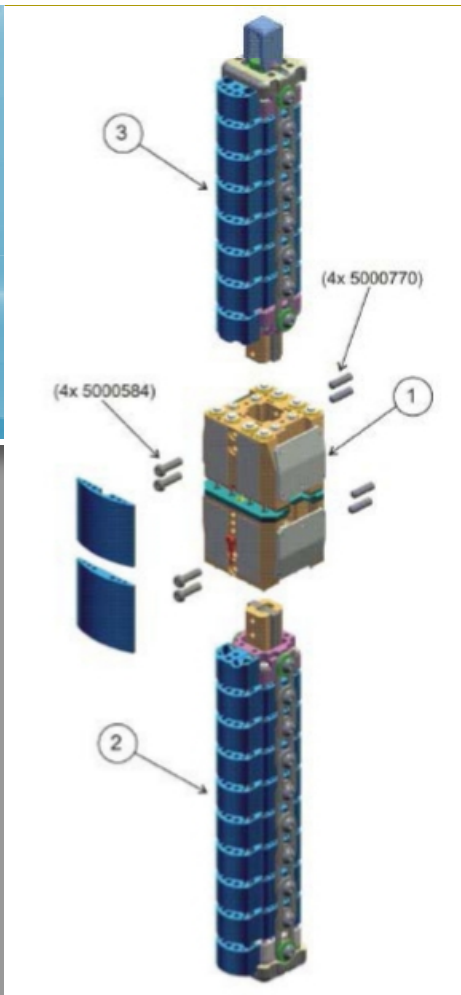


FLEX PLI Update for Alliance of Automobile Manufacturers



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Content

- ▶ **Background**
 - Why was one vs two versions of Flex GTR discussed
- ▶ **Flex Update since last Auto Alliance meeting**
 - Vinylester bone biofidelity
 - Longer rubber flesh, affect on performance
 - Bone shimming process, bone replacement
 - Lab to lab repeatability
- ▶ **GSRP Informal Group Task Force and current work plan**
- ▶ **Current Production**

BACKGROUND

Overall Summary of Key points

Step 1: Bone Core 7 tests
 Quasi-static 3-Point Bending Test
 (Femur bone core, Tibia bone core)



Step 2: Femur and Tibia 2 tests
 Quasi-static 3-Point Bending Test
 (Femur, Tibia)



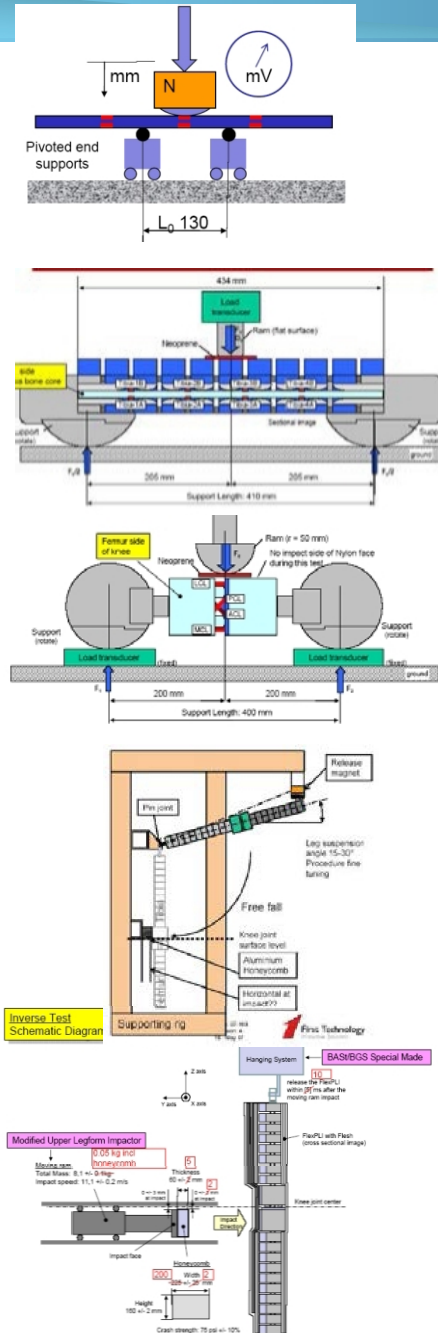
Step 3: Knee, 1 test
 Quasi-static 3-Point Bending Test



Step 4: Assembly 1 test
 Femur-Knee-Tibia
 Dynamic Pendulum Calibration Test



Step 4: Assembly 1 test
 Femur-Knee-Tibia
 Dynamic Inversion Calibration Test



Background of Observations for Project before Sept 2011

Investigated Batch to Batch variation from supplier
 Investigated Test variation
 Investigated gage application procedures
 Investigated bone thickness adjustments for each batch to fit into static bone corridors
 Determined that the Vinyl ester bones needed to tested in the original biofidelity test

Investigated assembly procedures
 Shims adjustment
 Bumper thickness
 Test to test variation of static assembly test

Investigated spring adjustment influence on test results

Was able to pass Pendulum test

Humanetics offered for sale a leg that would pass pendulum test only

Was not able to pass Inverse test

Humanetics could not offered for sale a leg that would pass the inverse test

UPDATE SINCE SEPT. 2011

One Version Flex PLI

- ▶ There had been some concern that Humanetics had been making two versions on the leg.
- ▶ One version to pass inverse and one to pass pendulum.
 - Confusion occurred when customers asked for pendulum test only and internal sales code was –P or –I for internal testing (Pendulum and Inverse). If a customer asked for a Flex Pli that would pass the pendulum test only, the code was just –P only. If customers required data from both tests then a –P and -I would be entered to provide both test results. From experience we get as close as we can in inverse by making bones on the stiff side within the static corridor. Typically T3 and T4 are our problem channels

Vinyl ester Bone Biofidelity

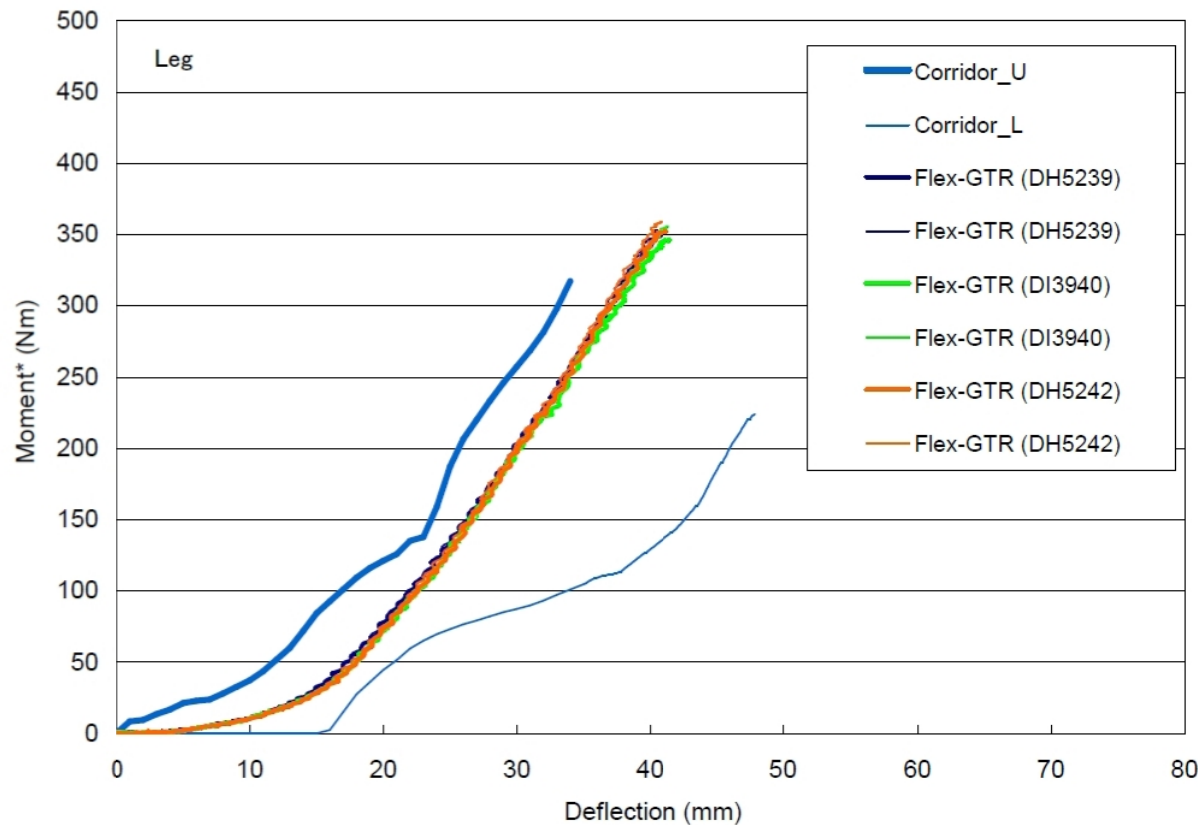
- ▶ To determine that the Vinyl ester bones met original biofidelity
 - Biofidelity on Vinyl ester bones had not been confirmed
 - We had seen a difference with vinyl ester performance so wanted to confirm this was within corridor and similar to Polyester.
 - JARI kindly carried out check with 6 bones from 3 different batches (2, 3 and 4) with identical setup to original biofidelity
 - Bones were confirmed to be within corridor

BIO Testing Comparison Tibia

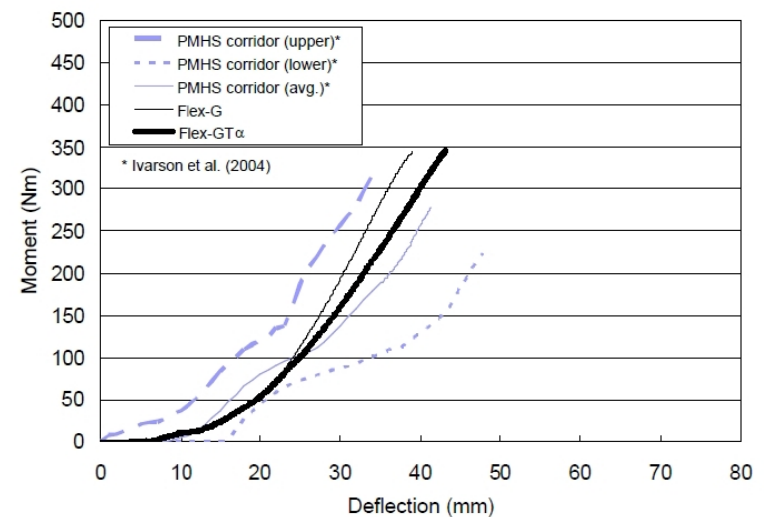
Vinyl Ester Bones Sept 2011

67.8 Kg, R 25 mm
50 mm drop

Test Results for Leg (Flex-GTR-latest-production)



Flex-G and Flex-GT α



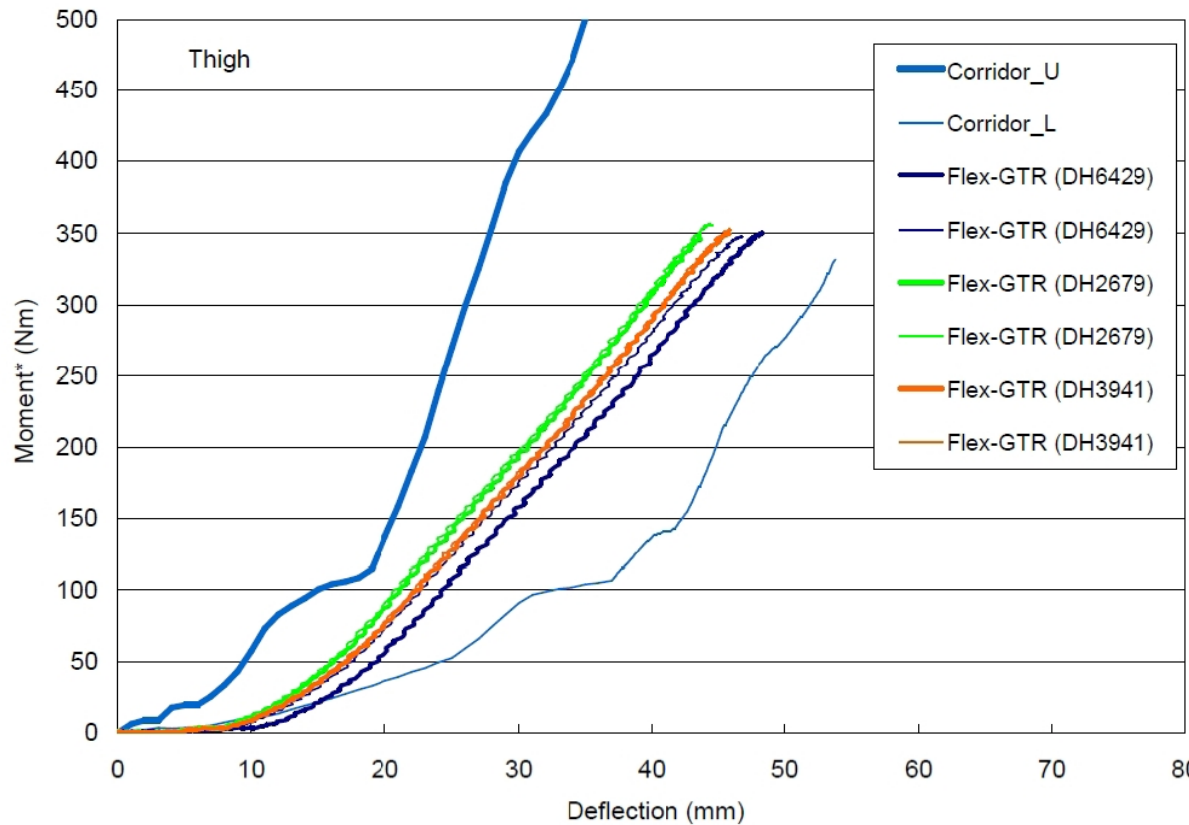
Flex-GT α (Leg) has slightly smaller bending stiffness than that of Flex-G.

BIO Testing Comparison Femur

Vinyl ester bones Sept 2011

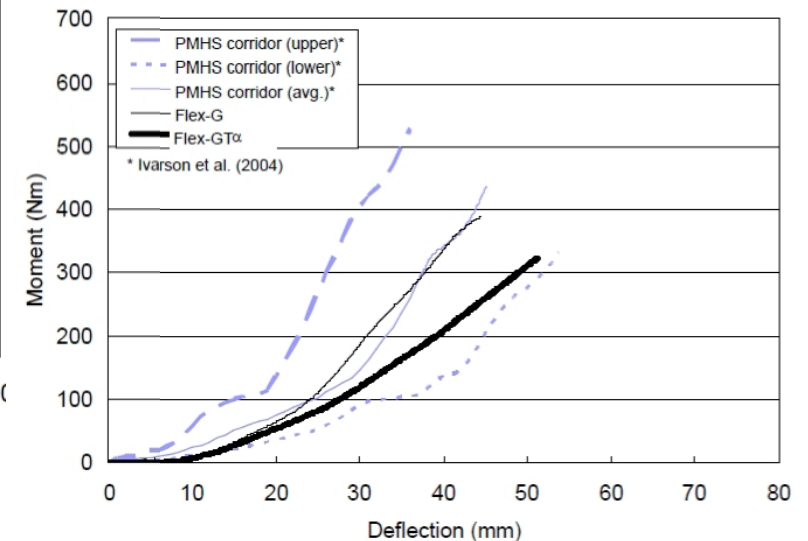
Test Results for Thigh (Flex-GTR-latest-production)

67.8 Kg, r 25mm
50mm drop



Below Flex GT and GT Alpha
with polyester bones TEG report
TEG-021 2006

Flex-G and Flex-GT α



Flex-GT α (Thigh) has slightly smaller bending stiffness than that of Flex-G.

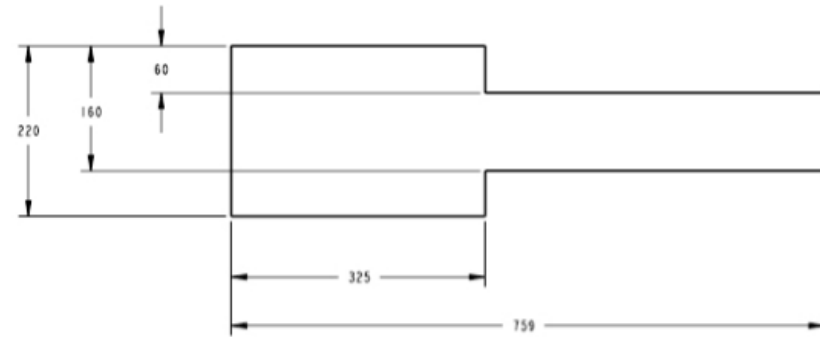
Long rubber verses short rubber effects on the Pendulum and Inverse test

- ▶ Short rubber flesh was used when Inverse upper and lower limits were developed. (146mm x 10 thick extended down tibia as leg was exposed to car bumper).
- ▶ Humanetics carried out tests to compare the difference using internal engineering leg.
 - The Long and Short rubber had more affect on the Inverse than the Pendulum tests.
 - The short rubber Tibia Inverse moments increased 3 – 6.4 Nm. The Pendulum short rubber Tibia moments increase .5 to 1.3Nm.
 - Very little effect on MCL, PCL, and ACL in both tests

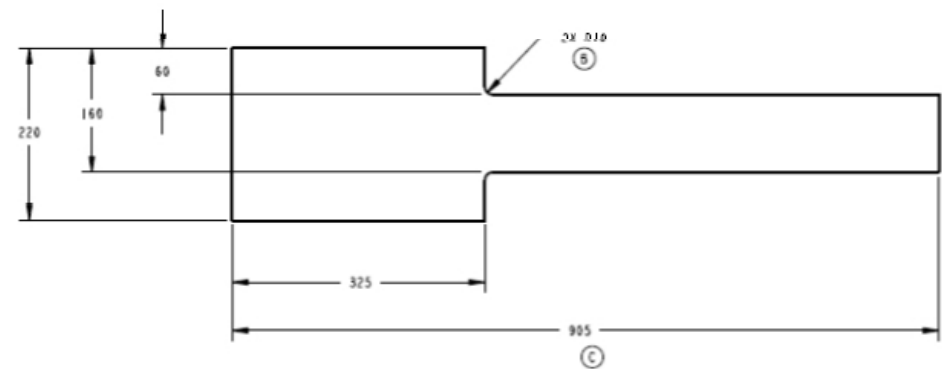
Long and Short Rubber Flesh



Photo of long flesh assembled
short rubber used 5 straps not 6



Short flesh profile

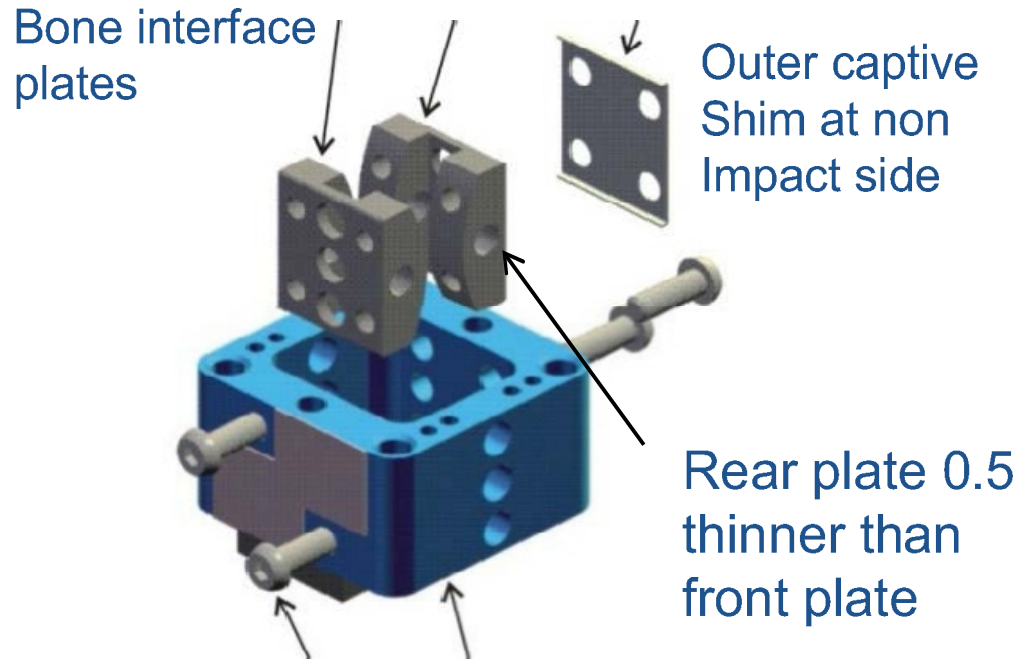


Current longer flesh profile

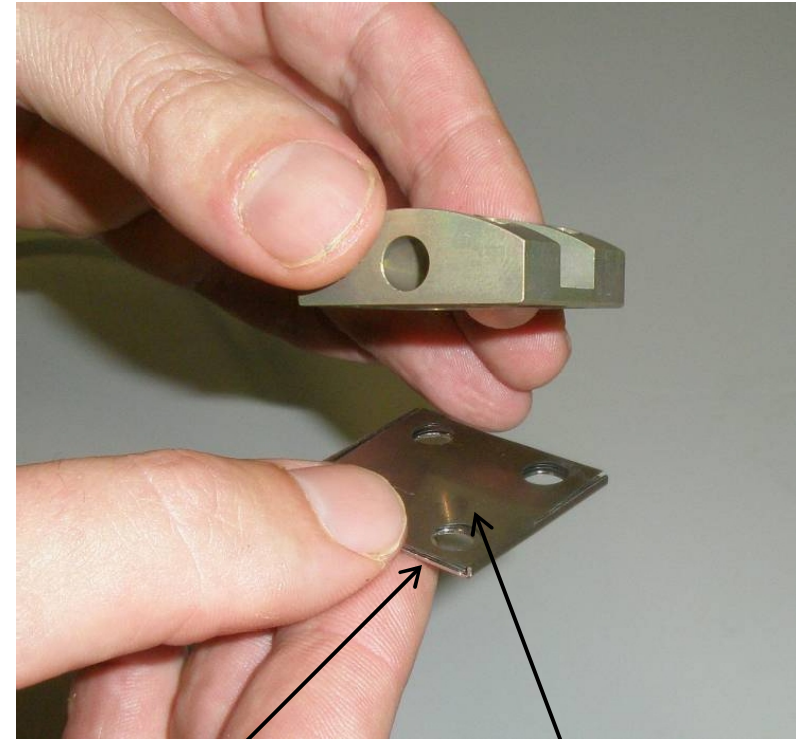
Shimming process on leg Assembly

- ▶ On any leg assembly new or old each segment is shimmed as tight as possible to allow for wear and provide a consistent build. See pictures next slide.
- ▶ With use the fit between the bone and the curved interface plates can become a little loose due to high loading to the bone and line contact with the interface plate. If the leg still certifies this less tight fit is still OK. Only when the leg fails dynamic certification would the bone need checking or replacing and then the leg would be re shimmed tight when reassembled.
- ▶ Legs can still certify with a loose fit and is not normally the reason for a failing channel.

Flex PLI Shimming detail



Typical Flex Segment



Outer captive Shim 0.4, 0.5 or 0.6 mm

Fine adjustment Shims inside captive shim options 0.05 0.1, 0.2 and 0.4 mm

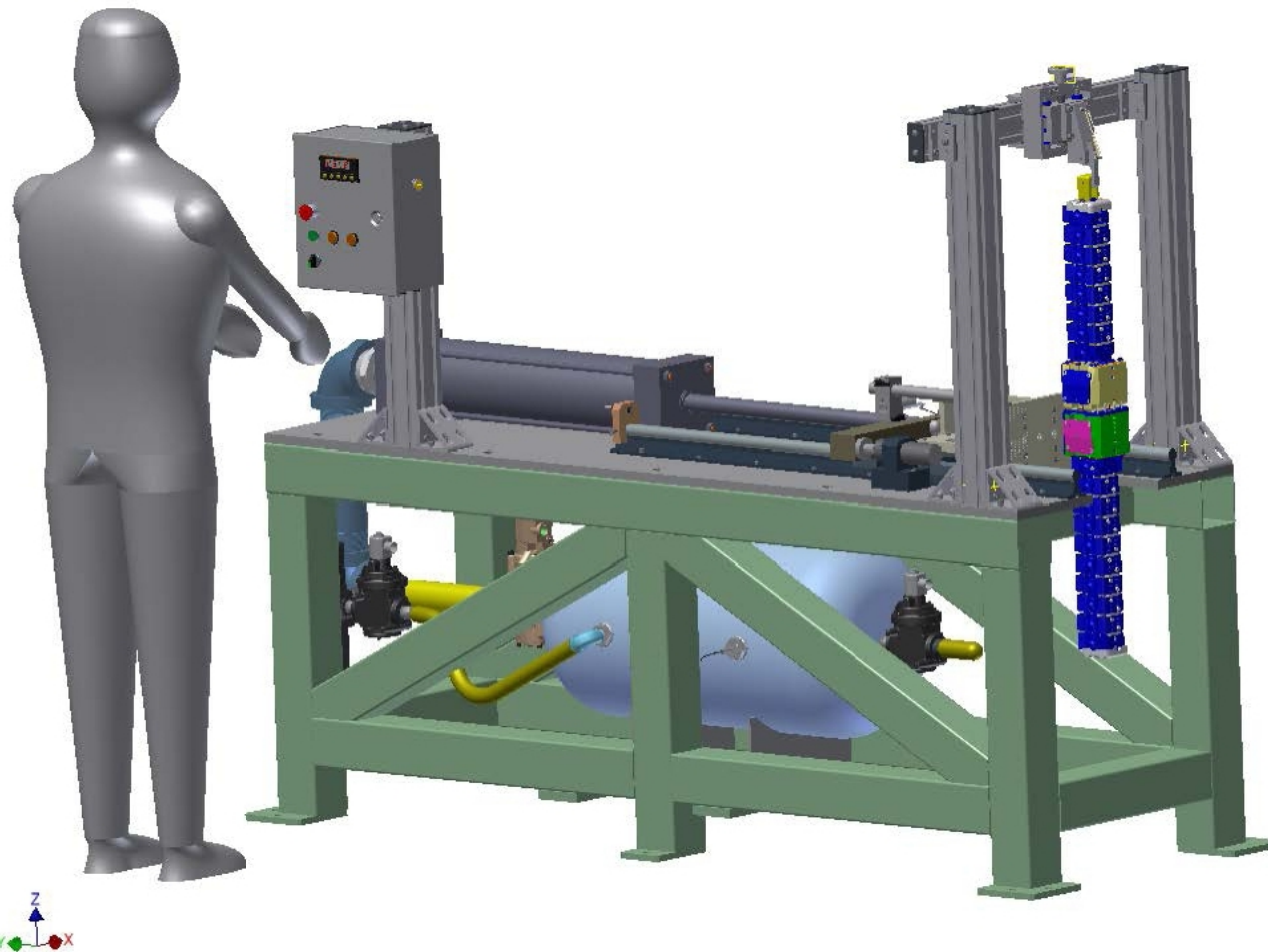
Lab to Lab Variability Pendulum

- ▶ Pendulum tests seen so far between BAST, JARI and Humanetics U.S and Japan have been reasonably comparative. Japanese responses tend to be a little higher and BAST results a little lower than Humanetics.
- ▶ We would like to see more data on pendulum which we will get from the RR. Main focus has been on inverse.
- ▶ True comparison should be without car tests in between testing to ensure no changes have occurred to the leg due to high loading. So data on this is limited

Lab to Lab Variability Inverse

- ▶ Initially the Inverse testing between Humanetics, BAST and Bertrandt have been comparative.
 - Note the use of onboard DAS will increase results by as much 2%. All legs are to be tested with onboard DAS in the future and in RR. This is how legs are sold and used.
- ▶ More Recently Humanetics has found greater differences in results between BAST and Humanetics lab results. An investigation has been started.
 - Results have been exchanged with BAST to identify and correct the problem.
- ▶ A new rig has been designed by Humanetics to increase stroke and improve stability.

Humanetics New Inverse Test Rig



TASK FORCE UPDATE

GRSP Informal Group TF

- ▶ Within the IG GTR9-PH2 a separate task force was formed TF-RUCC (Task Force-Review and Update Certification Corridors) to specifically look at the problem with the Flex GTR not meeting the current corridors.
- ▶ In our last TF meeting (27 Jan) specific detailed plans were made to run testing and present tentative corridors before the next IG meeting 28-29 March.

Task Force Work Plan

- ▶ Before the bone is gaged it has a 3 point bend test to establish its stiffness then it is ground to meet the corridor.
- ▶ JARI obtained lower stiffness on their fixture to Humanetics so we were always lower in the corridor than the original intended middle of the corridor. We had found we needed to be on the stiff side with our fixture for best results
- ▶ JARI will lend Humanetics their fixture to look at reason for fixture difference. Humanetics will prepare 6 sets of bones in middle of corridor with different batches for JARI selection.
- ▶ JARI will check Humanetics results, build 3 sets of bones and run static tests on PE sheet not rollers and present results in TF meeting 19 March.
- ▶ JARI will also check Humanetics knee assemblies, build 3 legs and run both dynamic tests and propose tentative upper and lower limits in TF meeting.
- ▶ Round robin will then start to gather results for final corridors. Testing should be completed by end on June.
- ▶ Humanetic as manufacturer will need to confirm same static bone assys as JARI

Overall Summary Informal Group task force plan to reassess current GTR corridors

Step 1: Bone Core 7 tests
Quasi-static 3-Point Bending Test
(Femur bone core, Tibia bone core)



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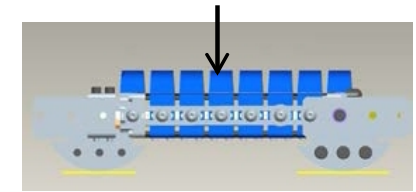
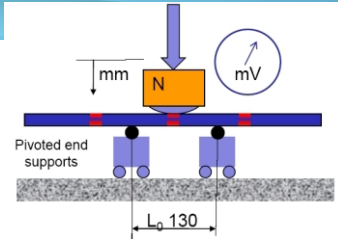
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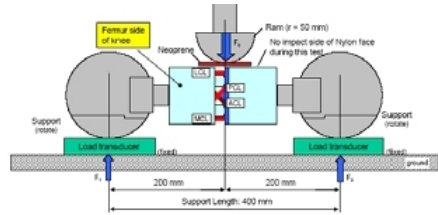


Step 4: Assembly 1 test
Femur-Knee-Tibia
Dynamic Inversion Calibration Test

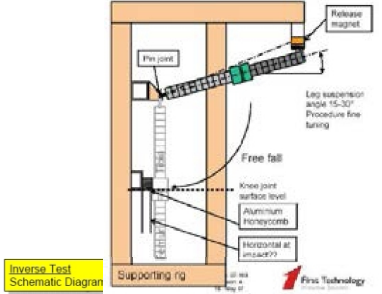


Process unchanged calculate gage sensitivity at 380 Nm (max, relaxation value)

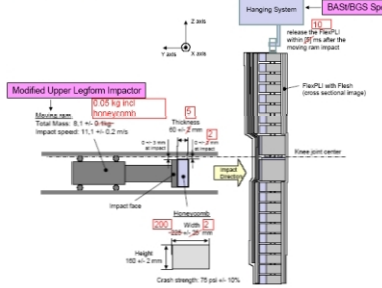
Remove roller ball carriage from below end pivots and use PE sheet. PE sheet has been proven to be stable and more repeatable



As above with PE sheet not rollers



Re-assess pendulum with revised bone set up and different bone batches. Use onboard DAS



Re-assess inverse with revised bone Set up and different bone batches. Use onboard DAS

CURRENT PRODUCTION

FLEX Pli Current Production

- ▶ The manufacture of the Flex PLI has continued.
 - Internal development has established the best bone stiffness inside the corridor to obtain the best possible combined results for both dynamic tests. Humanetics can pass GTR pendulum but moment results tend to be on the high side and MCL is always low in the corridor.
 - We cannot guarantee legs will pass inverse. Legs are being built to same build condition as RR legs so legs should meet any shift to the corridor.
- ▶ Bone biofidelity is not changing so no changes are intended to the injury thresholds.
- ▶ The intention is to adjust corridor relative to the mid value and not to widen corridors.
 - Flex PLI has tight corridors and this will be maintained as it was always intended as an improvement over the wider corridors of the EEVC WG17 leg form impactor along with improved biofidelity.

Thank you for your attention!