# HUMAN TOLERANCE TO LOWER EXTREMITIES IMPACTS

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# ABSTRACT

This paper presents the results of direct impact test on both the knee of seated and lower leg of standing unembalmed human cadavers. Variables studied in the program included impactor energy and momentum, impact force, and impact direction (axial, oblique, frontal and lateral). Multiple strain gage rosettes were applied to the femure to determine the strain distribution in the bone.

The test results indicate that the unembalmed skeletal system of the lower extremities is capable of carrying significantly greater loads than those determined in tests with embalmed subjects (the only similar data reported in the present literature). The strain analysis indicated that significant bending moments are generated in the femur with axial knee impact.

THE BONES OF THE LOWER EXTREMITIES (pelvis, femur, patella, tibia, fibula, and the bones of the foot) can be subjected to a variety of types of loads in automobile crashes. This is true for both unrestrained and restrained vehicle occupants. Improvements in the design of automobile interiors have significantly reduced some forms of lower extremity injuries (1)\*\* However, as the crashworthiness of vehicle structures is upgraded, the protective requirements of the vehicle interior must also be upgraded and optimized. The proper use of belt restraint systems has been shown to reduce lower extremity injuries. Recent developments in passive restraint systems (the Volkswagen RA passive shoulder belt (2) and the air cushion restraint system) utilize the knees and upper legs as a means of restraining the lower body in lieu of a lap belt. Optimization of such methods of occupant restraint, and the minimization of lower extremity injury in general, requires a thorough knowledge of the biomechanics of the lower extremity skeletal system. The only injury criteria presently applied to the lower extremities in occupant protection evaluation is the 1700 lb. (7560 N) maximum axial femur force limit level set forth in FMVSS 208.

The first research on the impact tolerance of the lower extremities with respect to the automobile occupant was the work of Patrick, Kroell, and Mertz (3). Unrestrained seated embalmed cadavers were impacted into instrumented chest, head, and knee targets to simulate a vehicle interior. The knee targets were covered with 1.44 in. (3.65 cm.) of padding in most cases. Fractures of the femur were produced at a load as low as 1500 lbs. (6670 N) while loads as high as 3850 lbs. (17,130 N) were sustained with no fracture of the femur, but with a fractured patella and pelvis. The majority of the femoral fractures were found to occur at the distal end of the bone. The authors concluded that failure of the femur occured at slightly lower load levels than those of either the patella or pelvis. They suggested a conservative overall injury threshold load level of 1400 lb. (6230 N). In a later paper (4) they raised this estimate to 1950 lbs. (8675 N). A feature of much of the fracture load data presented in that work was that multiple high-load-level tests were run on the subjects prior to obtaining fractures. This technique introduces the uncertainty of possible progressive predamage to the skeletal structure, particularly to the pelvis.

\*From The University of Michigan, Ann Arbor, Michigan, USA \*\*Numbers in parentheses designate References at end of paper. The most recently reported study of knee impact is that of Powell, Advani, et al. (5). Using seated embalmed cadavers, an impact load was applied to one flexed leg at a time by means of a striker pendulum with a 34.3 lb. (15.6 kg) striker head. The impact face of the striker head was a rigid flat surface. The cadaver was seated in a modified barber's chair which included back support. A total of six tests on four cadavers were reported. All but one fracture involved the femoral condyles or patella. The average failure load was 2360 lbs. (10,490 N) with a range of 1960-2810 lbs. (8730 - 12,510 N). The authors indicated that bending effects in the shaft of the femur play a significant role in femur response to longitudinal impacts; however these effects were not measured in the study.

# ACCIDENT INVESTIGATION DATA ON LOWER EXTREMITY INJURIES

The Collision Performance and Injury Reports (CPIR) (6) file at HSRI was searched for cases with pelvis and lower extremity injuries which satisfied the following conditions:

- (a) Primary damage of case vehicle front.
- (b) Case vehicle direction of primary impact force 11 o'clock to 1 o'clock.
- (c) Case vehicle had to be a passenger car.
- (d) Case vehicle collision deformation classification (CDC) had to be 1 through 5. Note: CDC of six means windshield involvement.
- (e) Only front and rear seat <u>sitting unbelted</u> passengers 12 years or older could be included.
- (f) AIS injury levels of 0, 8, and 9 for the legs and pelvis were excluded.

Out of the 13,088 cases in the CPIR file, there were 2,024 cases which satisfied the above requirements. These cases included injuries to the lower legs and the feet. Three hundred and eighty two of the cases had an AIS of 2 or more for at least a leg or the pelvis. The original Multidisciplinary Accident Investigation (MDAI) (7) data files were examined for these cases, and those which involved either knee fractures, femur fractures, or pelvis fractures were selected for an in-depth study.

The detailed study revealed 142 cases of interest, and additional information on occupant kinematics and details of upper leg and pelvis injuries were obtained. Wherever possible, detailed location and type of fractures were noted. The relative frequency of the various injuries is outlined below:

Pelvis and both femurs fractured - 2.7% Pelvis and one femur fractured - 6.3% Only pelvis fractured - 19.8% One femur fractured - 46.8% Both femurs fractured - 8.1% Only patella fractured - 16.2%

From the information obtained, it appeared that:

(a) Distal femoral and patellar fractures occur when the occupants' kinematics cause the upper legs to move generally straight ahead, impacting the instrument panel or seat back (rear passengers) with little subsequent upper body forward pitching.

(b) Hip dislocations occur when there is frontal impact combined with torso rotation to the left or right.

(c) Pelvis fractures and proximal femur fractures probably occur when there is steering wheel involvement and forward torso rotation. This is difficult to assess since exact occupant kinematics are not known. Another significant factor is that of having the femur axis at other than 90° to the torso and instrument panel.

(d) There seems to be no significant difference in the distribution of different injuries by VDI. This suggests that the location of femur fracture is mainly dependent on occupant kinematics and not severity of impact.

#### EXPERIMENTAL METHODS

IMPACT TESTS - All impact tests in this program were conducted using a pneumatically operated testing machine specially constructed for impact studies. The machine consists of an air reservoir and a ground and honed cylinder with two carefully fitted pistons. One piston is a transfer piston which is propelled by compressed air through the cylinder from the air reservoir chamber and transfers its momentum to the impact piston. A striker surface with an inertiacompensated load cell is attached to the impact piston. The impact piston is allowed to travel up to 6 inches (15.2 cm.) and then its motion is arrested by an inversion tube which absorbs the remaining kinetic energy of the piston. The desired impactor stroke can be precisely controlled by initial positioning of the impact piston with respect to the inversion tube. The impactor velocity is controlled by reservoir pressure and the ratio of the masses of the transfer and impact pistons. The load cell is a Kistler 904A piezoelectric load washer with a Kistler 805A piezoelectric accelerometer mounted internally for inertially compensating the load cell for the striker mass between the load cell and the impact surface. The mass of the impact-piston load-cell striker assembly was 45.9 lbs (20.9 kg) or 12.3 lbs (5.5 kg). The striker was a 6-inch (15.2 cm) diameter rigid disc faced veriom paddings. The output of the load cell was filtered at channel class 1000 (SAE Standard J 211). High-speed motion pictures (3000 frames/second) were taken in many of the tests with a HyCam movie camera.

#### KNEE IMPACTS

The test subjects in the knee impact program were unembalmed human cadavers. Preparation of the cadavers for testing consisted of making a careful longitudinal incision in the soft tissue of the upper leg near the distal end of the femur and spreading the tissue to expose the shaft of the femur, applying strain gages to the surface of the femur with a cyano-acrylate adhesive (M-Bond 200), and the waterproofing the installation. The gages were applied approximately 4 inches (10.2 cm) from the distal end of the femur to approximate the load cell location in test dummies. In many of the tests, two strain gage rosettes and one uniaxial gage were installed to allow the strain distribution to be determined at three points on the periphery of the femoral shaft. Following preparation, the cadaver was seated in front of the impactor and positioned with the thigh horizontal and in line with the impactor axis with the knee flexed to  $90^\circ$ (Figure 1). In some tests the thigh was not lined up along the impactor axis but was abducted (rotated laterally) relative to the axis to study oblique frontal impacts. Another variation was to abduct the thigh but orient the cadaver such that the impact axis was along the femoral axis rather than the A-P axis of the cadaver. In all knee tests the cadaver was supported such that the lower torso was free to translate rearward while being impacted. To insure relatively free motion, the cadaver was seated on two layers of polyethylene sheeting (Figure 2).



FIGURE 1: STRAIN GAGED FEMUR



FIGURE 2: TEST-SET-UP FOR KNEE IMPACTS

LOWER LEG IMPACTS - Unembalmed cadavers were also used in this study. The cadavers were supported in the standing position by the use of a Ferno Washington Model 69X Build-A-Board Orthopedic stretcher. The impact was approximately one-quarter of the way down the tibia as measured from the middle of the knee. A shoe was placed on the foot and the cadaver's foot placed on a concrete surface. The impactor for these tests was a 6-inch (15.2 cm) diameter, 6-inch (15.2 cm) long cylinder split along its length and mounted to the Cannon Impactor's shaft. The contact surface was the curved part of the cylinder (Figure 3).



FIGURE 3: TEST SET-UP FOR LOWER LEG IMPACT

### EXPERIMENTAL RESULTS

KNEE IMPACT TEST - A total of fifty-eight impact tests to the knees of twentyone cadavers have been performed in the program to date (Table 1). The results of the impact tests are summarized in Table 2 for axial knee impacts, and Table 3 for thigh abducted impacts. The most outstanding feature of the test results is the high values of impact loads tolerated by the unembalmed kneefemur-pelvis complex when compared to the existing data on embalmed subjects (3, 4, 5). No detectable failure of the patella femur, or pelvis have occurred for peak loads below approximately 3000 lbs (13.3 knt.) with the exception of two highly osteoporotic subjects (Test Nos. 76A143, 76A157, 76A163, 76A164, and 76A159), and one test series with femurs having target screw holes in the femoral shaft (Test Nos. 75A069 and 75A070).

A subfailure impact characteristically produced a double peaked wave form consisting of an initial high load peak followed by a lower, longer duration peak. In a fracture-producing impact, the second peak is greatly diminished or missing altogether.

The impulse (the area under the force-time curve) was calculated for each impact.

LOWER LEG IMPACT TEST - A total of nineteen impact tests to the lower legs of nine cadavers have been performed in the program to date (Table 1). The results of the impact tests are summarized in Table 4.

# DISCUSSION

All of the fractures produced in the study to date have been in the distal third and supracondylar region of the femur and the patella. A typical fracture is shown in Figure 4. No discernible damage has been produced in the proximal end of the femur or pelvis as determined by x-ray and dissection. In view of the findings of the accident data analysis presented earlier in this paper, the



FIGURE 4: A TYPICAL FEMUR FRACTURE

well controlled geometry of the test situation used in this study should tend to produce distal region failures. In those tests where oblique impacts were applied to the knee, it was not possible to transfer a great deal of impact momentum to the knee using the present test techniques. Instead, the upper leg would just rotate away from the impactor. Axial impacts to abducted legs still produced distal failures with no apparent damage or fracture to the pelvis or proximal end of the femur.

A plot of peak impact force versus available impactor momentum is shown in Figure 5. Examination of this plot indicates that peak load alone is not an adequate indicator of impending fracture. It appears that a sufficiently high energy or momentum level must be associated with the impact to produce fracture. In the data shown in Figure 5, the threshold momentum level appears to be between 40-50 lb-sec. (178-220 N-sec.) and the corresponding force threshold level is about 3000 lbs. (13,350 N). Impactor energy could have been used in place of momentum, but in crashworthiness testing with dummies, only forces are recorded in femur impacts and the impulse of the resulting femur load-time trace can be obtained easily. In all of the high-energy impacts conducted in this study, the available impactor momentum was transferred to the knee, as indicated by the impulse calculations, in those cases where fracture did not When fracture occurs in the cadaver knee, its load-carrying ability occur. is diminished and, with the test procedures used in this study, only part of the available momentum is indicated by the impulse calculation. Direct application of the data generated in this study to the interpretation of test dummy results cannot be made, however. Preliminary tests on a dummy indicate that, under the same test conditions used in the cadaver tests, the lack of biomechanical equivalence of the dummy knee-femur-pelvis complex produces considerably higher forces for a given impulse level.

Analysis of the strain gage data has shown pronounced bending strain distributions in the shaft of the femur under axial knee impact. The results of such an analysis are shown in Figure 6 in terms of the orientation of the neutral axis of the strain distribution with respect to the axis of the femoral neck. The eccentricity produced by the femoral neck appears to be responsible for the resulting bending strains. Driving point impedance data (7) suggest







FIGURE 6: STRAIN GAGE DATA RESULTS

that, for automotive-type impacts on the order of 5-10 msec and longer in duration, resonance effects in the femur need not be considered. The characteristic pattern shown in Figure 4 is much less comminuted than those shown by Powell, Advani, et al. (5) for embalmed bones. This may indicate the basic reason for the higher fracture loads in this study using embalmed subjects. The degree of comminution or shattering of the bone material could be interpreted as an indicator of the fracture toughness of the bone material. That is, the fracture toughness of the bone material. Moreover, the fracture toughness of embalmed bone may be much lower than that of embalmed bone and thus embalmed bone may not be a good model of the living human femur for purposes of determining loadbearing tolerance. The embalming process replaces the water in bone with the embalming chemicals and in this way could modify the bonding of the bone microstructure. Such effects would influence the fracture toughness of the bone material more significantly than it would the ultimate tensile strength or strain (8).

#### CONCLUSIONS

The results of the tests performed to date in this program indicate that the unembalmed skeletal system of the lower extremities is capable of carrying significantly greater loads than those determined in tests with embalmed subjects. The test results also indicate that load level alone is not a sufficient indicator of impending fracture conditions. It is suggested that the impulse associated with the force-time history of the impact in conjunction with the peak force produced would be a reasonable means of assessing the injury potential to the knee-femur-pelvis complex in dummy tests. However, direct application of data produced in cadaver tests to assess dummy test data cannot be made due to a lack of biomechanical equivalence in the knee impact response of existing dummies.

Analysis of the state of strain existing in the femoral shaft during axial knee impact indicates that significant bending moments are produced, while driving point impedance data of the femur indicate that femur structural resonances are not produced in padded impacts characteristic of automotive-type knee impacts into effectively designed vehicle interior structures.

The lower leg impact tests indicate lower fracture levels (approximately by 30%) than those for the knee. Impacts to the sides of the lower legs resulted in fractures much lower than those for front impacts to the lower legs.

# REFERENCES

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TABLE	1	TEST	SUBJECT	DATA

NUMBER	CADAVER NUMBER	HEIG in (	HT cm)	WEIGHT 1bs (kg)	AGE yrs.	SEX
VRIC-1	L0D*	66	(168)	149 (55.6)	90	М
VRIC-2	LOD	LOD		133 (49.6)	57	Μ
VRIC-3	LOD	69.5	(177)	178 (66.4)	51	Μ
VRIC-4	LOD	LOD		128 (47.8)	85	F
VRIC-5	L00	LOD		384 (68.7)	77	м
MVMA-2- MVMA-4	20033	LOD		LOD	62	M
74A006- 74A009	20089	64	(163)	237 (88.5)	55	м
75A033- 75A036	20122	64	(163)	150 (56.0)	45	F
75A037- 75A041	20117	70	(178)	106 (39.6)	66	м
75A055- 75A059	20166	65	(165)	155 ( <b>57.9)</b>	67	F
75A060- 75A064	20185	70	(178)	135 (50.4)	46	м
75A065- 75A066	20208	LOD		LOD	49	м
75A067- 75A070	20218	67	(170)	118 (44.0)	60	м
75A071- 75A072	20219	LOD		116 (43.3)	74	F
75A073- 75A074	20225	70	(178)	198 (73.9)	57	м
75A075- 75A078	20229	68.4	(174)	188 (70.2)	68	м
75A097- 75A <b>09</b> 8	20272	65.2	(166)	81 <b>(30.2)</b>	69	F
75A099- 75A100	20282	67.6	(172)	168 (62.7)	64	м
75A101- 75A102	20291	64.3	(163)	177 (66.1)	72	м
75A103- 75A104	20289	64.4	(164)	125 (46.7)	55	F
75A113- 75A115	20332	70.5	(179)	183 (68.3)	54	н
75A116- 75A120	20333	60	(152)	97 (36.2)	66	F
76A121- 76A124	20375	L <b>00</b>		L 00	53	M
76A126- 76A132	20401	71	(180)	179 (66.8)	65	N
76A133	20404	69	(175)	180 (67.2)	54	M
76A134	20407	67	(170)	104 (38.8)	72	F
76A135	20413	53	(135)	140 (52.3)	58	F
76A136	20418	67.2	(170.6)	198 (73.9)	88	H
76A137- 76A143	20429	60.3	(153)	48 (21.9)	89	F
76A144	20447	66.3	(168.3)	166 (61.9)	45	H
76A145- 76A151	20459	62.8	(159.5)	177 (65.9)	78	F
76A152-	20460	63.1	(160)	LOD	66	F
76A158	20400					
76A158 76A159	20468	69.5	(177)	108 (40.3)	41	м

\*LOSS OF DATA

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TABLE 2 CADAVER AXIAL WEE IMPACT DATA

NI         Z 34 ( 64)         200 ( 1201)         6 ( 49)         3.1 ( 41.)         No freezene. One fond ficolite.           V-R         R         2.1 ( 1.1)         200 ( 1792)         9.6 ( 130)         3.0 ( 130)         No freezene. One fond ficolite.           V-R         R         3.1 ( 1.1)         200 ( 1792)         9.6 ( 130)         3.0 ( 130)         No freezene. One fond ficolite.           V-R         R         3.1 ( 1.1)         200 ( 1792)         1.0 ( 1792)         2.0 ( 1792)         No freezene. One fond ficolite.           V-R         R         3.1 ( 1.1)         200 ( 1392)         1.0 ( 130)         3.1 ( 130)         No freezene. One fond ficolite.           V-R         R         3.1 ( 1.1)         200 ( 1392)         1.0 ( 100)         2.3 ( 132)         No freezene. One fond ficolite.           V-R         R         2.0 ( 1292)         2.0 ( 110)         2.3 ( 120)         No freezene. One fond ficolite.           V-2         R         2.1 ( 130)         2.2 ( 130)         1.1 ( 120)         2.3 ( 130)         No freezene. One ficolite.           V-2         R         2.0 ( 101)         1.0 ( 101)         2.3 ( 130)         1.0 ( 101)         1.0 ( 101)         1.0 ( 101)           V-2         R         2.1 ( 120)         2.1 ( 120)	TEST NUMBER	LE6	IMPACTOR VELOCITY ft/sec (m/sec)	PEAK FORCE 1b (N)	INITIAL FORCE DURA TION RS ec	ENERGY ft·lb (joules)	MOMENTUM slug-ft/sec (kg-m/sec)	COMMENTS
via         B         213 (11)         206 (120)         30 (130)         31 (131)         Mercance. One into fixabilit.           via         I         B         15 (15)         000 (1797)         31 (131)         Mercance. One into fixabilit.           via         I         B         110 (11)         000 (1797)         31 (120)         B         Mercance. One into fixabilit.           via         I         B         B         110 (11)         B         100 (100)         544(322)         Mercance. One into fixabilit.           via         B         B         110 (11)         B         100 (100)         544(322)         Mercance. One into fixabilit.           via         B         B         B         110 (11)         B         100 (11)         Mercance. One into fixabilit.           via         B         B         110 (11)         B         100 (110)         100 (110)         Mercance. One into fixabilit.           via         B         B         110 (11)         100 (110)         100 (110)         100 (110)         Mercance. One into fixabilit.           via         B         B         B         100 (11)         100 (110)         100 (110)         100 (110)           Via         B         B <td>JI-V</td> <td>_</td> <td>22.6 ( 6.9)</td> <td>2300 (10231)</td> <td>8.5</td> <td>365 ( 494)</td> <td>32.3 (143.7)</td> <td>No fracture. One inch Ensolite.</td>	JI-V	_	22.6 ( 6.9)	2300 (10231)	8.5	365 ( 494)	32.3 (143.7)	No fracture. One inch Ensolite.
1         8         1         8         1         8         1	N-IR	œ	23.3 ( 3.1)	2700 (12010)	0.9	388 ( 526)	33.3 (148.1)	No fracture. One inch Ensolite.
v.x.         1         215         0.51         336         1001         14         344         460         313         1323         100         0 </td <td>V-2</td> <td>-</td> <td>20.7 (6.3)</td> <td>4000 (17792)</td> <td>9.5</td> <td>306 (415)</td> <td>29.6 (131.7)</td> <td>No fracture. One inch Ensolite.</td>	V-2	-	20.7 (6.3)	4000 (17792)	9.5	306 (415)	29.6 (131.7)	No fracture. One inch Ensolite.
year         3.3         0.3         0.3         0.4         0.32         0.2         0.2         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0         0.0 <td>۷-3ل</td> <td>_</td> <td>21.9 ( 6.7)</td> <td>3376 (15017)</td> <td>14</td> <td>344 ( 466)</td> <td>31.3 (139.2)</td> <td>No fracture. One inch Ensolite.</td>	۷-3ل	_	21.9 ( 6.7)	3376 (15017)	14	344 ( 466)	31.3 (139.2)	No fracture. One inch Ensolite.
y-4         8         31         (1,1)         400 (1952)         8         023 (104)         54.4(32.2)         Fracture.         0ne fracture.	V-3R	œ	35.8 (10.9)	4961 (22068)	п	917 (1243)	51.2 (227.7)	No fracture. One inch Ensolite.
y-5         8         3.2         (10.4)         5800         (2446)         10         6.0         100	V-4	œ	38.1 (11.6)	4400 (19572)	80	1037 (1406)	54.44(242.2)	Fracture. One inch Ensolite.
#2         8         100         860         3850         13         100         Fracture.         One fracture.	V-5	œ	34.2 (10.4)	5500 (24465)	10	834 (1131)	48.87(217.4)	No Fracture. One inch Ensolite.
#4.3         R         BAO (19.1)         BA (17.1)         Control (19.1)         Control (19.1) <thcontrol (19.<="" td=""><td>M-2</td><td>œ</td><td>L00*</td><td>860 ( 3825)</td><td>18</td><td>L00</td><td>007</td><td>No Fracture. One inch Ensolite.</td></thcontrol>	M-2	œ	L00*	860 ( 3825)	18	L00	007	No Fracture. One inch Ensolite.
#4         8         31, (11.5)         660 (1363)         9         001 (139)         11, (130)	E-#	œ	30.0 ( 9.1)	3800 (16903)	14	638 ( 865)	42.5 (189.0)	No Fracture. One inch Ensolite.
XM006         R         12.4 (1.3.4)         600 ( 2660)         22         111 ( 150)         11.7 ( 7.1.7)         No Fracture. One fuch fasolite.           XM006         I         23.4 ( 12.5)         390 ( 153.61)         11         718 ( 97)         55.7 (15.5)         No Fracture. One fuch fasolite.           XM008         I         33.5 ( 15.5)         130 ( 153.61)         10.2 ( 137)         53.7 (15.5)         No Fracture. One fuch fasolite.           XM008         I         33.5 ( 15.5)         130 ( 155.61)         10.0 ( 123 ( 12.5)         53.7 (15.5)         No Fracture. One fuch fasolite.           XM031         R         31.4 ( 13.2.)         530 ( 155.61)         13.0 ( 156.61)         13.0 ( 156.61)         No Fracture. One fuch fasolite.           XM031         R         31.4 ( 13.2.)         530 ( 156.7)         10.0         720 ( 159.6)         31.9 ( 15.7)         No Fracture. One fuch fasolite.           XM031         R         31.4 ( 13.2.0)         530 ( 156.7)         10.1 <td>M-4</td> <td>œ</td> <td>38.1 (11.5)</td> <td>4050 (18015)</td> <td>80</td> <td>1031 (1398)</td> <td>54.1 (240.6)</td> <td>Fracture. One inch Ensolite.</td>	M-4	œ	38.1 (11.5)	4050 (18015)	80	1031 (1398)	54.1 (240.6)	Fracture. One inch Ensolite.
XM000         R         31.8 (19.7)         350 (157.1)         118 (19.7)         551 (155.7)         165 Fracture.         0ne inch Enol He.           XM000         L         24.6 (7.5)         2580 (1256)         14         41 (58)         35.0 (155.7)         166 Fracture.         0ne inch Enol He.           XM000         L         34.6 (7.5)         550 (25430)         11         102 (1372)         551 (253)         140 (151)         15.0         134.1 (181)         61.1 (12.1)         15.0         134.1 (181)         61.1 (12.1)         15.0         15.3         150 (1563)         15.4         150 (111)         15.0 </td <td>744006</td> <td>~</td> <td>12.4 ( 3.8)</td> <td>600 (2669)</td> <td>22</td> <td>(051 ) 111</td> <td>17.7 ( 78.7)</td> <td>No Fracture. One inch Ensolite.</td>	744006	~	12.4 ( 3.8)	600 (2669)	22	(051 ) 111	17.7 ( 78.7)	No Fracture. One inch Ensolite.
74000         1         24.6         (7.5)         2900         125.0         13.0         (13.7.1)         35.0         (13.5.1)         10.0         (13.7.1)         35.0         (13.5.1)         10.0         (13.7.1)         10.0         (13.7.1)         10.0         (13.7.1)         13.0         (13.2.1)         13.0         (13.2.1)         13.0         (13.2.1)         13.0         (13.2.1)         13.0         (13.2.1)         13.0         (13.2.1)         13.0         (13.2.1)         13.0         (13.2.1)         13.0         (13.2.1)         13.0         (13.2.1)         13.0         (13.2.1)         13.0         (13.0.1)         (13.0.1)	744007	~	31.8 ( 9.7)	3540 (15747)	11	718 ( 973)	45.2 (201.1)	No Fracture. One inch Ensolite.
74008         1         712         53.7         (2.8.4)         11         012         (13.2)         53.7         (2.8.4)         11         012         (13.2)         53.7         (11.5)         5510         (2.8.1)         11         012         (13.2)         33.7         (13.2)         53.7         (13.2)         5500         (13.55)         15.9         1141         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.2)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.2)         (13.2)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.1)         (13.2)         (13.2)         (13.1)         (13.1)         (13.1)         (13.2)         (13.2)         (13.2)         (13.2)         (14.1)         (13.2)         (13.1)         (13.2)         (13.1)         (13.2)         (13.2)         (13.2)         (13.2)         (14.2)         (14.2)         (14.2)         (14.2)         (14.2)         (14.2)         (14.2)         (14.2)         (14.2)         (14.2)         (14.2)         (14	74A 008	_	24.6 (7.5)	2980 (13256)	14	431 ( 584)	35.0 (155.7)	No Fracture. One inch Ensolite.
754033         R         24.5 (7.5)         1480 (553)         9.4         428 (50)         34 (15.2)         No Fracture. One finch Ensolite.           754034         R         31.4 (13.2)         3500 (1556)         15.4         16.8 (27.4.5)         Roh Fractured at trange tobil tobil.           754034         L         31.9 (13.2)         3500 (1556)         15.1         10.0         7517)         10.0         7517)         10.0         7517)         10.0         7517)         10.0         75179)         50.4 (22.4.2)         Februar fractured at target boil tobil.         Infaolite.           754070         L         31.4 (10.6)         320 (14619)         2.6         882 (1729)         50.4 (22.4.1)         No Fracture of fewr faogtue at target boil tobil.         Infaolite.           754071         R         31.4 (10.6)         2.6         886 (1093)         47.3 (23.1.1)         No Fracture of fewr faogtue at target boil tobil.         Infaolite.           754071         L         31.7 (10.3)         380 (17030)         6.6         886 (1093)         47.3 (23.1.1)         No Fracture of fewr faogte of tobil.         No Fracture of fewr faogte of tobil.           754071         L         31.7 (10.3)         381 (109.5)         51.3 (23.9.9)         No Fracture. Rigid fapactor.           7540	74A009	-	37.7 (11.5)	5510 (24510)	11	1012 (1372)	53.7 (238.4)	No Fracture. One inch Ensolite.
754034         8         41.4         (13.2)         3600 (156.9)         15.9         1341 (1818)         61.6         (234.9)         Right femur fractured at the net oit hole. 1° fisoitte.           754056         L         31.8 (3.7)         1600 (711)         12.0         430 (546)         33.9 (16.0.6)         Femur fractured at target tolt hole. 1° fisoitte.           754070         L         31.8 (10.6)         1600 (711)         12.0         400 (1901)         2.6         807 (175)         50.4 (224.2)         Feature of femur just above patella; patella           754071         R         35.4 (10.6)         300 (14618)         10.0         867 (1175)         49.7 (221.1)         No fracture of femur just above patella; patella           754071         L         31.7 (10.3)         300 (14618)         6.6         806 (1093)         47.3 (23.1.1)         No fracture of femur just above patella; patella           754073         L         31.7 (10.3)         300 (14618)         6.1         80.7 (132.1)         No fracture. No info fracture of target in tensitie.           754074         R         31.6 (10.5)         5.3         51.3 (169.5)         No fracture. No info fracture.         No fracture of femur just above patella; fracture in tensitie.           754074         L         32.4 (10.5)         53.0 (1155)	754033	~	24.5 (7.5)	1480 ( 6583)	9.4	428 ( 580)	34.9 (155.2)	No Fracture. One inch Ensolite.
754069         L         31.8         (9.7)         1630         7371         10.0         720         5460         3.3         (10.3)         6901         (1717)         12.0         403         (546)         3.3         (150.3)         Feature of farget boit hole. I* Ensolite.           754071         R         35.4         (10.3)         4090         (1878)         2.0         493         546)         3.3         (10.3)         504         17.2         330         (1478)         2.0         493         546)         3.3         (10.3)         501         17.1         12.0         493         561         17.2         51.1         No         754071         1         160         17.1         12.0         493         151         161         17.2         160         17.1         10.4         1175         530         153         169         17.2         169         17.1         10.4         1175         10.4         1175         10.4         1175         10.4         1175         10.4         1175         10.4         1175         10.4         1175         10.4         1175         10.4         1175         10.4         1175         10.4         1175         10.4         10.4         <	754034	~	43.4 (13.2)	3500 (15569)	15.9	1341 (1818)	61.8 (274.9)	Right femur fractured at the neck at knee end. Patella uninjured. One inch Ensolite.
754070         L         2.3.8         (7.3)         1600         7117)         12.0         403         546         3.3.9         (150.8)         Fmacture of femr just above patella. patella           754071         R         35.4         (10.8)         2.6         892         (1299)         50.4         22.4.2.2         Fmacture of femr just above patella. patella           754071         L         34.9         (10.6)         3300         (14678)         L00         867         (1175)         49.7         (221.1)         No fracture. Of femr inst above patella. patella           754071         L         34.9         (10.3)         860         (1031)         47.9         (231.1)         No fracture. Of femr inst above patella. patella           754073         L         34.9         (10.3)         5.3         104         (1375)         53.1         (169.5)         No fracture. Rigid impactor.           754074         R         37.8         (10.3)         38.1         (169.5)         No fracture. Rigid impactor.           754075         L         30.6         9.3         (169.5)         No fracture. Rigid impactor.           754076         L         34.2         (169.5)         No fracture. Rigid impactor.           754078	75A069	-	31.8 ( 9.7)	1690 (7517)	10.0	720 ( 976)	45.3 (201.5)	Femur fractured at target bolt hole. 1" Ensolite.
754071         R         3.4 (10.8)         4050 (18015)         2.6         892 (1709)         50.4 (224.2)         Fracture of fewr just above patellar, pateture, super, patellar, patellar, patellar, patella	75A070	-	23.8 (7.3)	1600 ( 7117)	12.0	403 (546)	33.9 (150.8)	Femur fractured at target bolt hole. 1" Ensolite.
754072         L         34.9         (10.6)         3300         (14678)         Lob         867         (1175)         49.7         (231.1)         No fracture.         One finch Ensolite.           754073         L         33.7         (10.3)         3840         (17030)         6.6         806         (1093)         47.9         (213.1)         Left patella fractured into 5 pieces.           754074         R         37.8         (11.5)         5330         (23789)         6.3         1014         (1375)         53.1         238.3         No         Right impactor.           754075         R         35.9         (8.2)         5.00         (532659)         5.6         512<(694)	754071	œ	35.4 (10.8)	4050 (18015)	2.6	892 (1209)	50.4 (224.2)	Fracture of femur just above patella; patella split vertically in 2 places. Rigid impactor.
754073         L         33.7 (10.3)         340 (170 30)         6.6         806 (1033)         47.9 (213.1)         Left patella fractured into 5 pieces.           754074         R         37.8 (11.5)         5330 (237)80         6.3         1014 (1375)         53.7 (238.9)         Right impactor.           754074         R         37.8 (11.5)         530 (237)80         6.3         1014 (1375)         53.7 (238.9)         Right impactor.           754075         R         26.9 (8.2)         500 (1632)         7.0         512 (694)         38.1 (169.5)         Mo fracture. Right impactor.           754075         L         26.9 (8.2)         3640 (1632)         6.0         664 (900)         43.4 (193.1)         Mo fracture. Right impactor.           754076         L         30.6 (9.3)         4720 (20985)         6.0         664 (900)         43.4 (193.1)         Mo fracture. Right impactor.           754076         L         30.6 (9.3)         473 (196.5)         Mo fracture. Right impactor.         1014 (197.0.1000)           754076         L         30.6 (9.30)         47.7 (196.8)         38.1 (196.9)         Mo fracture. Right impactor.           754087         L         31.5 (9.6)         Left patella fracture. Right impactor.         1014 (197.0.0000000000000000000000000000000000	754072	-	34.9 (10.6)	3300 (14678)	100	867 (1175)	49.7 (221.1)	No fracture. Ome inch Ensolite.
754074         R         37.8         (11.5)         5330         (23796)         6.3         1014         (1375)         53.7         (238.9)         Right patella fractured into 4 pieces. Right inpactor.           754075         R         26.9         8.2         5100         25655         5.6         512         6.94)         38.1         (169.5)         No fracture. Rigid inpactor.           754076         L         26.9         3.8.0         (16192)         7.0         512         6.94)         38.1         (169.5)         No fracture. Rigid inpactor.           754076         L         26.9         5.2         828         (1123)         48.5         (215.7)         No fracture. Rigid inpactor.           754078         L         34.2         (10.4)         4410         (19616)         5.2         828         (1123)         48.5         (215.7)         Left patella bruised on front; grazed on rast:           754078         L         34.2         (10.4)         4410         (19616)         5.2         828         (1123)         48.5         (215.7)         Left patella bruised on front; grazed on rast:           754078         L         34.2         (10.4)         74.7         (198.8)         No fracture: Rigid inpactor.	75A073	_	33.7 (10.3)	3840 (17030)	6.6	806 (1093)	47.9 (213.1)	Left patella fractured into 5 pieces. Rigid impactor.
754075         R         26.9         (8.2)         5100         (25635)         5.6         512         634         38.1         (169.5)         No fracture.         Rigid impactor.           754076         L         26.9         (8.2)         3640         (16192)         7.0         512         634         38.1         (169.5)         No fracture.         Rigid impactor.           754077         L         30.6         (9.3)         4720         20995)         6.0         664         900)         43.4         (193.1)         No fracture.         Rigid impactor.           754077         L         30.5         (19.616)         5.2         828         (1123)         48.5         (215.7)         Left patella bruised on front; grazed on rear;           754078         L         34.2         (10.4)         4410         (19616)         5.2         828         (1123)         48.5         (215.7)         Left patella bruised on front; grazed on rear;           754078         L         31.5         (3.6)         43.7         (198.8)         No practal bruised on front; grazed on rear;           754079         L         31.5         (3.6)         10.8         43.7         (198.8)         No practal bruised on front; grazed on rear;	75A074	œ	37.8 (11.5)	5330 (23738)	6.3	1014 (1375)	53.7 (238.9)	Right patella fractured into 4 pieces. Rigid impactor.
754076         I.         26.9 (8.2)         3640 (16192)         7.0         512 (694)         38.1 (169.5)         No fracture. Rigid impactor.           754077         L         30.6 (9.3)         4720 (20995)         6.0         654 (900)         43.4 (193.1)         No fracture. Rigid impactor.           754078         L         30.6 (9.3)         4720 (20995)         6.0         654 (900)         43.4 (193.1)         No fracture. Rigid impactor.           754078         L         34.2 (10.4)         4410 (19616)         5.2         828 (1123)         48.5 (215.7)         Left patella bruised on front; grazed on rear; grazed on rear; Rigid impactor.           754078         L         34.2 (10.4)         4410 (19616)         5.2         828 (1123)         48.5 (215.7)         Left patella bruised on front; grazed on rear; Grazed on rear; Rigid impactor.           754078         L         31.5 (9.6)         L00         L00         705 (956)         44.7 (196.8)         Supra condular fractures of femar around patella.           754078         R         29.1 (9.1)         L00         L00         705 (956)         44.7 (196.8)         Supra condular fractures of femar around patella.           754078         R         29.9 (9.1)         L00         L00         205 (3650)         42.5 (189.0)         No patella frac	754075	œ	26.9 (8.2)	5100 (22685)	5.6	512 ( 694)	38.1 (169.5)	No fracture. Rigid impactor.
754077         L         30.6 (9.3)         4720 (20995)         6.0         64 (900)         43.4 (19.1)         No fracture. Rigid impactor.           754078         L         34.2 (10.4)         4410 (19616)         5.2         828 (1123)         48.5 (215.7)         Left patella bruised on front; grazed on rear; left femur broken into 3 pieces: 1 horizontal fracture intersecting with 1 vertical split.           754078         L         31.5 (9.6)         100         100         705 (956)         44.7 (198.8)         Supra condular fractures of femur around patella.           754098         R         21.5 (9.6)         L00         100         705 (956)         44.7 (198.8)         No patella fracture: 2 <sup>n</sup> slum honeycomb plus.           754098         R         29.9 (9.1)         L00         L00         635 (861)         42.5 (189.0)         No patella fracture: 2 <sup>n</sup> slum honeycomb plus.           754098         R         29.9 (9.1)         L00         L00         635 (861)         42.5 (189.0)         No patella fracture: 2 <sup>n</sup> slum honeycomb plus.           754098         R         29.9 (9.1)         L00         L00         635 (861)         55.1 (245.1)         No patella fracture: 5 <sup>n</sup> slum honeycomb plus.           754098         R         29.9 (9.1)         100         1069 (1449)         55.1 (245.1)         1	75A076	~	26.9 (8.2)	3640 (16192)	7.0	512 ( 694)	38.1 (169.5)	No fracture. Rigid impactor.
754078         L         34.2 (10.4)         4410 (19616)         5.2         828 (1123)         48.5 (215.7)         Left patella bruised on front; grazed on rear; reft feamer broken into 3 pieces: 1 horizontal frigid impactor.           754037         L         31.5 (9.6)         L00         705 (956)         44.7 (198.8)         Supra condular fractures of feamer around patella.           754038         R         29.9 (9.1)         L00         L00         705 (956)         44.7 (198.8)         No patella fractures of feamer around patella.           754038         R         29.9 (9.1)         L00         L00         705 (956)         42.5 (189.0)         No patella fracture. 2" alun honeycomb plus           754038         R         29.9 (9.1)         L00         L00         55.5 (861)         42.5 (189.0)         No patella fracture. 2" alun honeycomb plus           754039         R         29.9 (9.1)         L00         L00         55.5 (861)         42.5 (189.0)         No patella fracture. 2" alun honeycomb plus           754039         R         29.9 (9.1)         L00         L00         55.5 (861)         42.5 (189.0)         No patella fracture. 5" alun honeycomb plus           754039         R         29.9 (9.1)         100         L00         55.1 (245.1)         Horizontal fracture. 5" alun honeycomb plus	75A077	_	30.6 ( 9.3)	4720 (20995)	6.0	664 ( 900)	43.4 (193.1)	No fracture. Rigid impactor.
754037         L         31.5 (9.6)         L00         705 (956)         44.7 (196.8)         Supra condular fractures of femm around patella.           754038         R         29.9 (9.1)         L00         635 (861)         42.5 (189.0)         No patella fracture. 2" alun honeycomb plus           754038         R         29.9 (9.1)         L00         635 (861)         42.5 (189.0)         No patella fracture. Supra condular fractures           754038         R         29.9 (9.1)         L00         635 (861)         42.5 (189.0)         No patella fracture. Supra condular fractures           754039         R         29.9 (9.1)         L00         100         635 (861)         42.5 (189.0)         No patella fracture. Supra condular fractures           754039         R         29.9 (9.1)         100         100         105 (149)         55.1 (245.1)         Hortzontal fracture of femur Just above patella.           754030         L         33.3 (10.1)         3050 (13566)         7.3         787 (1067)         47.3 (210.4)         1 hortzontal mod 1 vertical fracture of femuri           754100         L         33.3 (10.1)         3050 (13566)         7.3         787 (1067)         47.3 (210.4)         1 hortzontal and 1 vertical fracture of femuri	75A078	_	34.2 (10.4)	4410 (19616)	5.2	828 (1123)	48.5 (215.7)	Left patella bruised on front; grazed on rear; left fewur broken into 3 pieces: I horizontal fracture intersecting with 1 vertical split. Rigid impactor.
75A098         R         29.9 (9.1)         LOD         LOD         635 (861)         42.5 (189.0)         No patella fracture. Supra condular fractures.           75A098         R         29.9 (9.1)         LOD         LOD         635 (861)         42.5 (189.0)         No patella fracture.         Supra condular fracture.           75A099         R         38.8 (11.8)         4470 (19883)         8.2         1069 (1449)         55.1 (245.1)         Horizontal fracture of feaur just above patella.           75A009         R         38.8 (11.8)         4470 (19883)         8.2         1069 (1449)         55.1 (245.1)         Horizontal fracture of feaur just above patella.           75A100         L         33.3 (10.1)         3050 (13566)         7.3         787 (1067)         47.3 (210.4)         1 horizontal and 1 vertical fracture of feauri	750097	-	31.5 ( 9.6)	8	8	705 ( 956)	44.7 (198.8)	Supra condular fractures of femur around patella. No patella fracture. 2ª alum honeycomb plus 1 " Ensolite.
754059         R         38.8 (11.8)         4470 (19683)         8.2         1069 (1449)         55.1 (245.1)         Horizontal fracture of femur just above patella.           754050         L         33.3 (10.1)         3050 (13566)         7.3         787 (1067)         47.3 (210.4)         1 horizontal and 1 vertical fracture of femuri           754100         L         33.3 (10.1)         3050 (13566)         7.3         787 (1067)         47.3 (210.4)         1 horizontal and 1 vertical fracture of femuri	75A098	œ	29.9 ( 9.1)	100	8	635 ( 861)	42.5 (189.0)	No patella fracture. Supra condular fractures of femur around patella. No patella fracture. 2ª alum honeycomb, plus 1ª Ensolite.
75A100 L 33.3 (10.1) 3050 (13566) 7.3 787 (1067) 47.3 (210.4) 1 horizontal and 1 vertical fracture of femuri broke into 3 pieces. 1" Ensolite. 20° back.	75A099	œ	38.8 (11.8)	4470 (19883)	8.2	1069 (1449)	55.1 (245.1)	Horizontal fracture of femur just above patella. 1ª Ensolite. 20° back.
	754100	-	33.3 (10.1)	3050 (13566)	7.3	787 (1067)	47.3 (210.4)	<pre>1 horizontal and 1 vertical fracture of femur; broke into 3 pieces. 1" Ensolite. 20° back.</pre>

			TABLE 2	CADAVE	R AXIAL KNEE IMPAC	T DATA (CONTINUED)	
75A101	R	32.5 ( 9.9)	3520 (15657)	6.3	750 (1017)	46.2 (205.5)	No fracture. 2" Hexcel. 20° back
75A102	L	31.6 ( 9.6)	3080 (13700)	5.0	709 ( 961)	44.8 (199.3)	No fracture. 2" Hexcel and 1" Ensolite. 20° back
75A103	R	40.5 (12.3)	2900 (12899)	10.7	1165 (1580)	44.9 (199.7)	No fracture. 1 " Ensolite. 20° back.
75A104	L	40.1 (12.2)	2320 (10319)	10.7	1142 (1548)	57.0 (253.5)	Formur fractured across lower helf. No patella injury, fractured in bending. 2" Mexcel.
75A1 17	R	31.7 ( 9.7)	2600 (11565)	8.5	709 ( 961)	44.8 (199.3)	No fractures, but contusions à lacerations at point of impact. l'Ensolite.
75A118	L	32.0 ( 9.8)	2400 (10675)	7.3	740 (1003)	45.3 (201.5)	No fractures, but contusions & lacerations at point of impact. 1"
75A122	L	37.0 (11.3)	5400 (24019)	8.5	965 (1308)	52.2 (232.2)	No fracture. 1" Ensolite.
75A123	R	55.6 (16.9)	6400 (28467)	5.3	1638 (2221)	58.9 (262.0)	Patella fractured into 6 pieces. Four fractures in femur. 1" Ensolite.
76A131	R	62.0 (18.9)	3600 (16013)	4.7	1026 (1391)	33.1 (147.2)	Patella fractured; "emulsified." l" Ensolite.
76A132	L	58.8 (17.9)	L00	L00	923 (1251)	31.4 (139.7)	Patella fractured; "emulsified." l" Ensolite.
76A142	R	76.0 (23.2)	LOD	L00	1103 (1495)	29.0 (129.0)	Many fractures of condyles. 1" Ensolite.
76A143	L	65.8 (20.1)	1660 ( 7384)	4.0	827 (1121)	25.1 (111.7)	Many fractures of condyles. 1" Ensolite.
76A150	R	39.4 (12.0)	LOD	£00	1067 (1447)	54.2 (241.1)	Fractured patella. 1" Ensolite.
76A151	L	46.0 (14.0)	3000 (13344)	7.4	1502 (2036)	65.3 (290.5)	Crushed patella. 5 fractures of femur area around patella. 1" Ensolite.
76A157	R	35.5 (10.8)	1800 (8006)	5.9	895 (1213)	50.4 (224.2)	Split patella. 1/2 inch Ensolite.
76A158	L	36.7 (11.2)	1740 (7740)	4.3	957 (1298)	52.1 (231.8)	Fractured patella. Femur fractured behind knee. 1/2 inch Ensolite.
76A163	R	45.6 (13.9)	1400 (6227)	5.3	1430 (1939)	62.7 (278.9)	Fractured patella. Fracture of rear quarter of femoral condyle. 1/2 inch Ensolite.
76A164	L	41.3 (12.6)	1540 (6850)	4.7	1173 (1590)	56.8 (252.7)	Fractured patella. Fracture of lower femur around patella. 1/2" Ensolite.
*L055 0	F DAT	A					

-	_			TABLE 3	ABDUC	TED KNEE IMPACT	DATA		
TEST Number	LEG	IMPACTOR VELOCITY ft/sec (m/s	PEAK FORCE sec) 1b (N)	PEAK FORCE AXIAL COMP. 15 (N)	INITIAL FORCE DURATION msec	ENERGY ft-lb (joules)	MOMENTUM slug.ft/sec (kg.m/sec)	COMMENTS	ABOUCTION
75A035	L	25.0 ( 7.	5) 1200 (5338	) 1088 ( 4838)	13.0	445 ( 603)	17.8 ( 79.2)	No leg fracture. 1" Ensolite.	25°
75A036	L	48.6 (14.	3) 3280 (14590	) 2972 (13211)	13.1	1682 (2280)	34.6 (154.0)	No leg fracture. 1" Ensolite.	25°
75A037	L	18.7 ( 5.	720 ( 3203	) 706 ( 3140)	13.7	249 (338)	13.3 ( 59.3)	No leg fracture. 1" Ensolite.	11°
75A038	L	45.8 (14.)	)) 1860 (8274	) 1825 (8118)	10.9	1494 (2026)	32.6 (144.7)	Left patella fractured & left femur fractured & shattered at the knee end. Osteoporotic. One inch Ensolite.	11°
75A039	R	20.2 ( 6.	2) 880 (3914	) 864 (3843)	12.8	291 ( 395)	14.4 ( 63.7)	No leg fracture. 1" Ensolite.	11°
75A040	R	49.6 (15.	1) 2400 (10676	) 2356 (10480)	10.9	1752 (2375)	35.3 (157.3)	Right patella fractured & right femur fractured & shattered at the knee end. Osteoporotic. 1" Ensolite.	11°
75A058	L	32.4 ( 9.9	4330 (19261	) 4330 (19261)	35.0	750 (1017)	23.1 (102.7)	No fracture. 1" Ensolite.	25° (Axial)
75A059	R	34.7 (10.	i) <b>340</b> 0 (15124	) 3400 (15124)	18.0	858 (1163)	24.7 (109.7)	Right patella intact. Femur fractured. l" Ensolite.	25° (Axial)
7 \$A062	L	51.25 (15.0	i) 1250 ( 5560	) 1250 ( 5560)	45.0	1873 (2539)	36.5 (162.8)	No fracture. 4" Starfoam. (Extra padding) 1" Ensolite	25° (Axial)
75A063	R	51.25 (15.0	i) LOD	LOD	LOD	1873 (2539)	36.5 (162.8)	No fracture. 4" Starfoam. (Extra padding) 1" Ensolite	25° (Axial)

UNDER	LEG	DIRECTION	IMPACTOR VELOCITY ft/sec (m/sec)	PEAK FORCE 1b (N)	FORCE DURATION msec	ENERGY ft·lb (Joules)	MOMENTUM slug.ft/sec (kg.m/sec)	COMMENTS
75A055	_	Front	36.4 (11.1)	5000(22241)	6.8	940 (1274)	51.7 (230.0)	No fracture. Rigid impactor.
75A056	œ	Front	34.4 (10.5)	1660 (7384)	8.2	840 (1139)	48.8 (217.0)	No fracture. Rigid impactor.
75A057	-	Front	40.2 (12.3)	1800 (8006)	22.1	1148 (1556)	57.1 (254.0)	Fracture of tibia from 6 cm to 10 cm below knee. Rigid impactor.
75A060	~	Front	33.5 (10.2)	2200 (9786)	1.2	772 (1047)	46.1 (205.1)	Compound fracture of tibia 6" below knee, no foam.
75A061	_	Front	33.5 (10.2)	3000(13345)	5.8	772 (1047)	46.1 (205.1)	Fracture of tibia 5" from patella, no foam.
75A065	-	Front	32.6 (9.9)	1720 (7651)	13.6	(166) 121	44.8 (199.3)	No fracture. One inch Ensolite.
75A066	œ	Front	32.3 (9.8)	2000 (8896)	10.0	717 (972)	44.4 (197.5)	No fracture. One inch Ensolite.
75A067	~	Front	43.4 (13.2)	2300 (13230)	5.5	1295 (1756)	59.7 (265.6)	Compound fracture of fibula & tibia. One inch Ensolite.
75A068	_	Front	42.3 (12.9)	1690 (7517)	L00	1230 (1668)	58.2 (258.9)	Compound fracture of tibia. 1" Ensolite
75A129	_	Outside	33.8 (10.3)	2900 (12899)	8	805 (1091)	47.6 (211.7)	No fracture. Rigid impactor.
75A130	۲	Outside	37.5 (11.4)	LOD	6	991 (1344)	52.8 (234.9)	Tibia fractured completely in 2 places. One fracture of fibula. Rigid impactor.
75A140	~	Outside	35.3 (10.8)	400 (1779)	4	878 (1190)	49.7 (221.1)	Tibia fractured once. Fibula fractured twice. Bumper type.
76A141	_	Outside	30.5 (9.3)	400 (1779)	4	656 (889)	43.0 (191.3)	Tibia fractured once. Fibula fractured once. Bumper type.
76A148		Outside	26.3 (8.0)	600 (2669)	13.2	476 (645)	36.2 (161.0)	No fracture. Bumper type.
76A149	~	Inside	33.5 (10.2)	600 (2669)	6.3	772 (1047)	46.1 (205.0)	No fracture. Bumper type.
76A155	_	Inside	32.5 (9.9)	900 (4003)	9.3	726 (984)	44.7 (198.8)	Three fractures of tibia. Bumper type.
76A156	~	Inside	30.8 (9.4)	800 (3559)	9.8	652 (884)	42.4 (188.6)	Dislocation. Bumper type.
76A161	_	Outside	35.5 (10.8)	<b>500</b> (2224)	15.1	866 (1174)	48.8 (217.1)	Fractures at top front part of tibia. Bumper type.
76A162	~	Instde	27.4 (8.4)	650 (2891)	10.2	516 (700)	37.7 (167.7)	No fracture. Bumper type.