus custom?

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Mouth guard tests (demo)

- Sample video 9.3 m/s



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Questions?

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