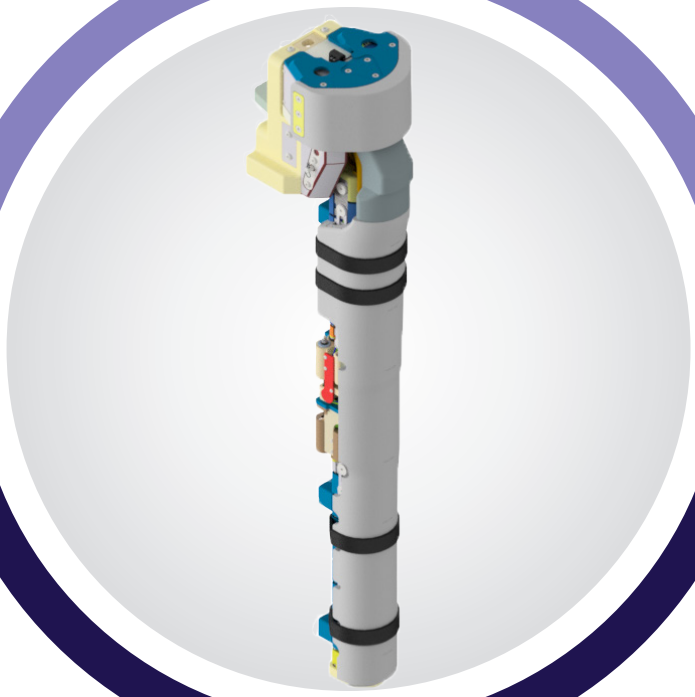
HUMANETICS

ADVANCED PEDESTRIAN LEGFORM IMPACTOR APLI 233-5000



233-9900 aPLI

USER MANUAL [Rev. 1]

HUMANETICS
23300 HAGGERTY ROAD
FARMINGTON HILLS, MICHIGAN 48335 USA

Our Vision

Global leadership in occupant safety test & measurement
for the development of safer vehicles, ultimately saving lives.

Our Mission

To achieve our vision and increase enterprise value,
our customer focused organization will:

- Attract and develop exceptional people
- Reduce performance variability of our products, systems, and services
- Continuously improve and innovate our products and services
- Invent the next generation of test & measurement products by facilitating the cooperation of industry, regulators, government, and academic institutions
- Exceed our customer's expectations of reliability, support, dependability and innovation
- Achieve supply chain and manufacturing excellence

Company & Support

Humanetics is the world's leading supplier in the design and manufacture of sophisticated crash test dummies, associated technical support and laboratory services, development and supply of finite element software dummy models for computerized crash test simulations and specialties in static and dynamic strain measurements.

Humanetics is the only full service provider worldwide offering on and off-site customer laboratory management service, training and consultancy. In addition, Humanetics' local offices and agents are capable of providing full technical support on both the physical and virtual product lines. Humanetics also has an Engineer to Order capability, catering to specific customer needs. Humanetics also designs and manufactures all applicable load cells in the crash safety area, ranging from single axis low-weight seat belt to multi-axis heavy duty crash wall load cells.

Calibration Laboratories

Crash Wall Load Cells

Dummy Load Cells

Engineer to Order Products

Localized Technical Support

Users Training

Spare Parts Management

Safety Symbols & Description

The safety instructions in this manual are structured and defined as follows:

DANGER
TYPE AND SOURCE OF DANGER
Refers to an immediately dangerous situation, which may lead to death or serious injury.

CAUTION
TYPE AND SOURCE OF DANGER
Refers to an immediately dangerous situation, which may lead to minor injuries or material damage if not prevented.

WARNING
TYPE AND SOURCE OF DANGER
Refers to an immediately dangerous situation, which may lead to death or serious injury.

NOTICE
Indicates useful tips, recommendations and information for an improved or more efficient and trouble-free operation.

General Safety Instructions

Non compliance with these general safety instructions can endanger the safety of humans (including death or serious injury), the environment and the equipment. This can lead to loss of any claims to compensation for damages.

DANGER
FATAL INJURY BY ELECTRIC SHOCK
There is a risk of electric shock when connecting the device to the power supply. Finding and removing faults on electrical components, cables, and connections may lead to accidents, including electrocution. All work on electrical connections must only be carried out by a qualified electrician in accordance with technical electrical regulations.

DANGER
SUBSTANCE RISKS
The operator must ensure that personnel are protected from material/substance hazards caused by the test set-up and procedure.

DANGER
RISK OF INJURY
There is a risk of injury due to the toppling and slipping of the device. Install the device on a industrial concrete floor with a minimum thickness of 15 cm. Position the device in the location specified and secure with suitable fastening bolts.

DANGER
RISK OF FATAL INJURY
The operator must ensure that the test device is completely visible from the operator's desk.

DANGER
RISK OF INJURIES CAUSED BY NOISE, FIRE, AND FLYING DEBRIS
The operator must ensure that personnel are protected against risks caused by the test set-up/procedure, for example, noise and fire risks or risks of injury as a result of flying debris.

Safety Symbols & Description

Additional safety symbols and descriptions:

WARNING
EXPLOSION
Refers to the risks and dangers of explosion.

WARNING
HAND INJURIES
Refers to the risks and dangers of hand injuries.

WARNING
HOT SURFACES
Refers to the risks and dangers of injury from hot surfaces.

WARNING
HIGH VOLTAGE
Refers to the risks and dangers of electric shock, possibly with fatal consequences.

WARNING
CORROSIVE
Refers to the risks and dangers of corrosion.

WARNING
ENTRAPMENT
Refers to the risks and dangers of entrapment.

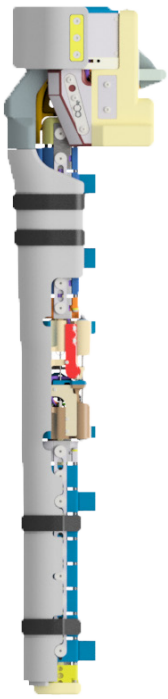
WARNING
OVERHEAD CRANE
Refers to the risks and dangers of lifted loads that can fall down or injure people.

WARNING
WEAR EYE PROTECTION
Refers to a potentially dangerous situation, which may lead to death or serious injury if not prevented.

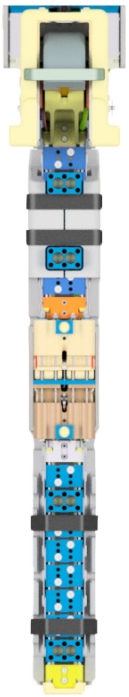
WARNING
WEAR HAND PROTECTION
Refers to a potentially dangerous situation, which may lead to death or serious injury if not prevented.

WARNING
READ INSTRUCTION MANUAL
Refers to a potentially dangerous situation, which may lead to death or serious injury if not prevented.

WARNING
WEAR FOOT PROTECTION
Refers to a potentially dangerous situation, which may lead to death or serious injury if not prevented.



LEFT



REAR

RIGHT

ISO

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SECTION 1

Introduction

1.1 The Advanced Pedestrian Legform Impactor (aPLI)

1.1.1 DEVELOPMENT HISTORY

The following features are improvements from Flex-PLI.

- **The addition of a SUBP (Simplified Upper Body Part) helps to better simulate the human body by adding mass to represent the body thus creating human like kinematics.**
- **Improved more human like bone profile.**
- **The use of disc springs in the knee helps to reduce weight. This along with lighter bone assemblies allows for a more accurate weight distribution.**
- **The LCL ligament sensor was removed from the knee since injury is not required. The ligament deflection sensors have been re-routed to be more human-like.**
- **A redesigned upper knee block includes a spherical design for the frontal lobe for 3D motion.**
- **The addition of launcher pushing blocks aids stable free flight motion.**
- **More mass was added to a one piece flesh assembly, which improves ease of assembly and provides more realistic mass distribution.**
- **Like the Flex-PLI, the aPLI has a symmetric design which allows it to be representative of either a right or left leg.**
- **Stiffer more biofidelic femur bone for injury assessment.**
- **Mass increased from 13.2 to 24.7 Kg.**

1.1.2 APPLICATION

Pedestrian legform impactors are used to evaluate pedestrian protection afforded by passenger vehicles in case of vehicle collision with a pedestrian.

1.2 Getting Familiar with the User Manual

This manual is designed to serve as a reference book for technical people working with the Advanced Pedestrian Legform Impactor (aPLI). Each assembly of the aPLI has been described in detail to assist technical personnel in the proper set-up and adjustment of the legform. The user manual has been divided into sections as outlined below:

- **Introduction**
- **Legform Preparation and Use**
- **Instrumentation**
- **Disassembly and Assembly**
- **Pretest Checks**
- **Storage**
- **Weight Specification**
- **Static Certification Procedures**
- **Dynamic Certification Procedures**

1.2.1 SECTION ORGANIZATION

Each section of this manual has been divided into dis-assembly and assembly subsections should the user wish to dismantle the leg.

1.2.2 CONVENTIONS USED THROUGHOUT THIS MANUAL

Right-hand and Left-hand

The references to the right-hand and left-hand side of a component or assembly are made with the assumption that the component is installed within the dummy. Reference is made as if the laboratory personnel is oriented in the same position as the legform.

Front and Back

The reference to front and back refers to anterior and posterior sides of the part or assembly based on the dummy reference system.

NOTICE
The aPLI Y direction is the impact direction as the leg is struck from the side (person walking across the road).

Top and Bottom

The reference to top and bottom refer to the superior and inferior sides of the part of assembly based on the dummy reference system

Dummy Coordinate System

All references made to the coordinate system of X, Y, and Z will be based on the SAE J-211 dummy coordinate system.

+X is laterally toward the left

+Y is toward anterior (front) of the dummy

+Z is toward the inferior (bottom) of the dummy

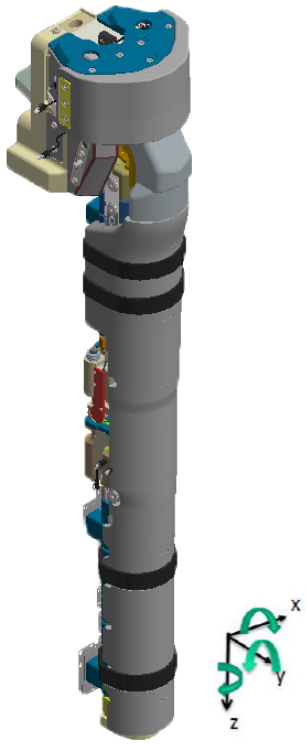


Figure 1.1 Dummy Coordinate System (SAE J1733 Issued DEC94)

SECTION 2

Dummy Preparation and Use

2.1 General

2.1.1 HARDWARE AND FASTENERS

All hardware and fasteners used on the aPLI are standard metric sizes, apart from the #2-56 SHCS used for the knee string potentiometers. The following abbreviations are used throughout this manual.

Table 2-1 Hardware and Fastener Abbreviations

Abbreviation	Description
FHCS	Flat Head Socket Cap Screw
BHCS	Button Head Socket Cap Screw
SHCS	Socket Head Cap Screw
FHCS	Flat Head Cap Screw
LHCS	(Socket) Low Head Cap Screw
SHSS	Socket Head Shoulder Screw
SSSCP	Socket Set Screw Cup Point

2.1.2 RECOMMENDED TOOLS

The following tool list includes the recommended standard tools which should be available at the test labs using the aPLI. This list will allow the laboratory personnel to make any necessary adjustments and to perform the standard disassembly and assembly procedures. These tools are listed in the table below.

Table 2-2 List of Recommended Tools

Tool Description	Size of Range
Set of “T” Handle Hex Wrenches (Ball End)	2, 2.5, 3, 4, 5, 6, 8, and 10 mm
Set of “l” Handle Hex Wrenches (Ball End)	1.5, 2, 2.5, 3, 4, 5, 6, 8, and 10 mm
Set of Straight Hex Wrenches (Screwdriver Style)	0.7, 0.9, 1.3, 1.5, 2, 2.5, and 3 mm
Open Ended Wrenches	4 and 5.5 mm (provided in tool kit)
Torque Wrench	
Wire Spacer Tool (133-5112)	(provided in tool kit)

Dummy Preparation and Use

The table below includes the contents provided in the tool kit with the leg upon delivery.

Table 2-3 Tool Kit Parts List

Item	Qty.	Part Number	Description
1	1	5000819	WRENCH, OPEN END 4mm 30° ANGLE MINI
2	1	6004602	WRENCH, OPEN END 5.5mm 30° ANGLE MINI
3	1	133-5112	WIRE SETTING TOOL
4	20	5000522	HEX NUT, M5 X 0.8 NYLOCK
5	1	6002558-13	TAPE, DOUBLE-SIDED, 50mm WIDE ROLL, 25m
6	1	6002739	FLASH DRIVE, 2GB USB, SWIVEL, HUMANETICS
7	1	233-5103	HANGER ASSEMBLY, DYNAMIC, CERTIFIED
8	40	6006010	FIR-TREE CLIP 6.5 HOLE X 2-6 THK BLACK

The strong double-sided tape included in the tool kit is used extensively on the aPLI. Humanetics recommends the use of this tape or a tape with the same strength to maintain performance.

2.1.3 TORQUE VALUES

The following table indicates the required torque values for various bolts used in the aPLI assemblies. For fasteners not listed, engineering judgment should be used to arrive at a “reasonable snug” torque which will prevent the fastener from vibrating loose during impact.

Table 2-4 Torque Requirements

Description	Torque (Nm)
All SUBP M10 SHCS	25
Attachment at pivot washer M8 FHCS	3
Attachment at curved impact face M6 BHCS	4
Attachment at curved impact face M8 SHCS	10
Attachment at meniscus plate M5 LHCS	3
Leg attachment to knee front M8 BHCS	8
Leg attachment to knee rear M8 SSSFP	8
All M6 X 16 BHCS	8
All M8 X 12 SSSCP	8
All M6 FHCS	3
Shoulder link screws (stepped bolts)	3

2.1.4 CABLE COLOR CODE

The following table describes the color code for the different cable types that are used in this manual.

Table 2-5 Cable Type Color Code

Cable Type	Color
Bones	Lime Green
Accelerometers	Orange
Angular Rate Sensors	Blue
Potentiometer	Purple
DAS	Light Gray

2.2 Dummy Serial Number

A serial number is designated to each legform. This serial number should be used as a reference during any correspondence regarding the use of the aPLI. The serial number is located at the top of the SUBP top housing (233-5166).

2.3 Dummy Handling

The travel pin should always remain installed when not performing testing unless the upper body mass is being disassembled or assembled. When the pin is removed, the SUBP can rotate freely. This free movement can cause injury to hands and fingers of the user if proper care is not taken. Before removing the pin, the SUBP and femur assemblies should be properly supported to reduce the risk of injury to the handler.

WARNING
The leg weight is 25 Kg (over 50 lbs). For safety reasons, it is advised the leg should be handled by two people when moving the leg.

SECTION 3

Instrumentation

3.1 Standard 18-Channel Instrumentation

The standard aPLI is offered with a SLICE Nano Data Acquisition System (DAS), with 18 channels of instrumentation. The channels intended for injury assessment are the three femur bending moments, the four tibia bending moments, the knee medial collateral ligament (MCL), anterior cruciate ligament (ACL), and posterior cruciate ligament (PCL) elongations. These channels are controlled by the certification procedures given in section 9.

The standard instrumentation is listed in the table below.

Table 3-1 Standard 18-Channel Instrumentation

Location	Instrumentation	Purpose	Standard
SUBP	SUBP acceleration, X	Leg performance	1
	SUBP acceleration, Y	Leg performance	1
	SUBP acceleration, Z	Leg performance	1
	SUBP angular velocity, X	Leg performance	1
	SUBP angular velocity, Y	Leg performance	1
	SUBP angular velocity, Z	Leg performance	1
Femur	Femur moment 1, 2, and 3	Injury assessment	3
Knee	Knee acceleration, Y	Leg performance	1
	Knee angular velocity, X	Leg performance	1
	MCL elongation	Injury assessment	1
	PCL elongation	Injury assessment	1
	ACL elongation	Injury assessment	1
Tibia	Tibia moment 1, 2, 3, and 4	Injury assessment	4
		Total	**18**

Instrumentation

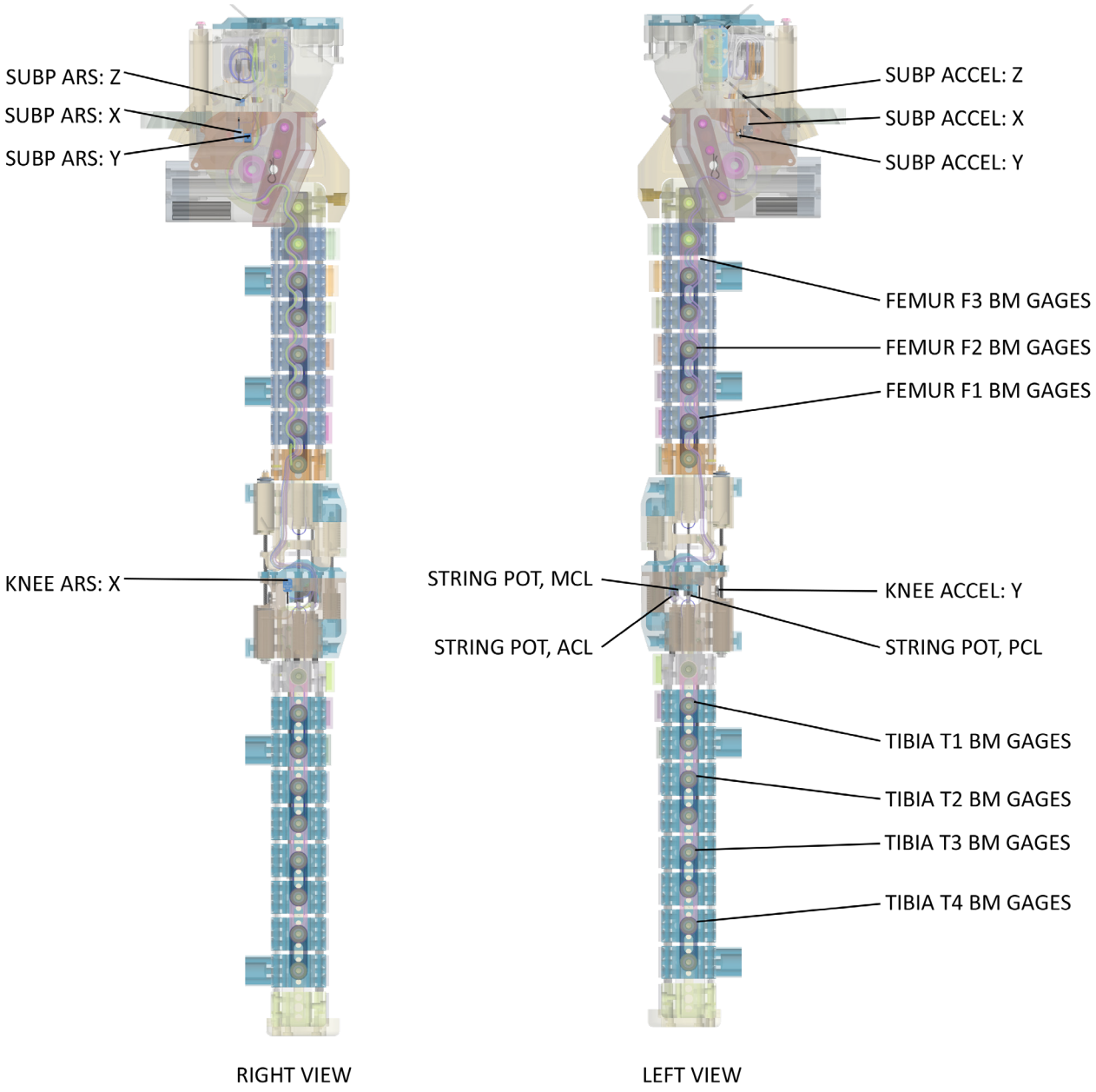


Figure 3.1 Location of aPLI Instrumentation

Table 3-2 Instrumentation Parts List

Location	Qty.	Part Number	Description	Channel(s)	Bridge	SLICE/Bridge Part Number
SUBP	1	61-123-05-200-5V	SUBP ACCEL, X	AX	BR5-70	TE-6002011-70
	1	61-123-05-200-5V	SUBP ACCEL, Y	AY	BR5-70	
	1	61-123-05-200-5V	SUBP ACCEL, Z	AZ	BR5-70	
	1	61-703-05-09-D0	SUBP ARS, X	RX	BR3-155	TE-6002105
	1	61-703-05-09-D0	SUBP ARS, Y	RY	BR3-155	
	1	61-703-05-09-D0	SUBP ARS, Z	RZ	BR3-155	
FEMUR	3	233-5165	FEMUR UPPER MOMENT	MX	BR2-155	TE-6002010-155
			FEMUR MIDDLE MOMENT	MX		
			FEMUR LOWER MOMENT	MX		
	1	61-507A-05-950-00-5V	KNEE STRING POT, MCL	DZ	BR4-70	TE-6002011-70
	1	61-123-05-1000-5V	KNEE ACCEL, Y	AY	BR4-70	
	1	61-503A-05-1150-00-5V	KNEE STRING POT, ACL	DZ	BR6-70	TE-6002011-70
	1	61-507B-05-1150-00-5V	KNEE STRING POT, PCL	DZ	BR6-70	
	1	61-703-05-08-D0	KNEE ARS, X	RX	BR6-70	
TIBIA	3	233-5565	TIBIA UPPER MOMENT	MX	BR1-45	TE-6002010-45
			TIBIA UPPER MIDDLE MOMENT	MX		
			TIBIA LOWER MIDDLE MOMENT	MX		
	1	233-5565	TIBIA LOWER MOMENT	MX	BR4-70	TE-6002011-70

3.2 Optional Instrumentation

The aPLI can be adapted for optional instrumentation. An example is using accelerometers for local force measurement. When running regulatory tests with optional instrumentation it is recommended to check that the total mass of the tool, including a certain amount of cable length, does not exceed any regulatory requirement.

3.3 ISO MME Codes

For the identification of sensor channels and for computer processing of signals the following codes have been established for ISO MME.

Table 3-3 ISO MME Codes

Location (Desc.)	Category	Test Object	Pos.	Transd Main Loc.	Fine Loc. 1	Fine Loc. 2	Fine Loc. 3	Physical Dim.	Direction	Filter Class
Pelvis Acceleration, X	Standard	D	0	PELV	00	00	PM	AC	X	P
Pelvis Acceleration, Y	Standard	D	0	PELV	00	00	PM	AC	Y	P
Pelvis Acceleration, Z	Standard	D	0	PELV	00	00	PM	AC	Z	P
Pelvis Angular Velocity, X	Standard	D	0	PELV	00	00	PM	AV	X	P
Pelvis Angular Velocity, Y	Standard	D	0	PELV	00	00	PM	AV	Y	P
Pelvis Angular Velocity, Z	Standard	D	0	PELV	00	00	PM	AV	Z	P

Location (Desc.)	Category	Test Object	Pos.	Transd Main Loc.	Fine Loc. 1	Fine Loc. 2	Fine Loc. 3	Physical Dim.	Direction	Filter Class
Femur Upper Moment, X	Standard	D	0	FEMR	UP	00	PM	MO	X	P
Femur Middle Moment, X	Standard	D	0	FEMR	MI	00	PM	MO	X	P
Femur Lower Moment, X	Standard	D	0	FEMR	LO	00	PM	MO	X	P
Knee Acceleration, Y	Standard	D	0	KNEE	00	00	PM	AC	Y	P
Knee Angular Velocity, X	Standard	D	0	KNEE	00	00	PM	AV	X	P
Knee MCL Elongation	Standard	D	0	KNEE	MC	00	PM	DS	0	P
Knee PCL Elongation	Standard	D	0	KNEE	PC	00	PM	DS	0	P

Location (Desc.)	Category	Test Object	Pos.	Transd Main Loc.	Fine Loc. 1	Fine Loc. 2	Fine Loc. 3	Physical Dim.	Direction	Filter Class
Knee ACL Elongation	Standard	D	0	KNEE	AC	00	PM	DS	0	P
Tibia Upper Moment, X	Standard	D	0	TIBI	UP	00	PM	MO	X	P
Tibia Middle Upper Moment, X	Standard	D	0	TIBI	MI	UP	PM	MO	X	P
Tibia Middle Lower Moment, X	Standard	D	0	TIBI	MI	LO	PM	MO	X	P
Tibia Lower Moment, X	Standard	D	0	TIBI	LO	00	PM	MO	X	P

3.3.1 SIGNAL POLARITY, SENSOR FUNCTION CHECK

The leg can be manipulated manually to test polarity and function for positive output. A spacer can be placed under the leg to assist in the bending of the leg. The positive outputs shown in the table below are preferred for standardization; users can use their own polarity if required.

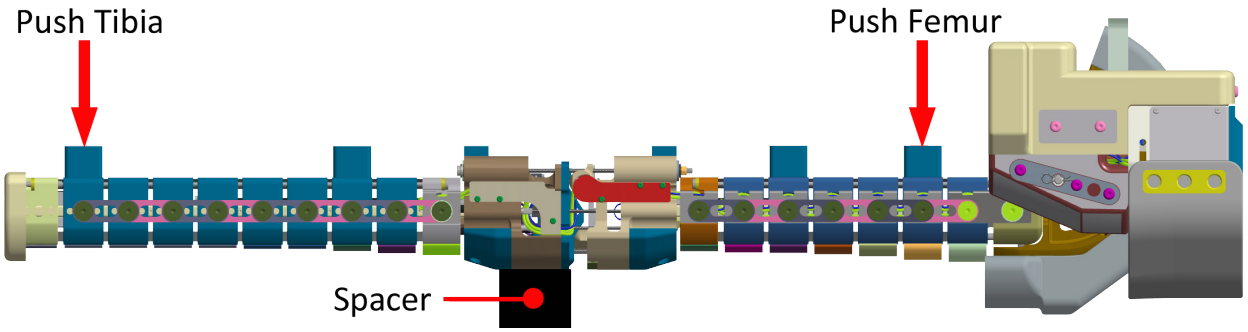


Figure 3.2 Leg Manipulations for Positive Output (Impact Side Down)

Table 3-4 Standard Polarity Based on Figure 3.1

Sensor	Polarity
MX Tibia	+ out
MX Femur	+ out
MCL	+ out
PCL	+ out
ACL	+ out

For accelerometers signal polarity, a blow in the direction of the positive axis should result in a positive acceleration output. Similarly, a blow in the direction of the negative axis should result in a negative acceleration output. Example: a blow (with a rubber mallet) on the knee in the negative y-direction, should result in a negative y-acceleration.

Table 3-5 Angular Velocity

Sensor	Manipulation	Output
UPPER MASS ANGULAR VELOCITY X	ROTATE UPPER MASS POSITIVE IN X AS PER FIGURE 1.1	POSITIVE
UPPER MASS ANGULAR VELOCITY Y	ROTATE aPLI POSITIVE Y AS PER FIGURE 1.1	POSITIVE
UPPER MASS ANGULAR VELOCITY Z	ROTATE aPLI POSITIVE Z AS PER FIGURE 1.1	POSITIVE
KNEE ANGULAR VELOCITY X	ROTATE aPLI POSITIVE X AS PER FIGURE 1.1	POSITIVE

3.3.2 FILTER CLASS

The filter class to be used on the aPLI is CFC180 for all channels.

3.4 Cable Routing

The legform has been designed such that all sensors plug into the DAS on the left-hand side of the SUBP. There are channels within the femur, knee, and tibia assemblies so that the instrumentation cables can be routed up the sides of the legform and across the SUBP.

3.5 Data Acquisition

Humanetics can provide onboard DAS systems from DTS SLICE nano, Mesring, and MG sensors. This section is provided in the manual for information only. For detailed and up to date information on DAS systems, please refer to the original DAS equipment manufacturer.

Routed up the right side of the leg are the 3 channel femur, knee ARS, PCL and ACL cables. The cables from two slice bridges are routed across the top of the SUBP top housing to the pocket on the right-hand side of the SUBP housing. In the right side pocket, the femur cable, along with the SUBP ARS cables, plug into the DAS. The knee ARS, PCL, and ACL cables are routed across the SUBP and plug into the DAS in the left side pocket. The 3 channel and 1 channel cables from the tibia are routed up the left side of the leg, as well as the MCL and knee accel. These cables, along with the SUBP accels, plug into the DAS on the left side.

On the right side are a three channel wire for the femur bone, and 6 single channel wires for the ACL and PCL string pots, and knee and SUBP angular rate sensors. On the left side are a three channel and single channel wire for the tibia bone, and 5 single channel wires for the MCL string pot, as well as the knee and SUBP accelerometers.

3.6 DTS Onboard SLICE Nano DAS

For detailed use and specifications please refer to supplier’s user instructions.

The SLICE is a modular system where a 3-channel bridge SLICE can be stacked onto a base SLICE; in this case one base SLICE handles 18 channels of data. As the aPLI has limited space to package the SLICE stack a mounting board has been designed by DTS to link six bridges together allowing one base SLICE to be used. The unit is fixed using four M3 screws. Sensor connection to the DAS is via either 7 or 16 pin round miniature connectors for 18 channel wiring arrangement. After disconnect launch, the DAS is powered by a DTS supercap+ mounted on the opposite side of the SUBP from the DAS. The super capacitor is quickly charged when reconnected. The wire disconnect can be a round 12 pin connector or a magnet connector hard mounted to the top of the SUBP. This disconnect position allows disconnect in the push phase from the launcher to avoid the connector affecting free flight stability. On reconnect the test data can be downloaded to a PC.

If required there is provision to wire in a tape switch for T=0, a wire is provided for this option out of the super cap housing.

Top Level Assembly

4.1 Top Level Assembly

4.1.1 TOP LEVEL PARTS LIST

The top level aPLI assembly, 233-5000-S18 exploded view is shown below.

WARNING

The leg weight is 25 Kg (over 50 lbs). For safety reasons, it is advised the leg should be handled by two people when lifting the leg.

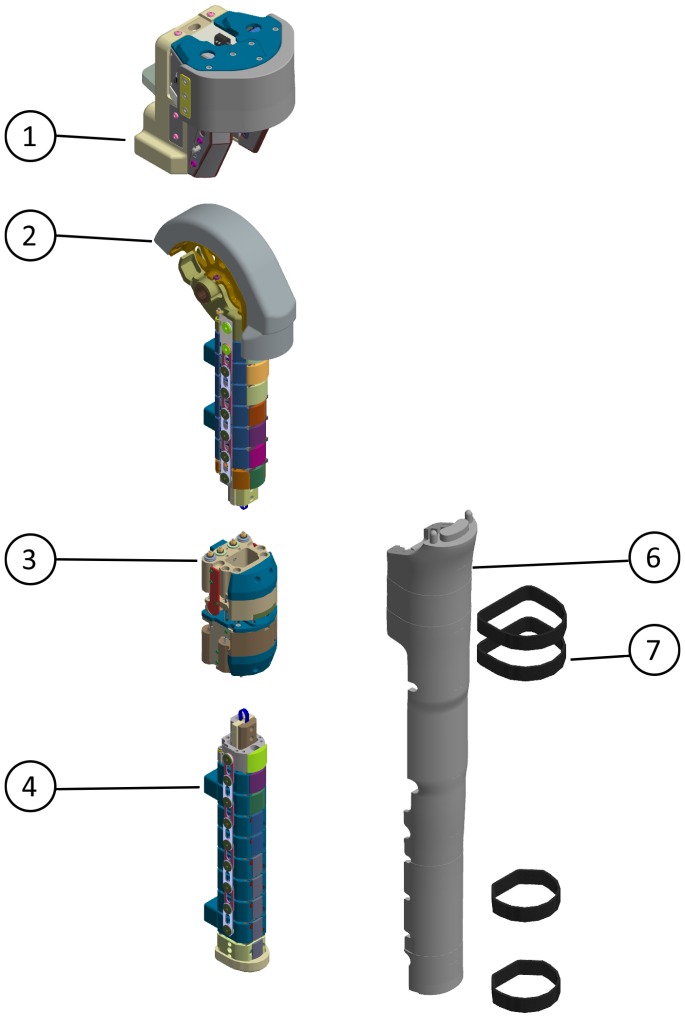


Figure 4.1 aPLI Assembly Exploded View

Top Level Assembly

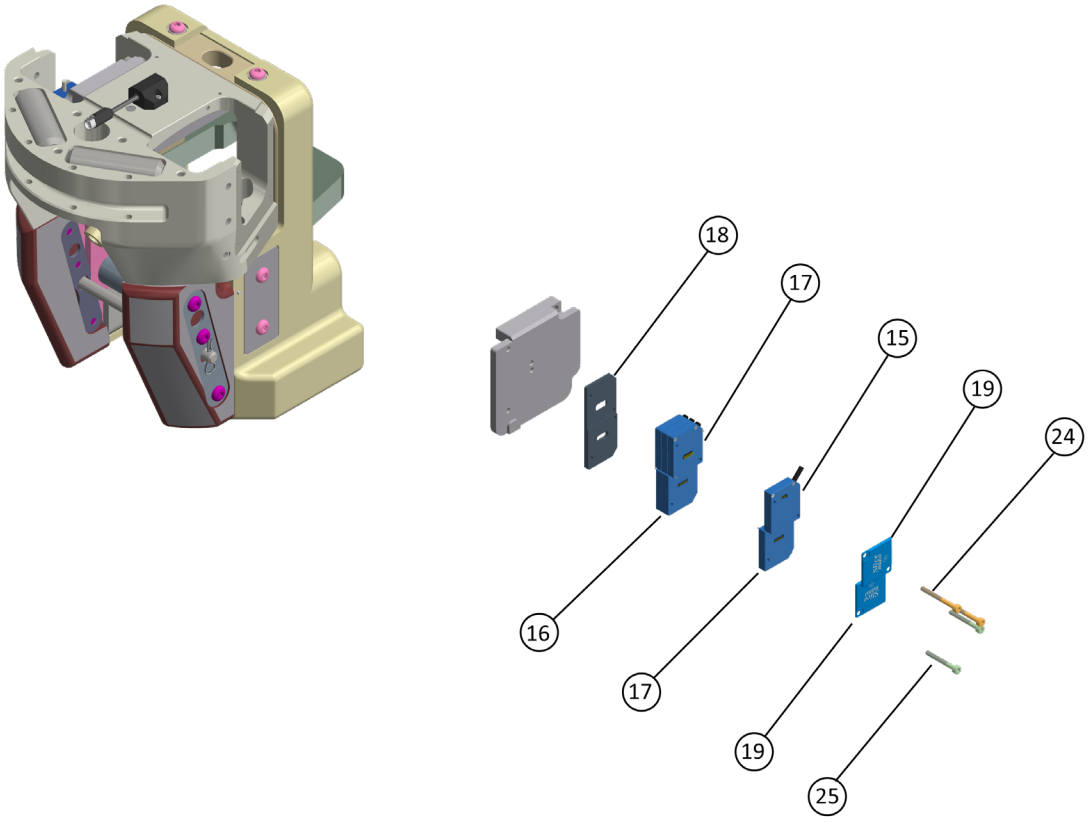


Figure 4.2 DAS Top Level Exploded View 1

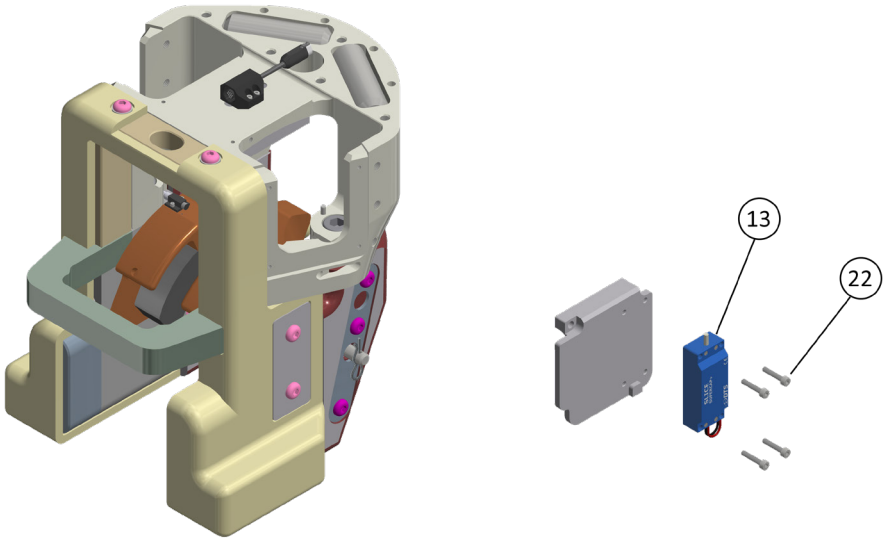


Figure 4.3 Supercap Top Level Exploded View 2

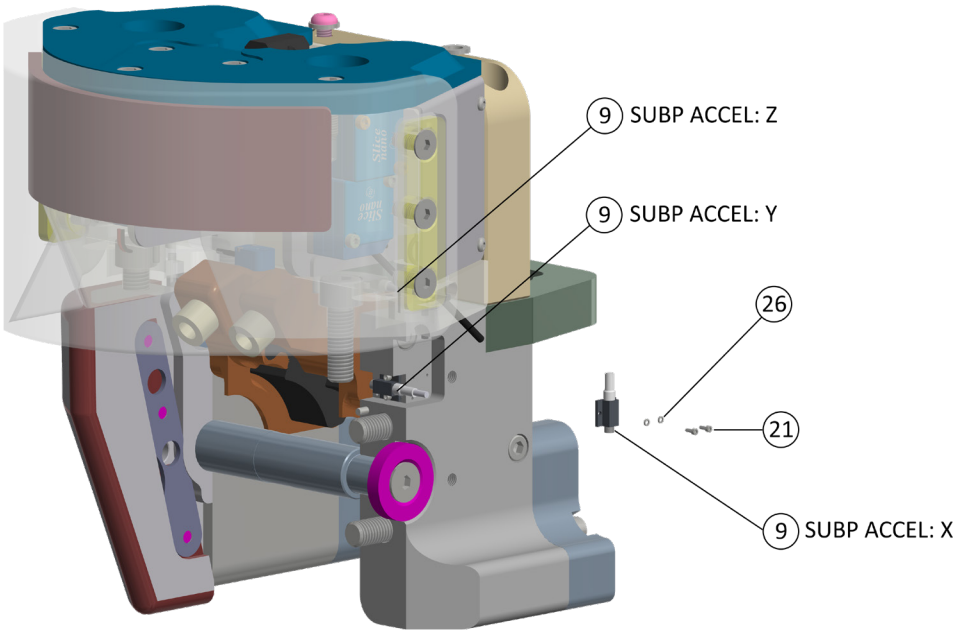


Figure 4.4 Accelerometers SUBP Top Level Exploded View 3

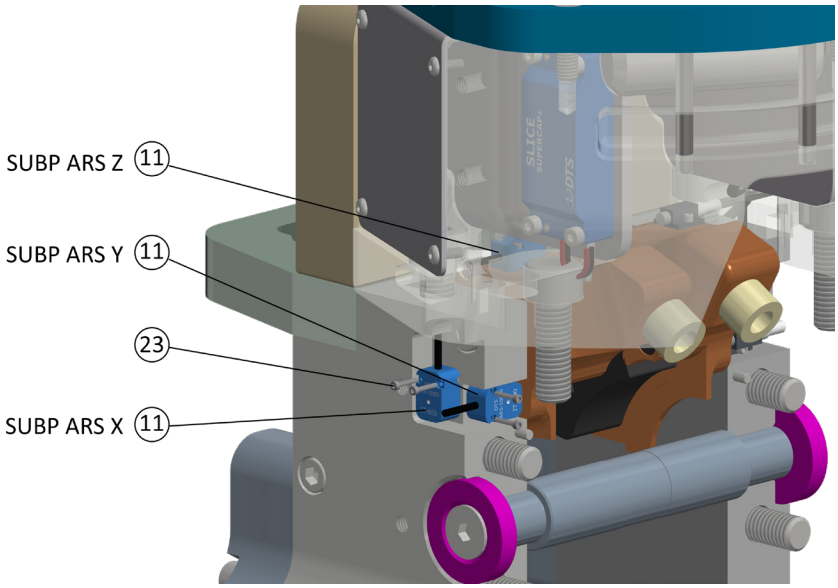


Figure 4.5 ARS SUBP Top Level Exploded View 4

Top Level Assembly

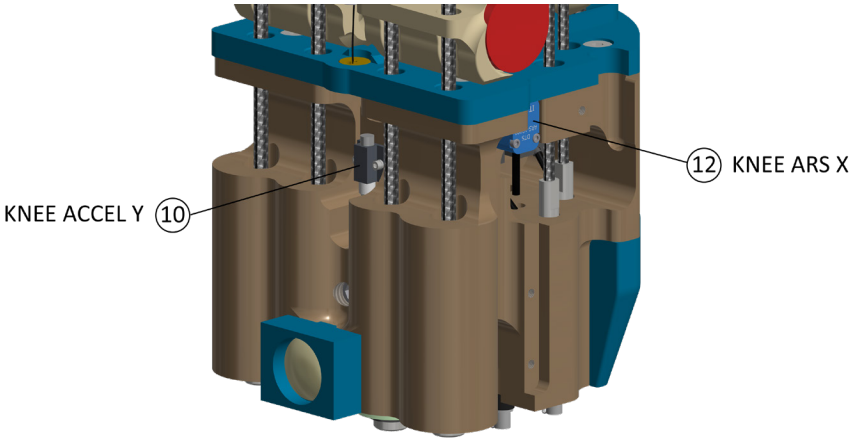


Figure 4.6 Accelerometer and ARS Knee Top Level Exploded View 5

Table 4-1 aPLI Top Level Assembly Parts List

Item	Qty.	Part Number	Description
1	1	233-5150	aPLI SUBP ASSEMBLY
2	1	233-5100	aPLI FEMUR ASSEMBLY, TESTED/CERTIFIED
3	1	233-5300	aPLI KNEE ASSEMBLY, TESTED/CERTIFIED
4	1	233-5500	aPLI TIBIA ASSEMBLY, TESTED/CERTIFIED
5	1	233-5250	FLESH COVER ASSEMBLY (NOT SHOWN)
6	1	233-5260	WEIGHTED FLESH ASSEMBLY
7	4	6005983	CABLE TIE HOOK & LOOP 1” X 24” BLACK
8	1	233-TOOL-KIT	TOOL KIT (NOT SHOWN)
9	3	61-123-05-200-5V	7264C-2000TZ ACCEL, 200mm, SLICE, SUBP
10	1	61-123-05-1000-5V	ACCEL, 7264C-2000TZ, 1000mm CBL, SLICE, KNEE Y
11	3	61-703-05-09-D0	ARS PRO 18K, 200mm CBL, SLICE, SUBP
12	1	61-703-05-08-D0	ARS PRO 18K, 1120mm CBL, SLICE, KNEE X
13	1	TE-6002144	SLICE SUPERCAP+ (200mm UP; 80mm PIGTAIL)
14	1	TE-6002190	EXIT CABLE, 8cm
15	1	TE-6000201-XX	SLICE NANO BASE 10cm, 10cm
16	1	TE-6002010-45-XX	SLICE NANO BRIDGE, 45mm
17	1	TE-6002010-155-XX	SLICE NANO BRIDGE, 155mm
18	3	TE-6002011-70-XX	SLICE NANO BRIDGE, 70mm
19	1	TE-6002105	SLICE NANO BRIDGE, 155mm CABLES
20	1	TE-6002012	SLICE NANO STACK EXTENDER
21	2	TE-6002115	SLICE NANO COVER
22	3	5000456	M2.5 X 0.45 X 10 LG. SHCS
23	8	5000375	M1.4 X 0.3 X 4 LG. SHCS
24	4	5000437	M3 X 0.5 X 16 LG. SHCS
25	8	5000727	M1.4 X 0.3 X 8 LG. SHCS
26	2	5000986	M3 X 0.5 X 30 LG. SHCS
27	2	5001057	M3 X 0.5 X 25 LG. SHCS

Item	Qty.	Part Number	Description
28	8	9000552	#0 FLAT WASHER
29	10	6006010	FIR-TREE CLIP 6.5 HOLE X 2-6 THK BLACK (NOT SHOWN)

4.1.2 DISASSEMBLY OF LEG SEGMENTS

This section describes how to disassemble body segments from the legform and assemble them back. For further work on each sub-segment, refer to the relevant sub-segment section of this manual. As a precaution, make sure to keep the leg on a stable surface during disassembly.

The leg can be broken down into five sub-assemblies: Simple Upper Body Part (SUBP), femur, knee, tibia, and molded flesh. Before any sub-assembly can be disassembled, the sensors must be disconnected from the DAS, which is in the SUBP. Therefore, the SUBP should always be the first sub-assembly to be disassembled.

The following is a step-by-step description of the disassembly procedure for the top assembly.

1. **Remove the flesh cover assembly (233-5250).**
2. **Undo the four cable tie hook & loop straps (6005983) and remove the weighted flesh assembly (233-5260) from the leg.**

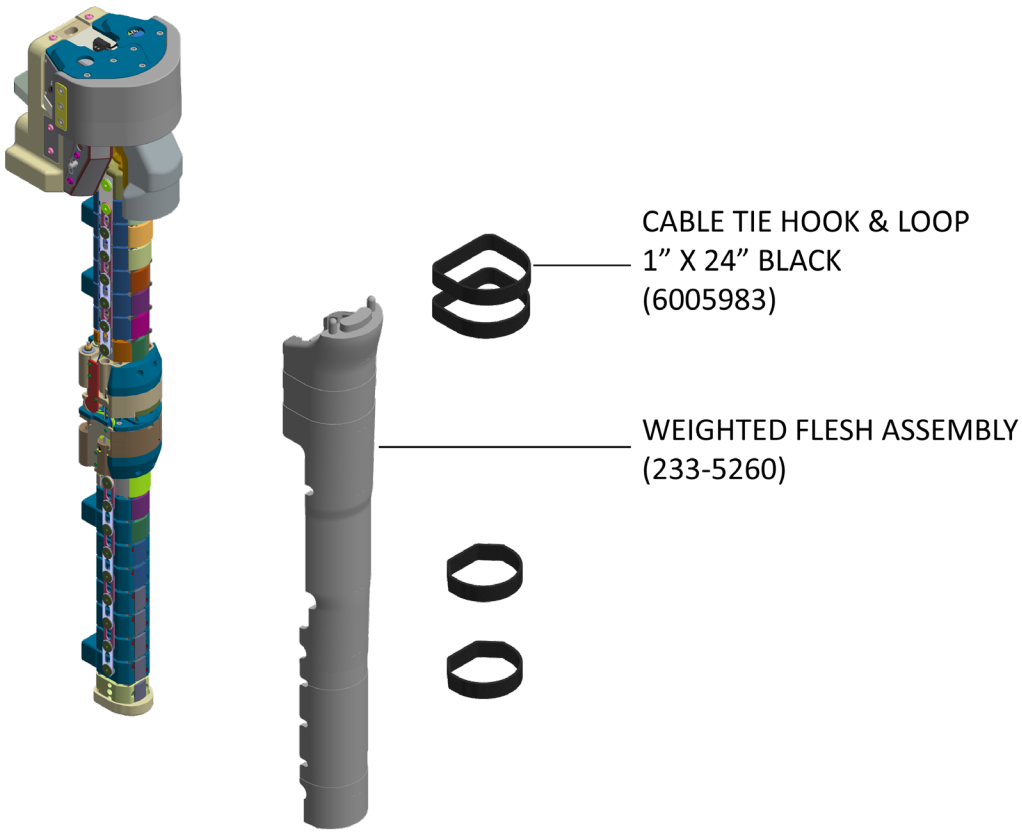


Figure 4.7 Remove the Cable Ties and Weighted Flesh

3. **Remove five M6 X 16 SHCS from the cover top plate (233-5151) and remove from the assembly.**

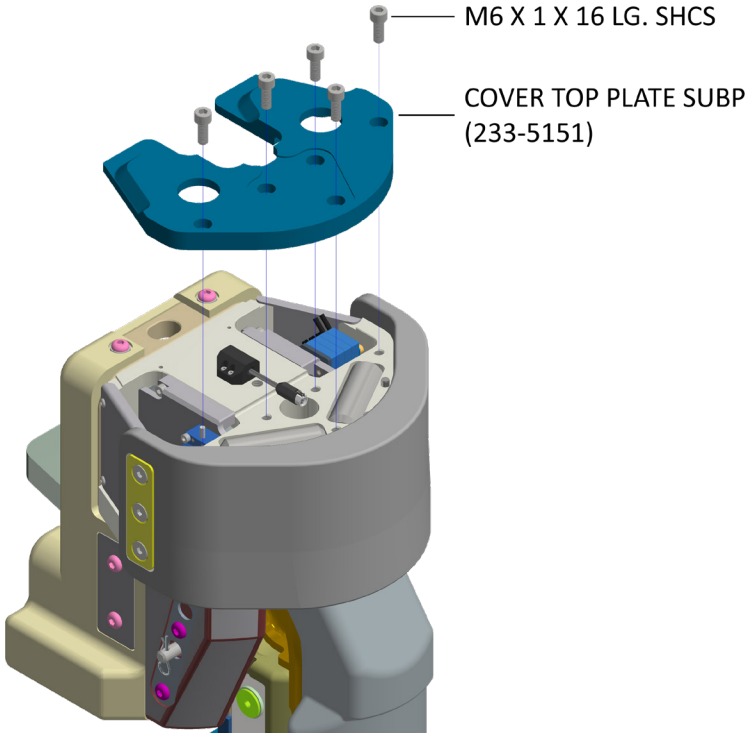


Figure 4.8 Remove Cover Top Plate

4. **Pull four M5 X 40 dowel pins from the SUBP top housing (233-5166).**

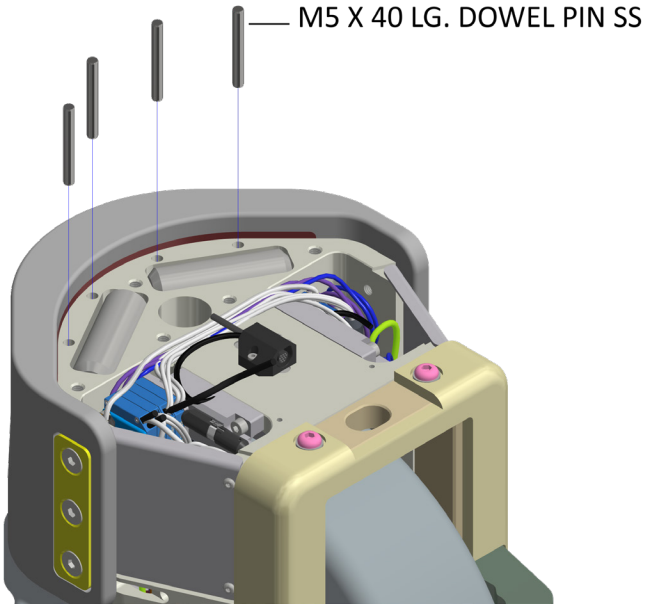


Figure 4.9 SUBP Top Housing Dowel Pins

5. Remove three M6 X 1 X 16 LG. FHCS that secures the flesh clamp plates (233-5186) from each side of the SUBP and pull these away. Remove the SUBP top flesh assembly (233-5210).

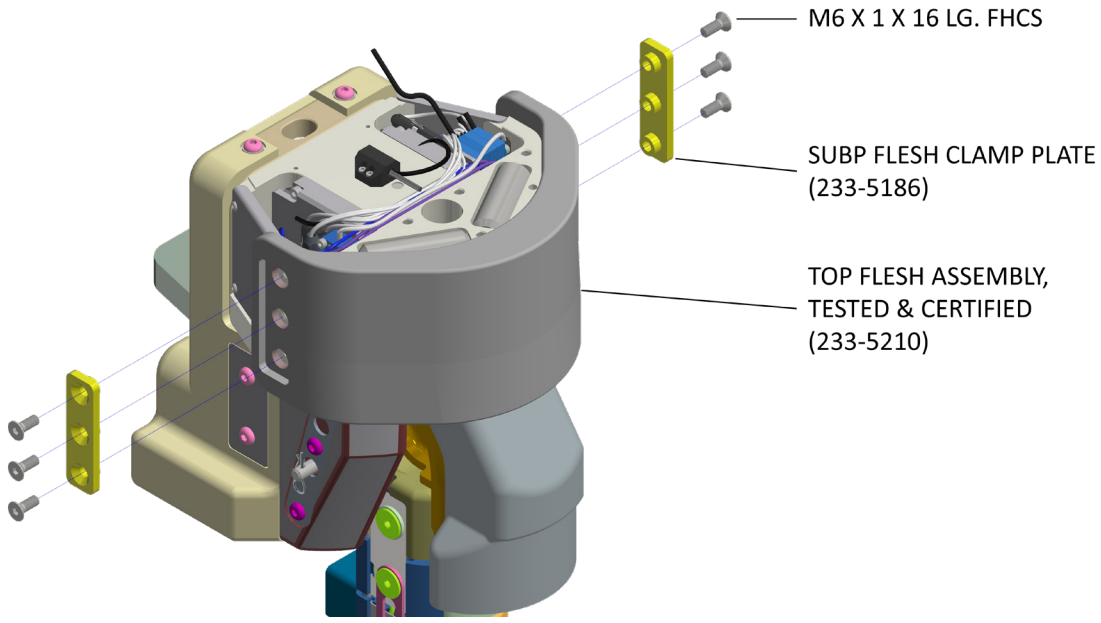


Figure 4.10 Remove the Flesh Clamp Plates and the Top Flesh Assembly

6. Remove four M3 X 0.5 X 6 LG. BHCS that secures each DAS covers (233-5172). The DAS and wiring are now exposed.

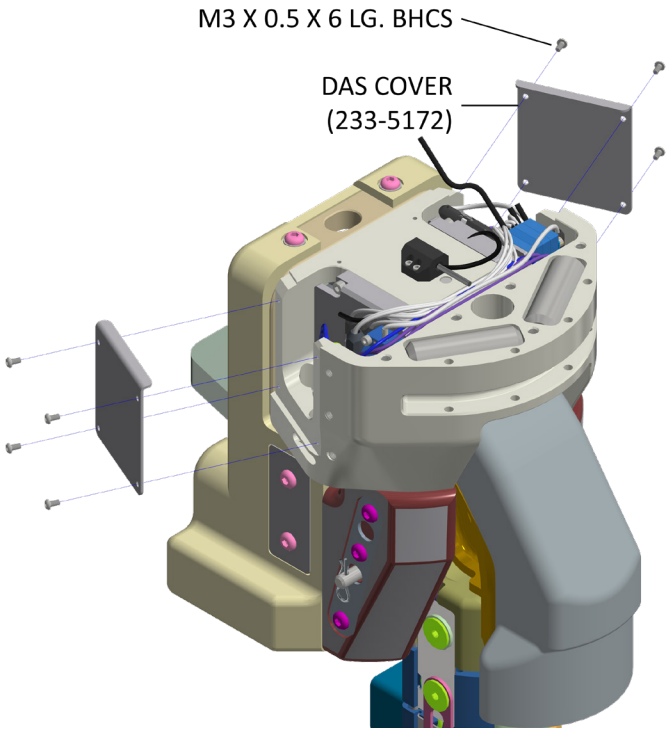


Figure 4.11 Remove the DAS Covers

7. Disconnect all sensors from the DAS.
8. Remove three M2.5 X 0.4 X 10 LG. SHCS and detach the Omnetic connector from the top of the SUBP housing.

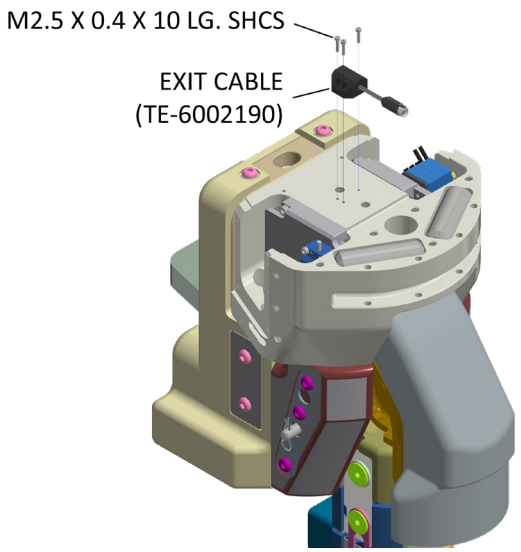


Figure 4.12 Detach the Omnetic Connector

9. Remove one M4 X 0.7 X 12 LG. SHCS from both the left (233-5152) and the right (233-5153) DTS mounting bracket. Carefully pull these brackets out by lifting upwards off the dowel.

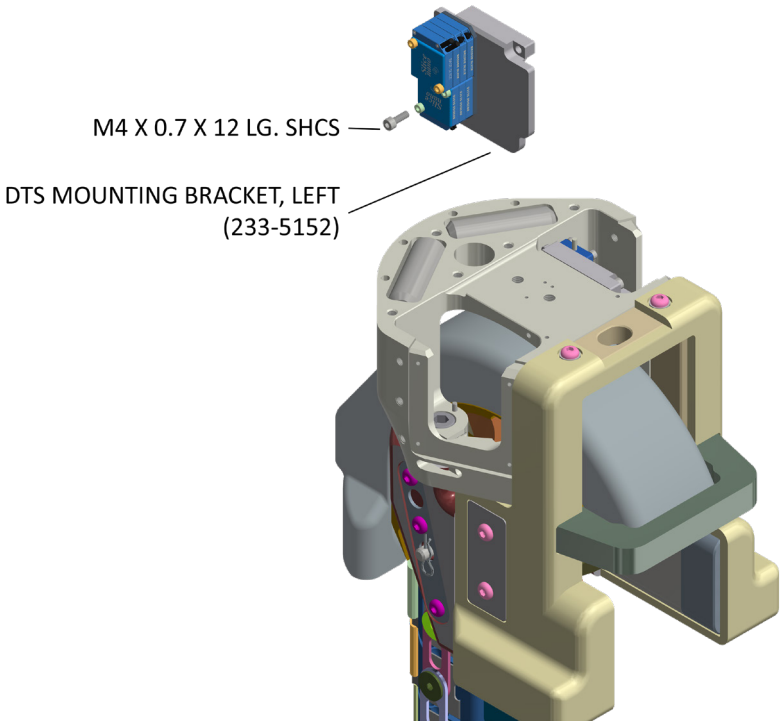


Figure 4.13 Remove the DTS Mounting Bracket, Left

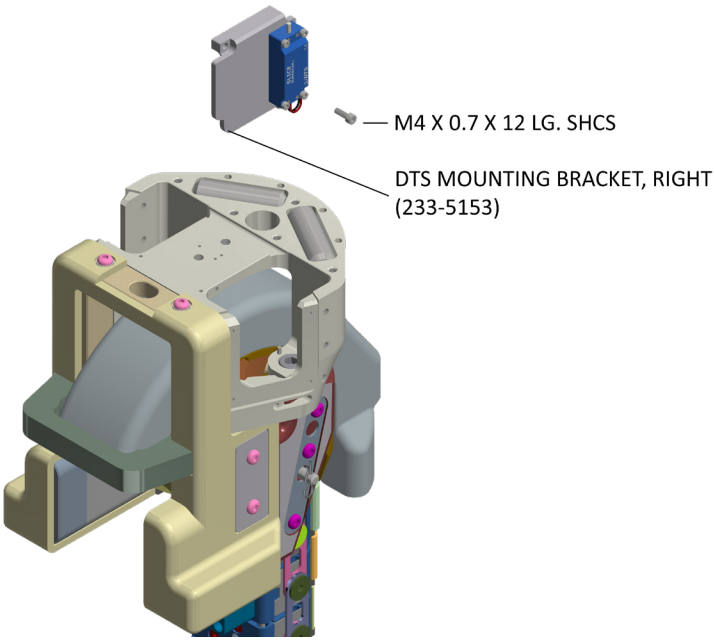


Figure 4.14 Remove the DTS Mounting Bracket, Right

10. The instrumentation cables for sensors in the femur, knee, and tibia can be pulled out of the SUBP top housing. These are routed through the slots in the bottom of the housing.
11. Remove four M10 X 1.5 X 30 LG. SHCS from inside the SUBP top housing. The housing can now be removed.

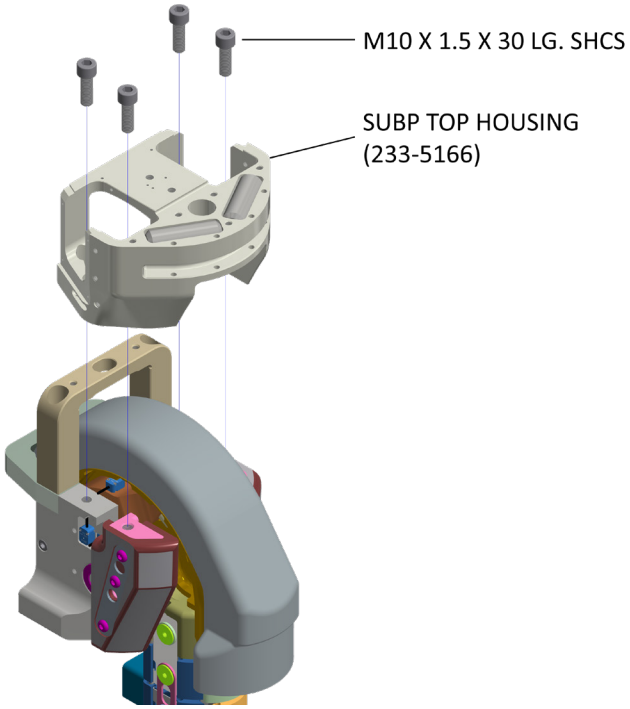


Figure 4.15 Remove SUBP Top Housing

12. **Remove two M6 X 1 X 12 LG. BHCS and side clamp plate (233-5162) from both sides of the rear impact protection (233-5204), as well as the two M6 X 1 X 12 LG. BHCS and two M6 flat washers from the top (six M6 X 12 BHCS will be removed in total). Pull the impact protection away from the assembly.**

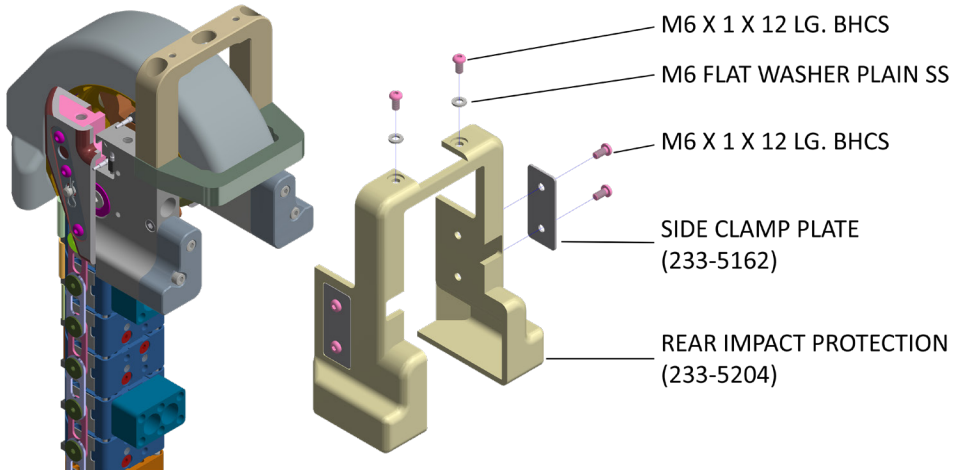


Figure 4.16 Remove the Side Clamp Plates and Rear Impact Protection

13. **Pull out one 5/16 hairpin cotter from either side of the travel pin (233-5161). Slide the travel pin out from the assembly.**

NOTICE

Once the travel pin is removed, the SUBP will be able to rotate freely. Ensure that the SUBP and femur assemblies are supported before removing the pin to reduce the risk of accidentally pinching a finger.

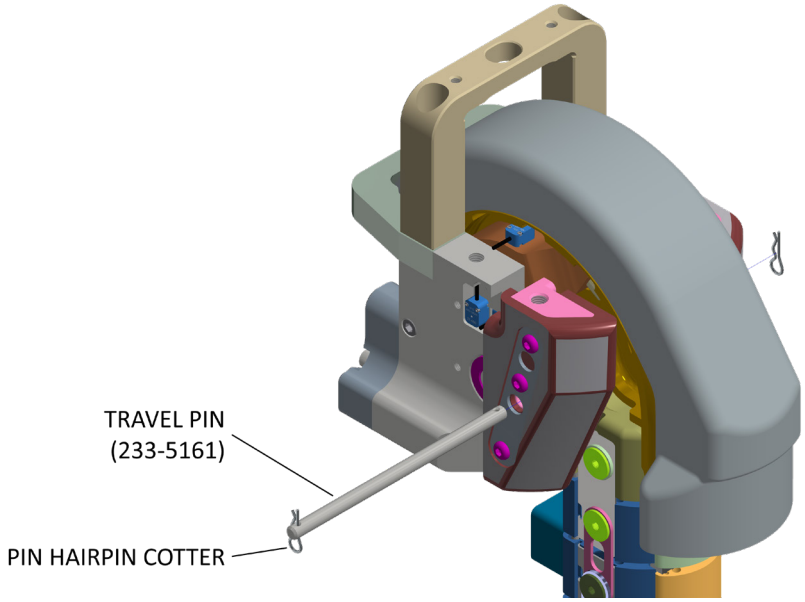


Figure 4.17 Remove the Hair Pin Cotter

14. Remove two M10 X 40 SHCS from the clamp support (233-5159). The clamp support (233-5159), and rear brace (233-5185) can now be removed.

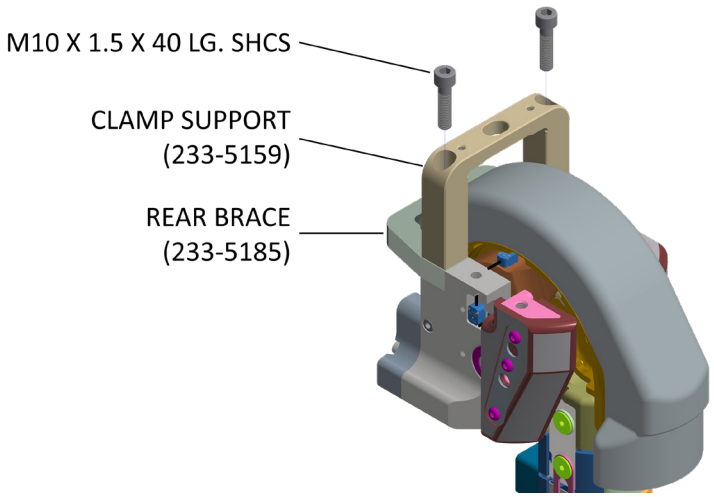


Figure 4.18 Remove the Clamp Support

15. Remove two M6 X 30 SHCS from both the left (233-5156) and right (233-5170) rear ballast clamp.

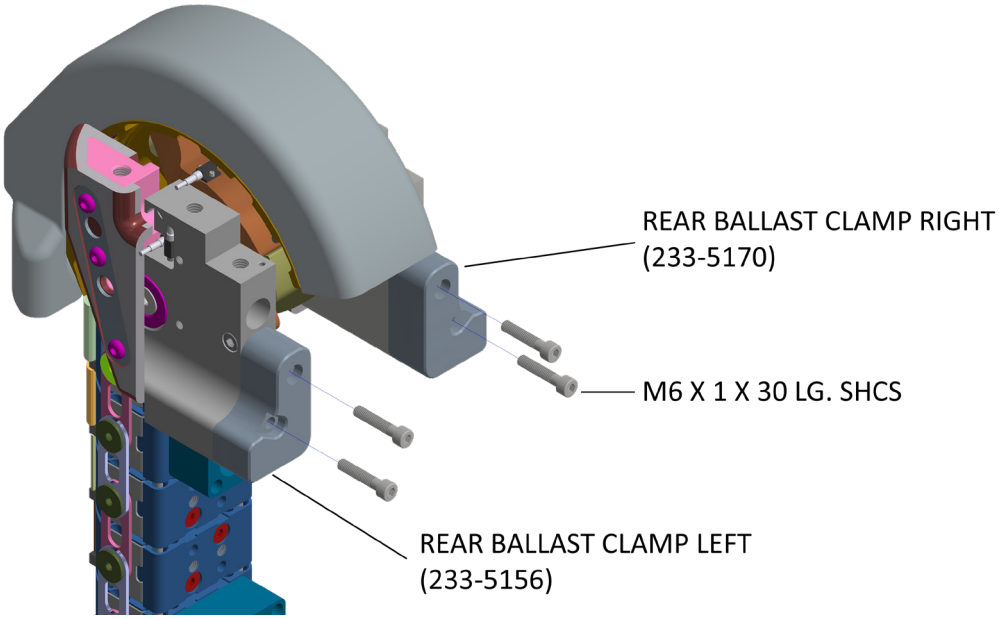


Figure 4.19 Remove Rear Ballast Clamp

16. Pull out six tungsten inserts (233-5155).

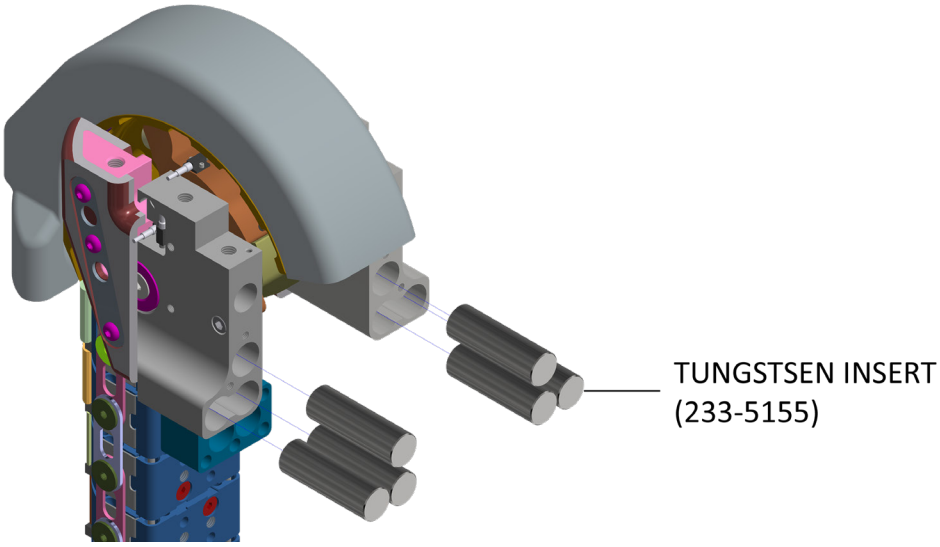


Figure 4.20 Pull Out the Tungsten Insert

17. Remove the M8 X 1.25 X 25 LG. FHCS and pivot clamp washers (233-5164) from both sides of the SUBP.

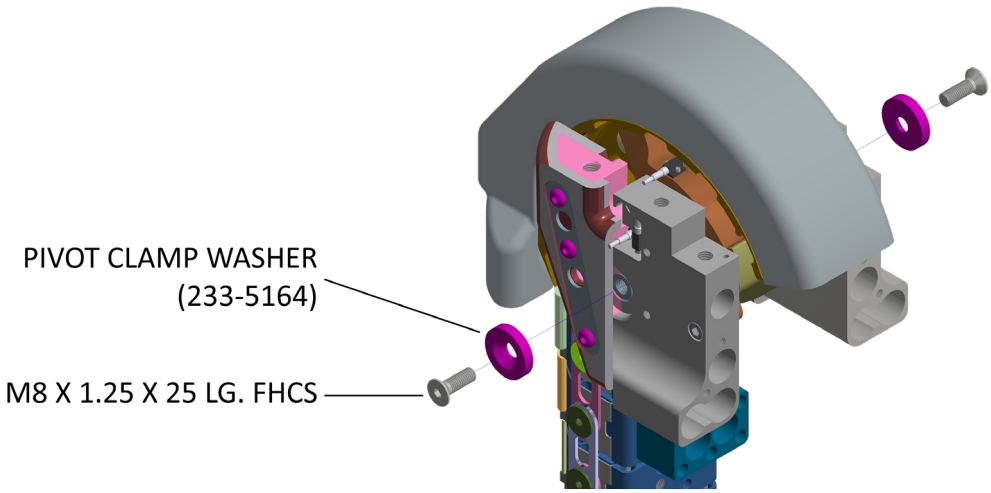


Figure 4.21 Remove the Pivot Clamp Washer

18. Remove one M10 X 1.5 X 60 LG. SHCS and one M10 X 1.5 X 30 LG. SHCS from both the left (233-5183) and right (233-5184) rear clamps.

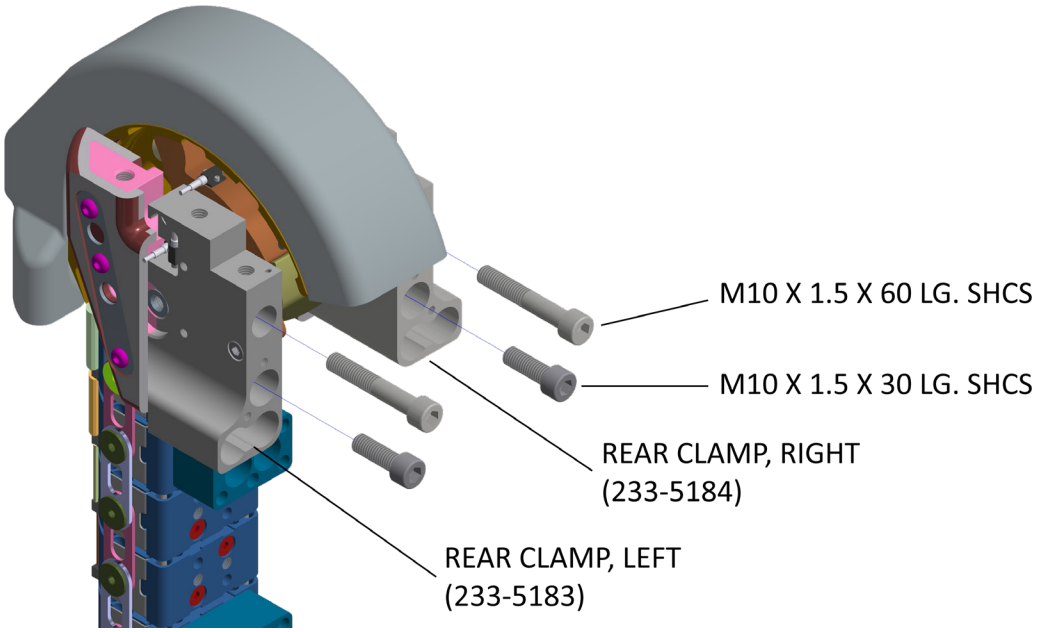


Figure 4.22 Remove the Rear Clamp

19. Remove the left (233-5180) and right lower clamps (233-5181).

NOTICE

The left (233-5220) and right (233-5230) lower buffers will still be attached to the lower clamps. These are secured with three M6 X 1 X 30 LG. BHCS, one sheet metal clamp (233-5179), and one clamp plate (233-5194) per buffer.

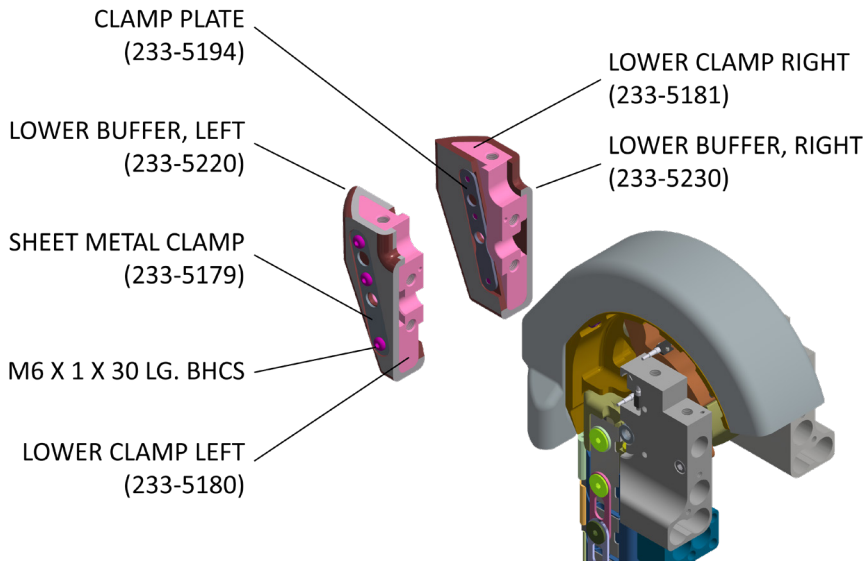


Figure 4.23 Remove the Lower Clamps

20. Remove one M6 X 1 X 22 LG. SHCS and one M6 X 1 X 18 LG. SHCS from both the left (233-5183) and right (233-5184) rear clamps. These can now be removed from the assembly.

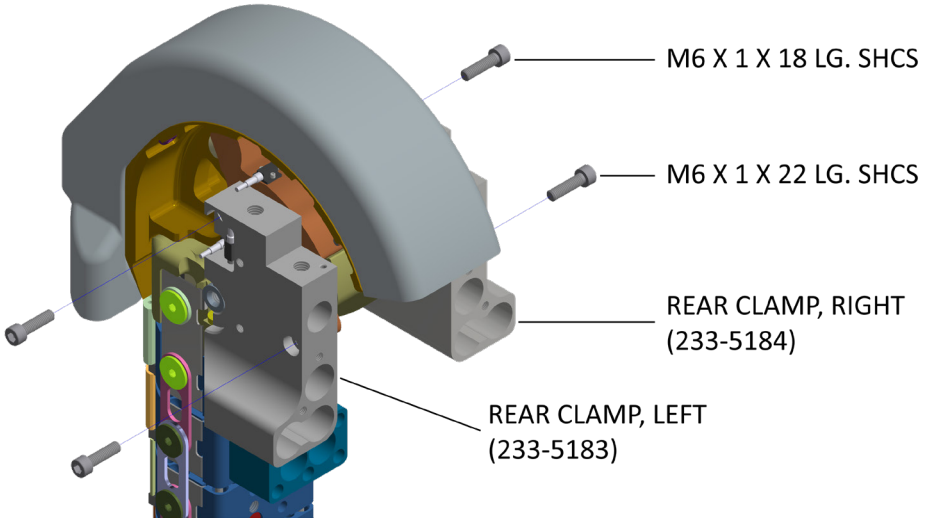


Figure 4.24 Remove the Rear Clamp

21. Pull out the instrumentation cables from the channels in the left (233-5198) and right (233-5199) bumper cover assemblies. The bumper cover assemblies can now be removed.

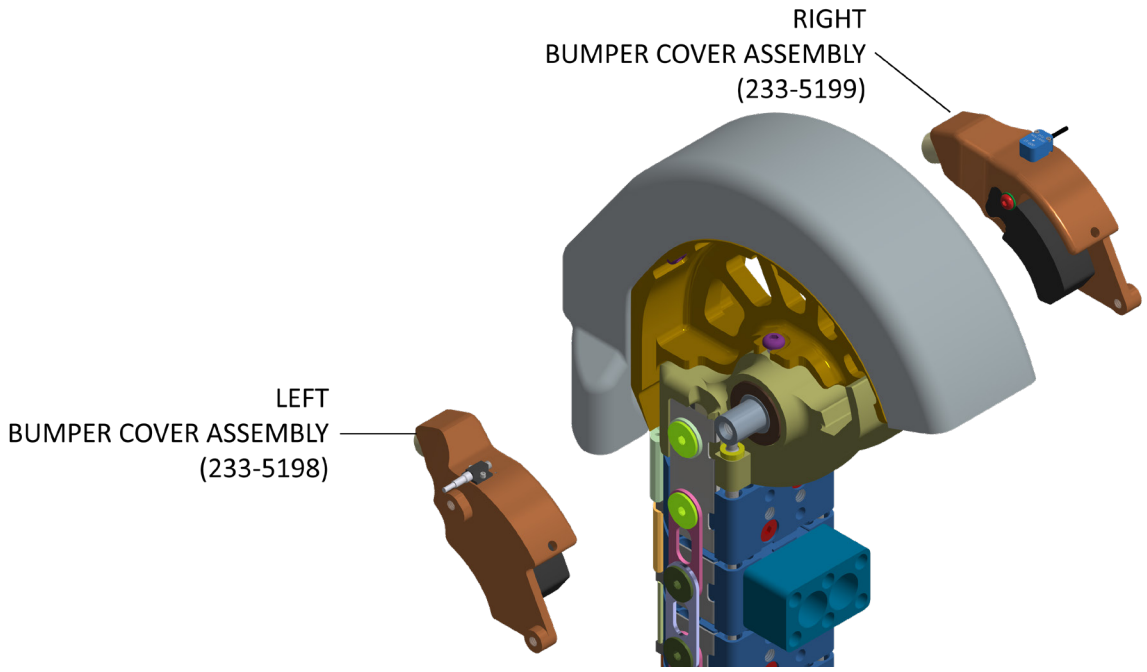


Figure 4.25 Remove the Bumper Cover Assemblies

22. Pull the x-axis shaft (233-5154) out from the top femur mounting bracket (233-5192). The leg is now free from the SUBP assembly.

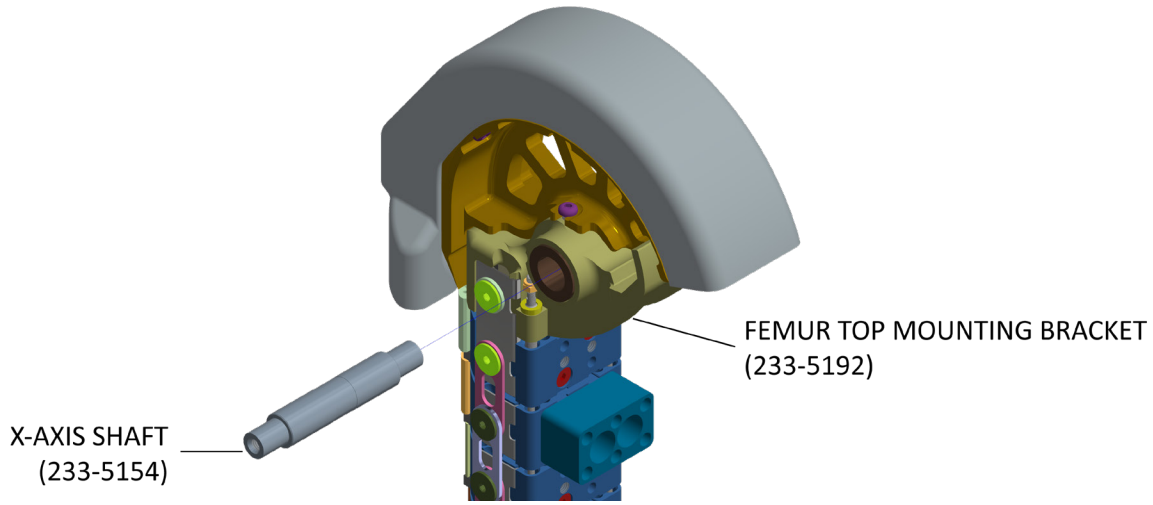


Figure 4.26 Pull out the X-axis Shaft

23. If the ARS and accelerometers needs to be re-calibrated, they can be removed from the bumper cover assemblies and rear clamps.
24. If the SUBP bumpers (233-5187) need to be removed or replaced, remove the M4 X 8 BHCS and M4 washer from the bumper cover assembly and then pull the bumper out.

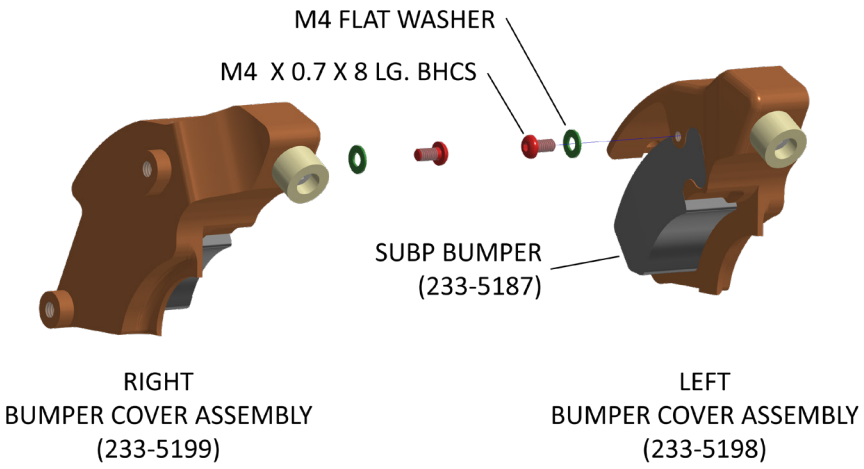


Figure 4.27 Remove the Fastener and Washer from the Bumper Cover Assemblies

25. The instrumentation cables will need to be freed from the femur. Remove six stepped bolts (233-5106), two short stepped bolts (233-5105), six links (233-5515), one femur cable cover (233-5121), six cable covers (233-5528), and two washers (233-5104) from both sides of the femur and pull the cables out.

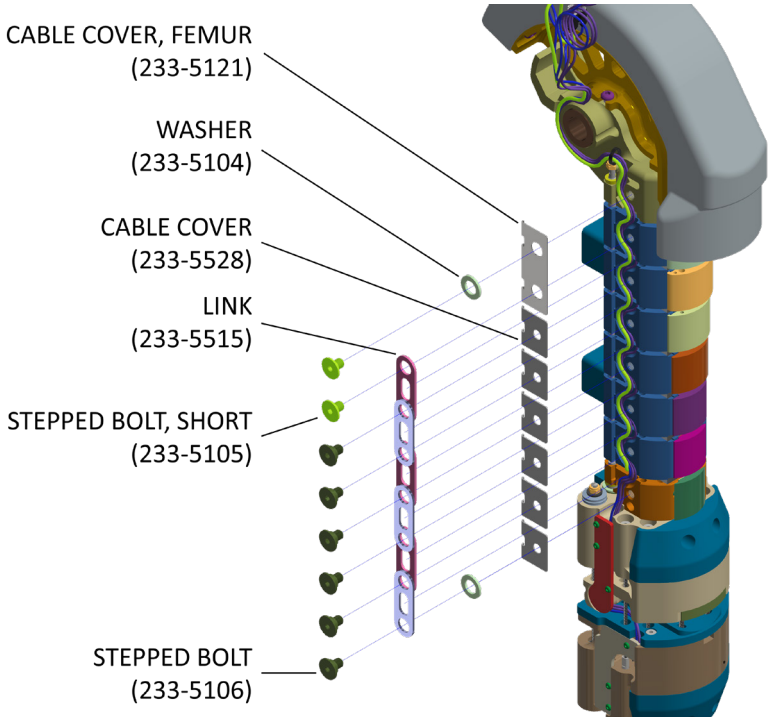


Figure 4.28 Remove the Stepped Bolts, Links, Washers, and Cable Covers

26. The instrumentation cables also need to be freed at the knee. Remove three M3 X 0.5 X 8 LG. BHCS from each of the two upper cable clamps (233-5315) and two lower cable clamps (233-5314). Pull the instrumentation cables out.

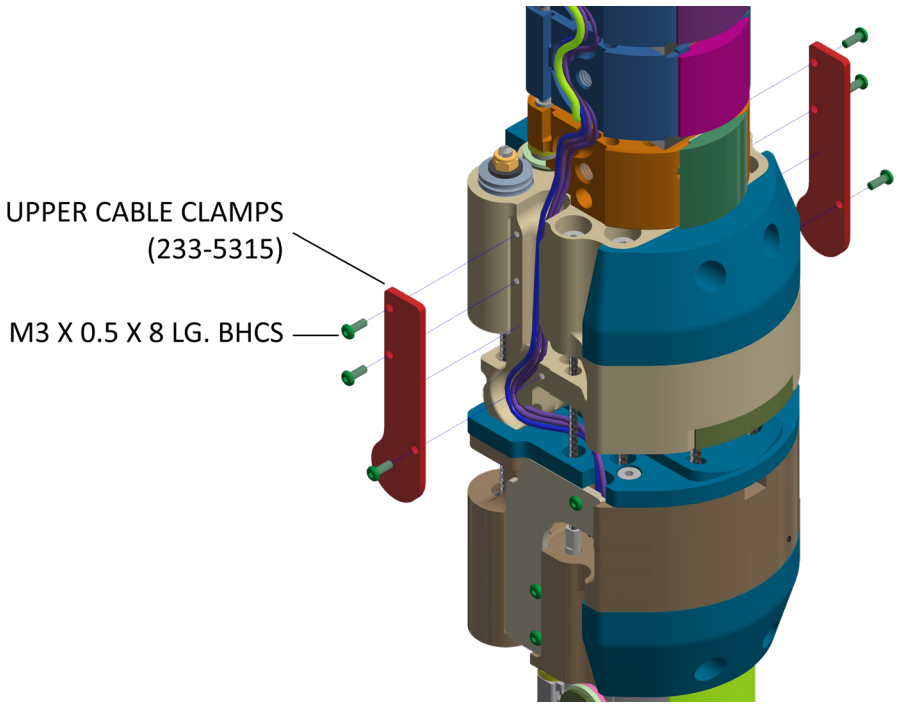


Figure 4.29 Remove the Upper Cable Clamps

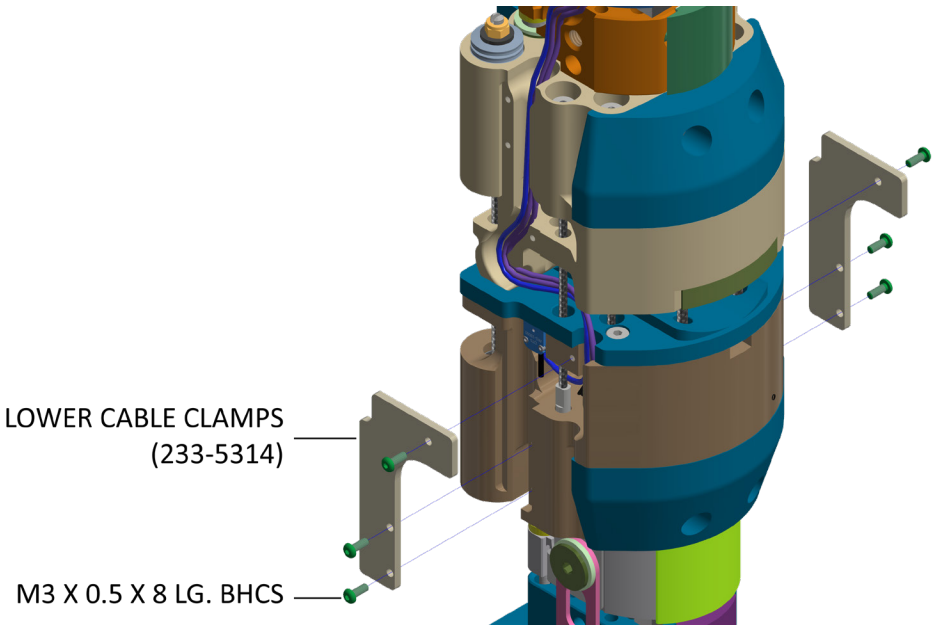


Figure 4.30 Remove the Lower Cable Clamps

27. Remove two M6 X 1 X 10 LG. BHCS from each of the two knee covers (233-5304) on the upper and lower knee blocks and pull them away from the assembly.

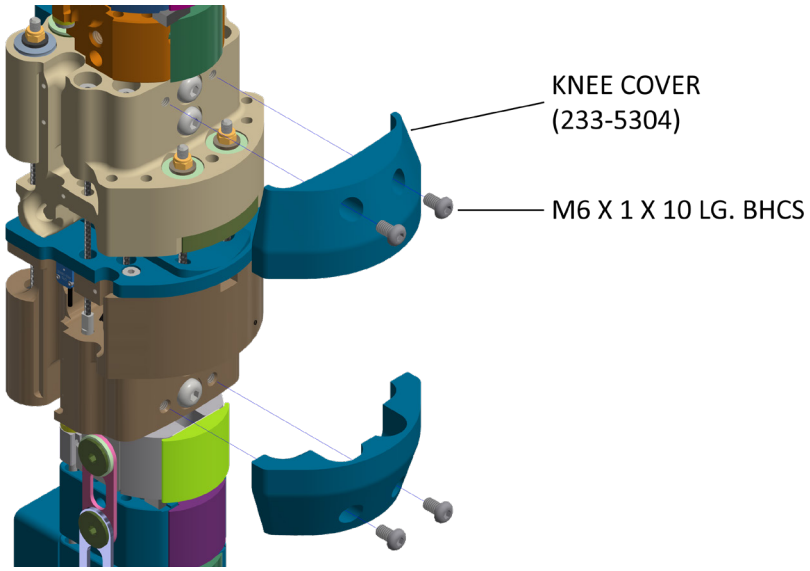


Figure 4.31 Remove the Knee Covers

28. Remove two M8 X 1.25 X 16 LG. BHCS from the impact side of the upper and lower knee blocks, which have been exposed by removing the knee covers.

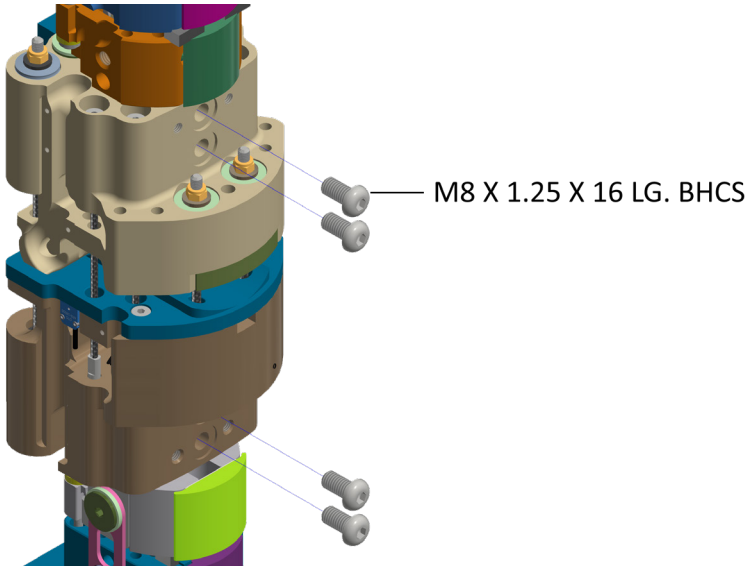


Figure 4.32 Remove M8X16 BHCS from the Knee Blocks

29. **Remove the two knee push pads (233-5305) from the non-impact side of the knee blocks by pulling them off. Loosen the two M8 X 20 set screws from both the non-impact side of the upper and lower knee blocks that have now been exposed by removing the push pads.**

NOTICE

The fir-tree clips (6006010) that secure the push pads to the knee should be replaced every time they are removed. If fit is loose, it must be replaced.

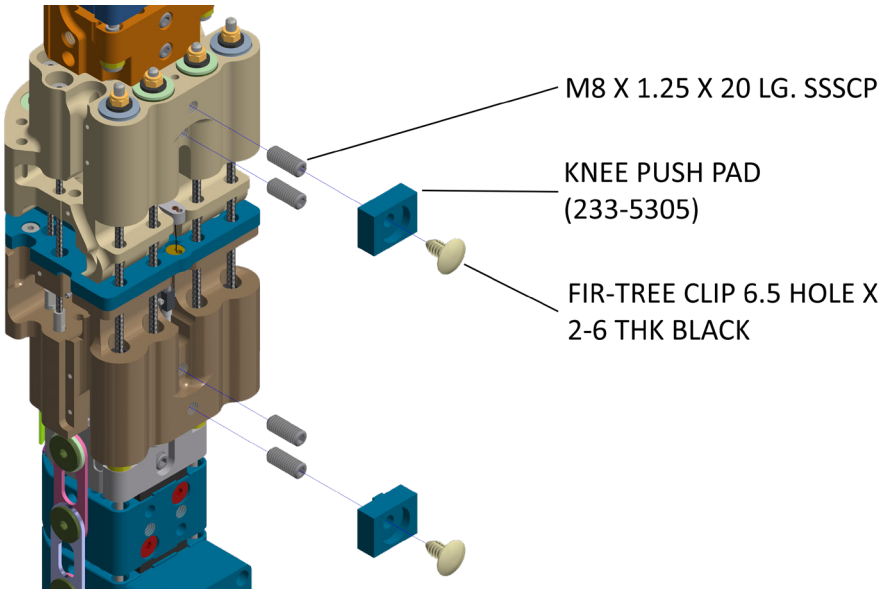


Figure 4.33 Remove the Push Pads and Fir-Tree Clips

30. The femur and tibia assemblies can now be removed.

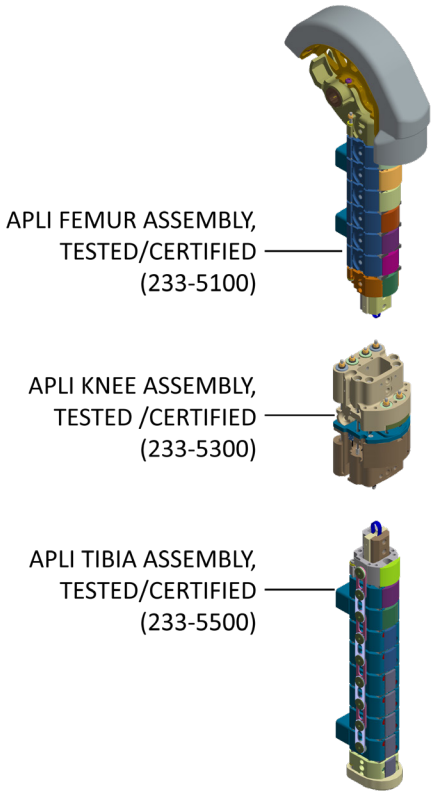


Figure 4.34 Remove the Femur and Tibia

31. Remove two M1.4 X 8 SHCS and pull away the ARS from the left side of the lower knee block. Be careful when pulling the instrumentation cable out through the assembly. For disassembly of the knee, follow steps 31-37.

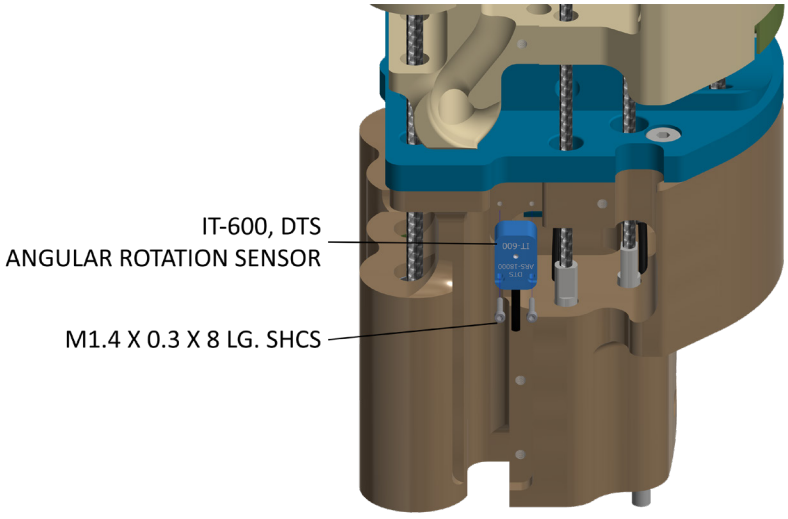


Figure 4.35 Removal of the Knee ARS

32. Remove two M3 X 0.5 X 10 LG. BHCS from the upper knee block that are attaching the knee string attachment (233-5302) to the block. Lower the knee string attachment onto the meniscus assembly (233-5313).

NOTICE

Support the knee string attachment while disassembling it from the upper knee block to prevent any damage from occurring to the string potentiometers.

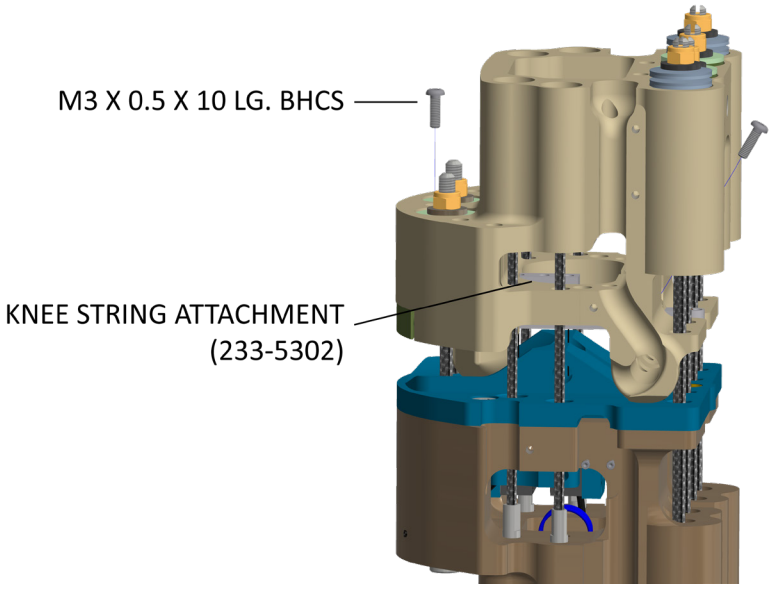


Figure 4.36 Remove the Fasteners from the Knee String Attachment

33. Use a 5.5mm open ended wrench (provided in the tool kit) to secure the four MCL cables (233-5350) on the top end fitting and remove the M5 lock nuts from the femur end of the cables. Remove the cable and belleville washer stacks from both ends of the knee.

NOTICE

The belleville washer must be kept in the same order as when they were disassembled and lock nuts back on the cables after disassembly. Set the cables aside so that they can be replaced back in the same counterbore in which they were removed from.

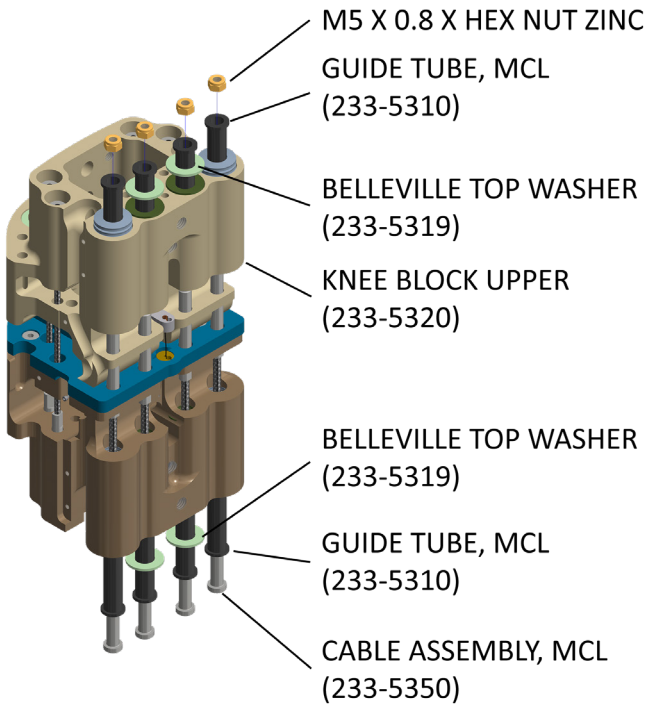


Figure 4.37 Remove the MCL Cables

34. **Remove the plastic rounding (233-5306) from the impact side of the upper knee block. This will expose the flat notches on the LCL cable.**

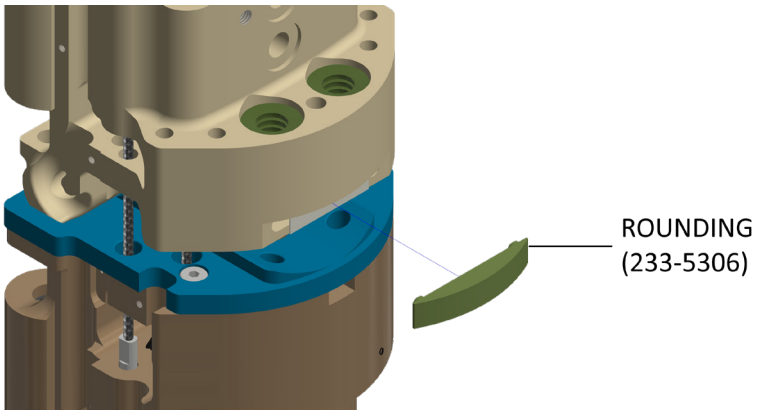


Figure 4.38 Remove the Plastic Rounding

35. **Use a 5.5mm open ended wrench (provided in the tool kit) to secure the two LCL cables (233-5370) on the top end fitting and remove the M5 lock nuts from the femur end of the cables. Remove the cable and belleville washer stacks from both ends of the knee.**

NOTICE

The belleville washers must be kept in the same order as when they were disassembled and lock nuts back on the cables after disassembly. Set the cables aside so that they can be replaced back in the same counterbore which they were removed from.

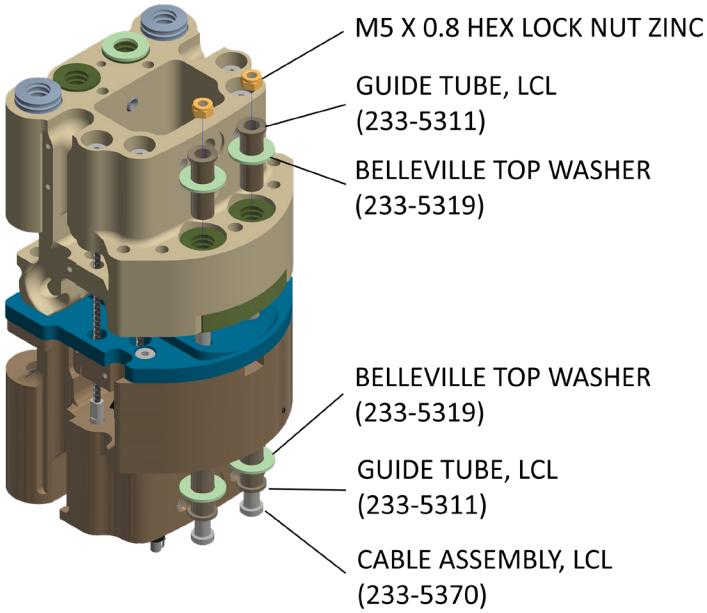


Figure 4.39 Remove the LCL Cables

36. Use a 4mm open ended wrench (provided in the tool kit) to secure the four ACL/PCL cables on the end fitting flats and remove the M5 lock nuts from the tibia end of the cables. Remove the cables and springs from both ends of the knee. The upper knee block 233-5320 is now free.

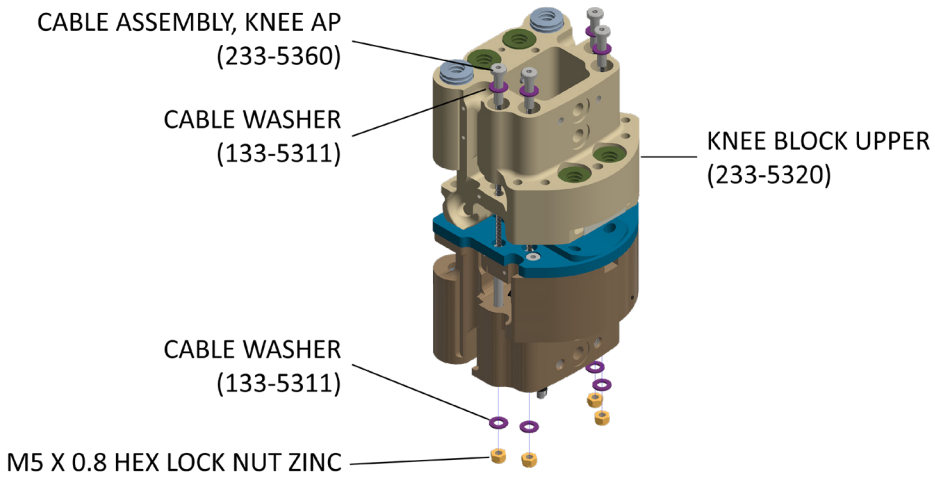


Figure 4.40 Remove the ACL/PCL Cables

37. Remove four M5 X 0.8 X 10 LG. LHCS that are securing the meniscus assembly (233-5313) to the lower knee block. Pull the meniscus assembly with the knee string attachment away from the assembly, taking care not to damage any wires.

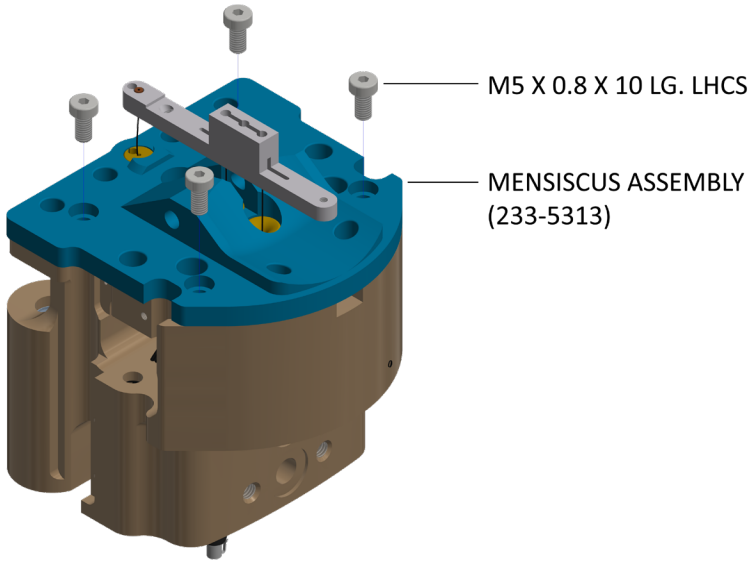


Figure 4.41 Remove the Fasteners from the Meniscus Assembly

38. For femur and tibia disassembly, it is the reverse of the their assembly. See sections 6 and 8.

4.1.3 LEG ASSEMBLY

The following procedure is a step-by-step description of the assembly procedure for the top assembly. The process is the same as disassembly, but in reverse.

1. **Insert the femur assembly into the upper knee block (233-5320) ensuring it is the correct way around with the impact segments on the impact side. Fit two M8 X 1.25 X 16 LG. BHCS into the knee block impact side counter bored holes and tighten. Fit or tighten two M8 X 1.25 X 20 LG. SSSCP on the non-impact side of the leg and screw them into their stops. The BHCS and set screws must be torqued to 8Nm.**

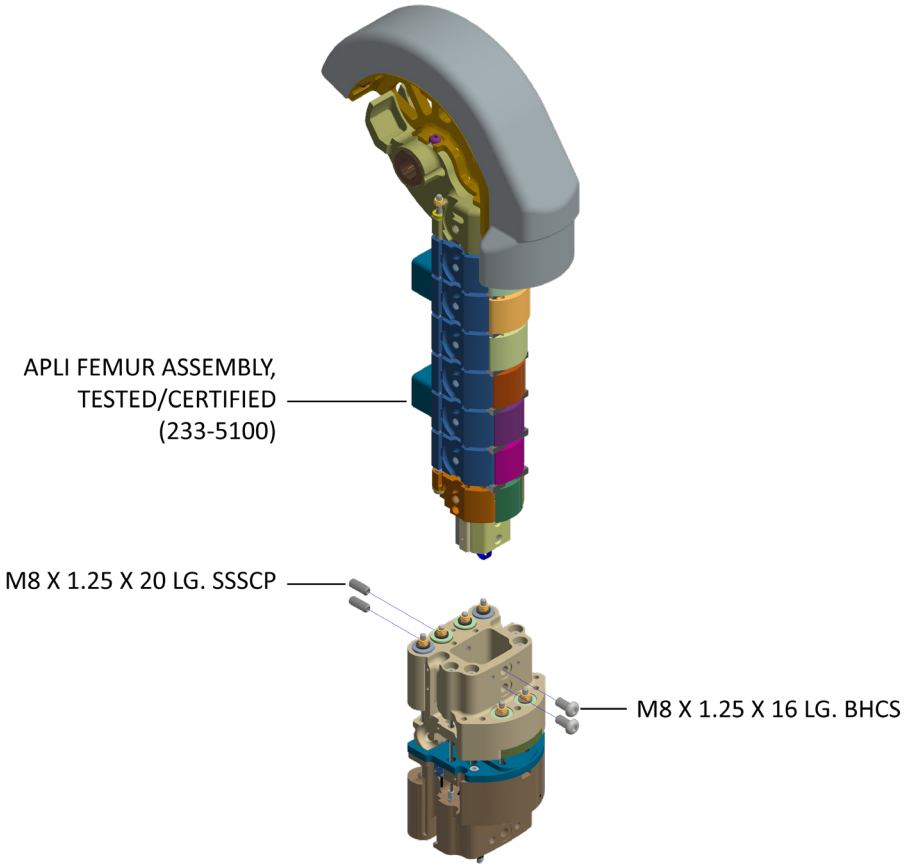


Figure 4.42 Insert the Femur Assembly into the Knee

2. Insert the tibia assembly into the lower knee block (233-5330) ensuring it is the correct way around with the impact segments on the impact side. Fit two M8 X 1.25 X 16 LG. BHCS into the knee block impact side counter bored holes and tighten. Fit two M8 X 1.25 X 20 LG. SSSCP on the non-impact side of the leg and screw them into their stops. The BHCS and set screws must be torqued to 8Nm.

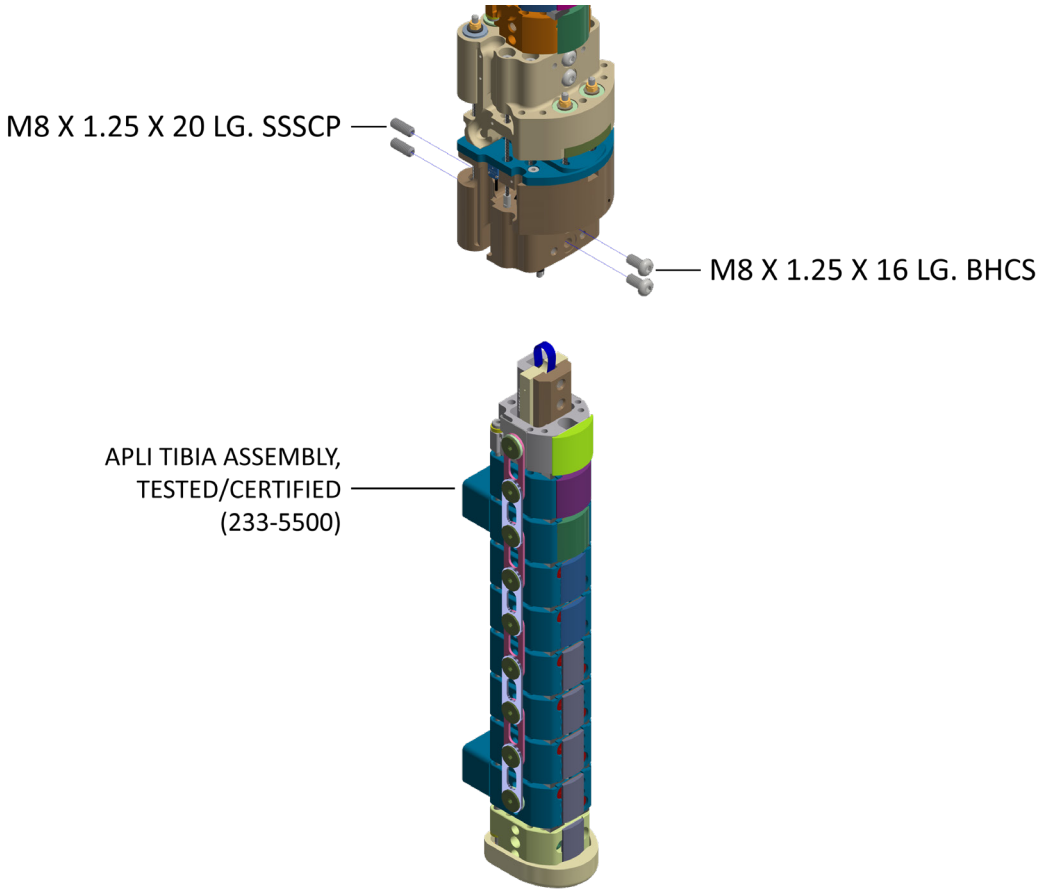


Figure 4.43 Insert the Tibia Assembly into the Knee

3. Attach the two knee push pads (233-5305) to the non-impact side of the knee blocks using fir-tree fixings (6006010). The fir-tree clips into the M8 threaded holes. Keeping the wider part of the block horizontal.

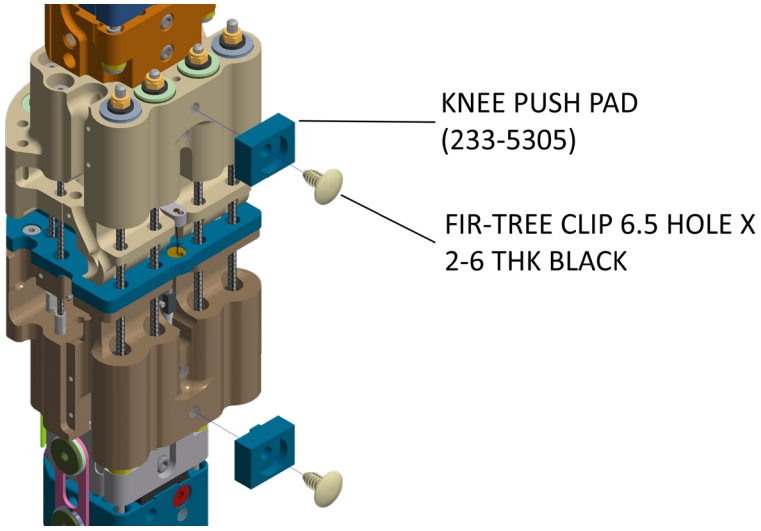


Figure 4.44 Attach the Knee Push Pad and Fir-Tree Clips

4. Secure the two knee covers (233-5304) with two M6 X 1 X 10 LG. BHCS per cover at the upper and lower knee blocks.

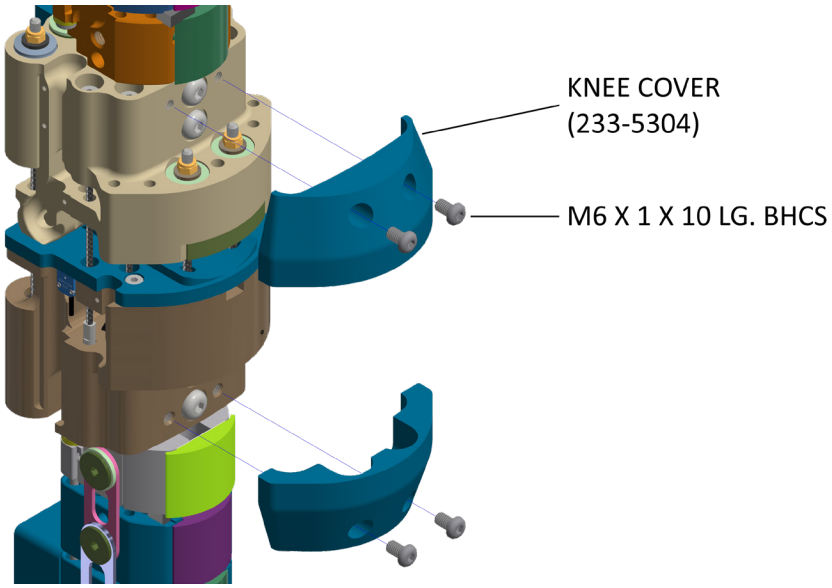


Figure 4.45 Attach the Knee Covers

5. The instrumentation cables from the tibia bone and sensors in the knee are routed up the channels on the sides on the knee. Secure these cables with two cable covers, 233-5315 and 233-5314. Use three M3 X 8 BHCS on each of the covers.

6. The cables from the instrumentation contained within the femur, knee, and tibia are routed up the sides of the legs. Inside the recesses in the segments.
7. Assemble the six stepped bolts (233-5106), two short stepped bolts (233-5105), six links (233-5515), one femur cable cover (233-5121), six cable covers (233-5528), and two washers (233-5104) on both sides of the femur. The short shoulder bolts are fitted to the top two segments.

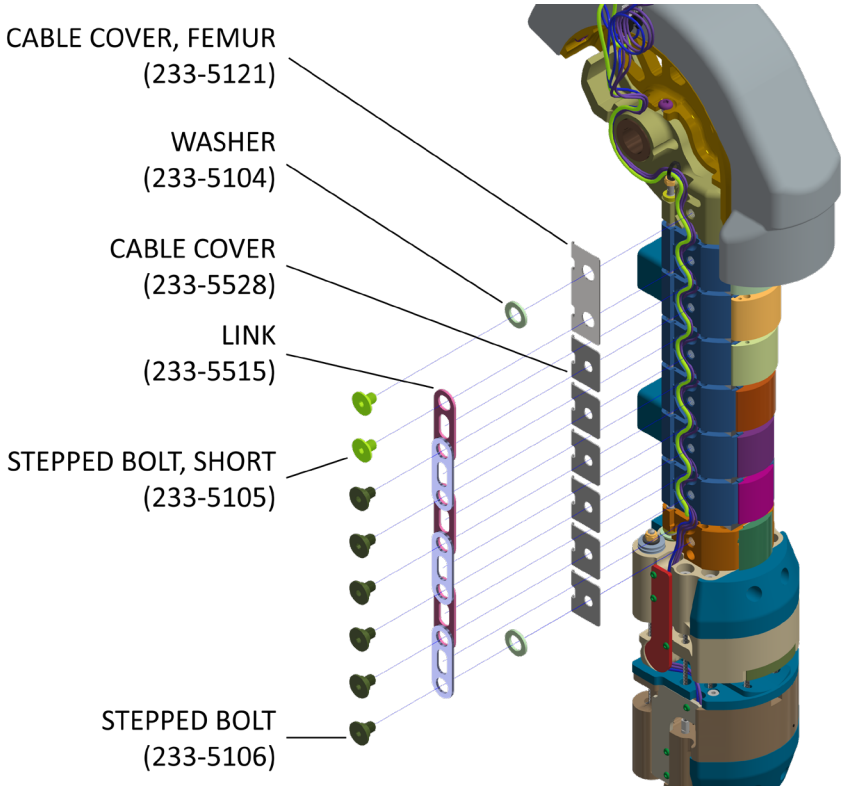


Figure 4.46 Assemble the Stepped Bolts, Links, Washers, and Cable Covers

8. Assemble the SUBP. See SUBP section for detailed instructions on how to assemble the upper body mass.
9. Assemble the weighted flesh assembly (233-5260) and secure to the legform using four black cable tie hook & loop straps (6005983). The buckles of the straps should be at the back of the weighted flesh (non-impact side). Recesses in the flesh show where to position the straps.

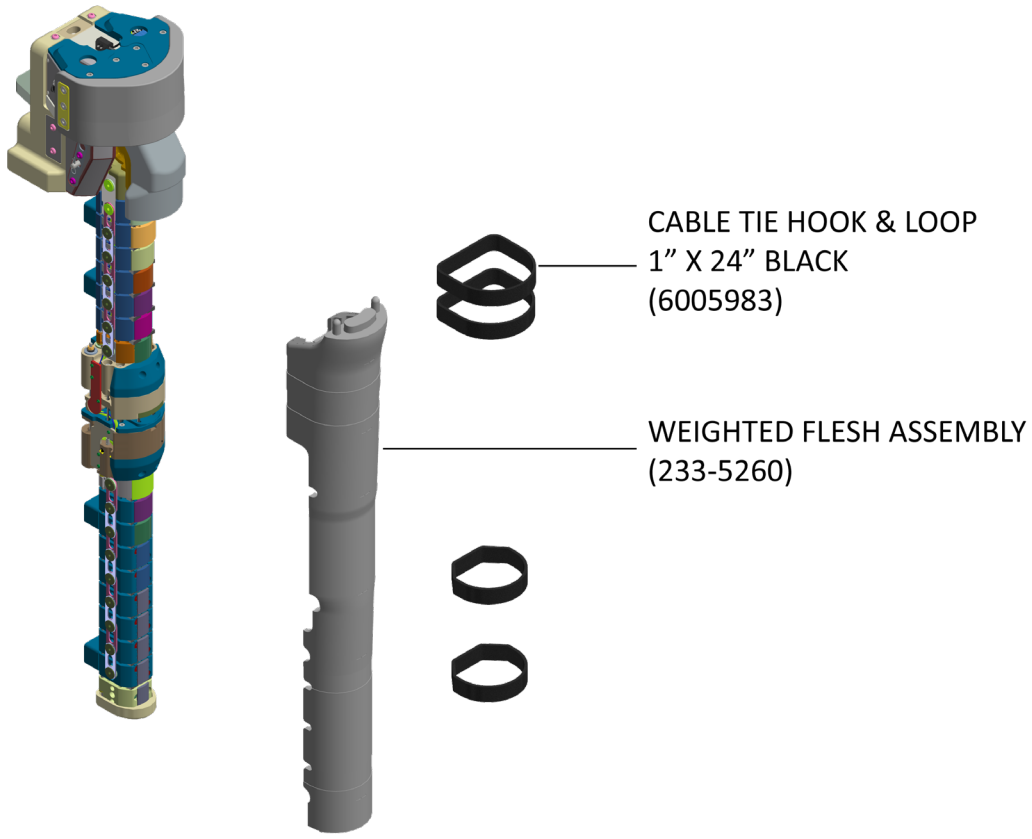


Figure 4.47 Attach the Weighted Flesh and Cable Tie

10. Secure the flesh cover assembly (233-5250) to the legform. The top Velcro loop should be routed between the curved impact face (233-5191) and femur top mounting bracket (233-5192). The flesh cover should not cover the legform push pads. Try to get a tight fit.

SECTION 5

SUBP Assembly

5.1 Description of SUBP Assembly and Features

The SUBP (Simplified Upper Body Part) has mass to represent the human body to help create human like kinematics.

5.2 Assembly of SUBP

5.2.1 SUBP ASSEMBLY PARTS LIST

The figures below are the assembly iso view and an exploded view of the SUBP Assembly, 233-5150 and the table gives a description of each item.

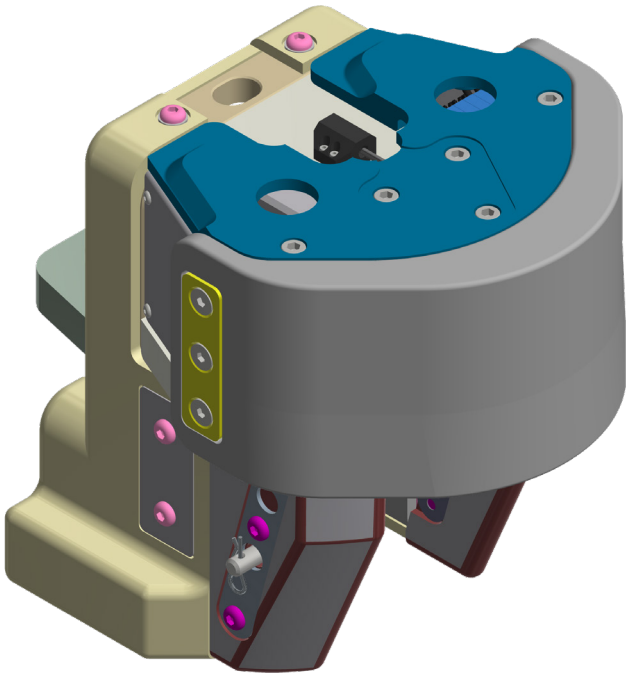


Figure 5.1 SUBP Assembly Iso View

SUBP Assembly

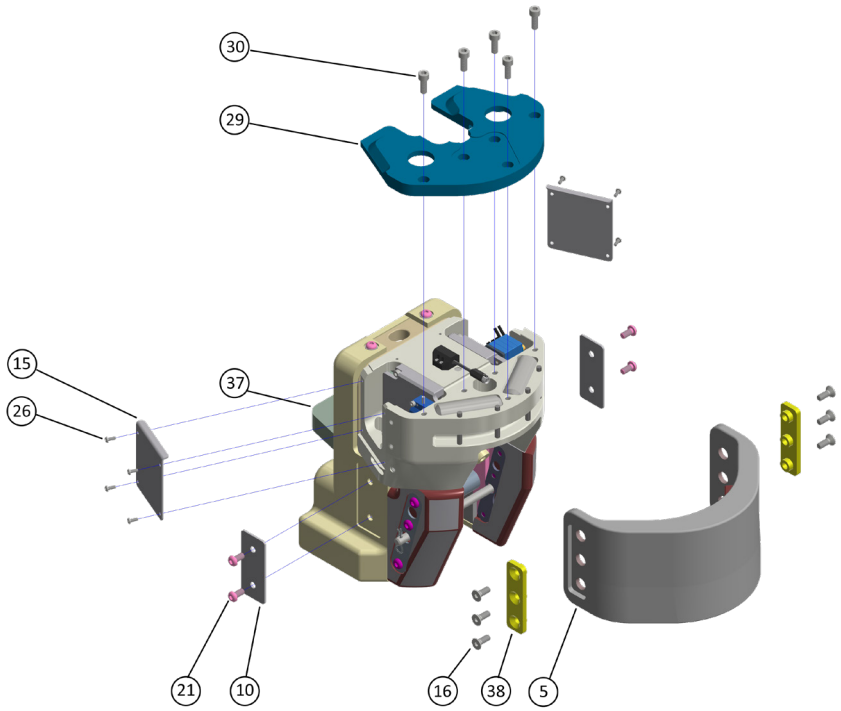


Figure 5.2 SUBP Assembly Exploded View 1

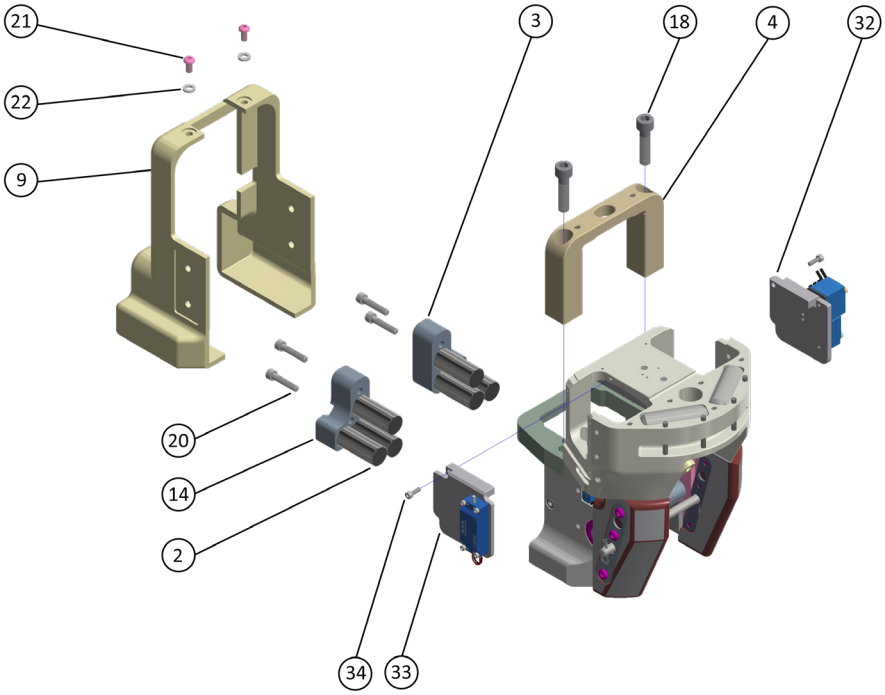


Figure 5.3 SUBP Assembly Exploded View 2

SUBP Assembly

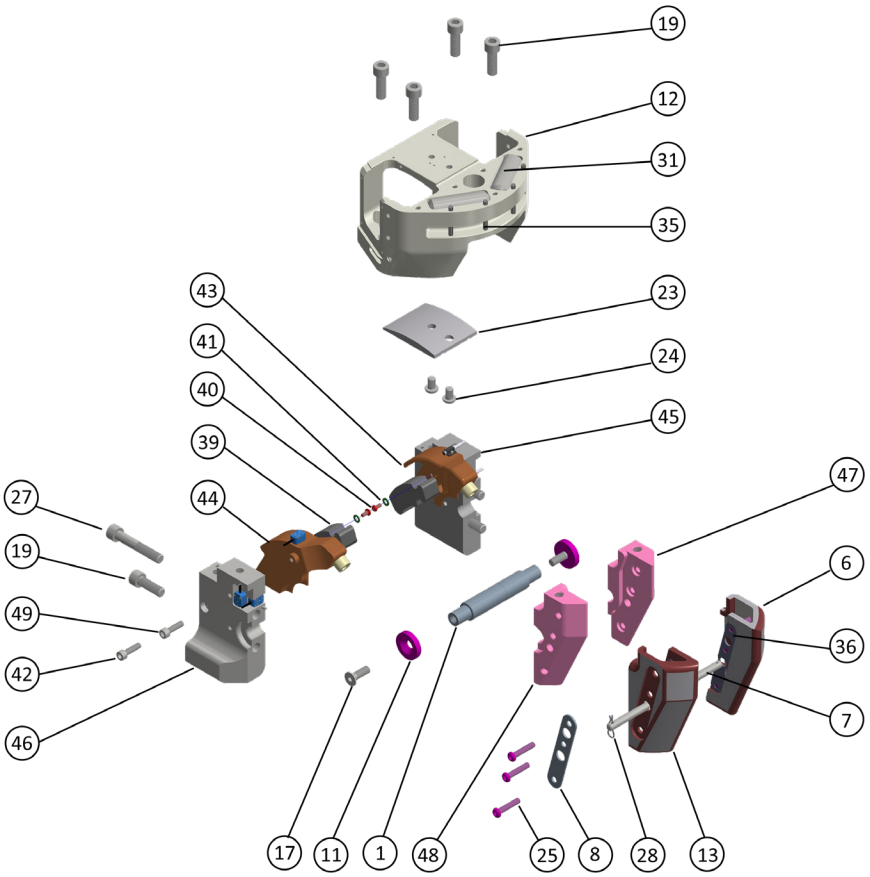


Figure 5.4 SUBP Assembly Exploded View 3

Table 5-1 aPLI SUBP Assembly Parts List

Item	Qty.	Part Number	Description
1	1	233-5154	X-AXIS SHAFT
2	6	233-5155	TUNGSTEN INSERT
3	1	233-5156	REAR BALLAST CLAMP LEFT
4	1	233-5159	CLAMP SUPPORT
5	1	233-5210	TOP FLESH ASSEMBLY, TESTED & CERTIFIED
6	1	233-5220	LOWER BUFFER, LEFT
7	1	233-5161	TRAVEL PIN
8	2	233-5179	SHEET METAL CLAMP
9	1	233-5204	REAR IMPACT PROTECTION
10	2	233-5162	SIDE CLAMP PLATE
11	2	233-5164	PIVOT CLAMP WASHER
12	1	233-5166	SUBP TOP HOUSING
13	1	233-5230	LOWER BUFFER, RIGHT

SUBP Assembly

Item	Qty.	Part Number	Description
14	1	233-5170	REAR BALLAST CLAMP RIGHT
15	2	233-5172	DAS COVER
16	6	5000090	M6 X 1 X 16 LG. FHCS
17	2	5000117	M8 X 1.25 X 25 LG. FHCS
18	2	5000930	M10 X 1.5 X 40 LG. SHCS
19	6	5000444	M10 X 1.5 X 30 LG. SHCS
20	4	5000008	M6 X 1 X 30 LG. SHCS
21	6	5000356	M6 X 1 X 12 LG. BHCS
22	2	5001580	M6 FLAT WASHER PLAIN SS
23	1	233-5171	LAUNCHER SUPPORT BRACKET
24	2	5000614	M8 X 1.25 X 12 LG. BHCS
25	6	5001754	M6 X 1 X 30 LG. BHCS
26	8	5001020	M3 X 0.5 X 6 LG. BHCS
27	2	5001753	M10 X 1.5 X 60 LG. SHCS
28	2	9004065	PIN HAIRPIN COTTER 5/16 ZINC
29	1	233-5151	COVER TOP PLATE SUBP
30	5	5000081	M6 X 1 X 16 LG. SHCS
31	2	233-5167	BALLAST DTS
32	1	233-5152	DTS MOUNTING BRACKET, LEFT
33	1	233-5153	DTS MOUNTING BRACKET, RIGHT
34	2	5000152	M4 X 0.7 X 12 LG. SHCS
35	4	5001773	M5 X 40 LG. DOWEL PIN SS
36	2	233-5194	CLAMP PLATE
37	1	233-5185	REAR BRACE
38	2	233-5186	SUBP FLESH CLAMP PLATE
39	2	233-5187	SUBP BUMPER
40	2	5000103	M4 X 0.7 X 8 LG. BHCS
41	2	5000155	M4 FLAT WASHER PLAIN ZINC
42	2	5000282	M6 X 1 X 22 LG. SHCS
43	1	233-5198	LEFT BUMPER COVER ASSEMBLY
44	1	233-5199	RIGHT BUMPER COVER ASSEMBLY
45	1	233-5183	REAR CLAMP, LEFT
46	1	233-5184	REAR CLAMP, RIGHT
47	1	233-5180	LOWER CLAMP LEFT
48	1	233-5181	LOWER CLAMP RIGHT
49	2	5000285	M6 X 1 X 18 LG. SHCS

5.2.2 ASSEMBLY OF SUBP COMPONENTS

The following procedure is a step-by-step description of the assembly procedure for the SUBP components. Before beginning assembling the SUBP, the other leg sub-assemblies (femur, knee, and tibia) should already be assembled. Check the condition of the front housing stops for damage. Replace front housing stops if damaged.

1. **Insert a SUBP bumper (233-5187) into the bumper cover assemblies as shown. Secure using one M4 flat washer and one M4 X 0.7 X 8 LG. BHCS per assembly.**

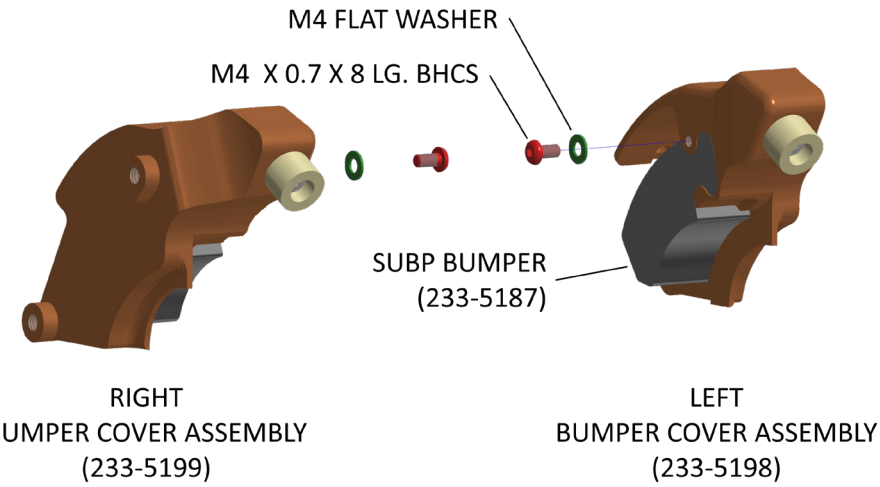


Figure 5.5 Insert SUBP Bumper

2. **Attach an ARS to the right bumper cover assembly (233-5199) using two M1.4 X 0.3 X 8 LG. SHCS.**

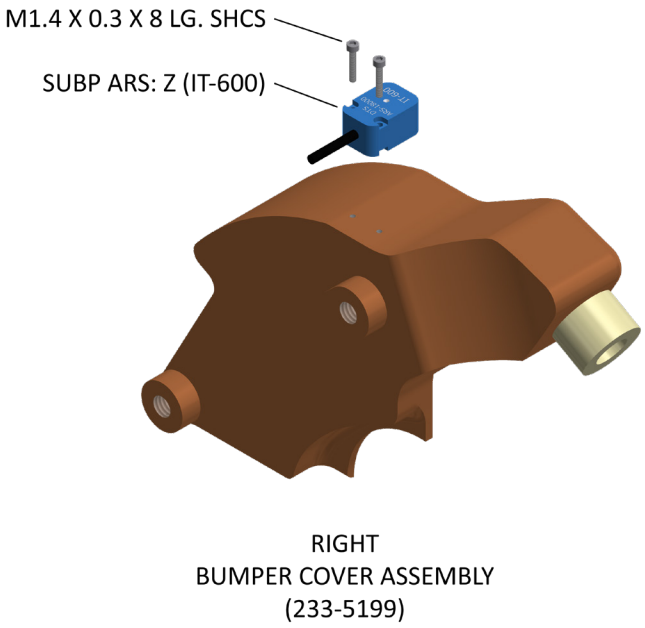


Figure 5.6 Attach the ARS to the Right Bumper Cover Assembly

3. **Attach two ARS to the right rear clamp (233-5184) and secure these using two M1.4 X 0.3 X 8 LG. SHCS per sensor.**

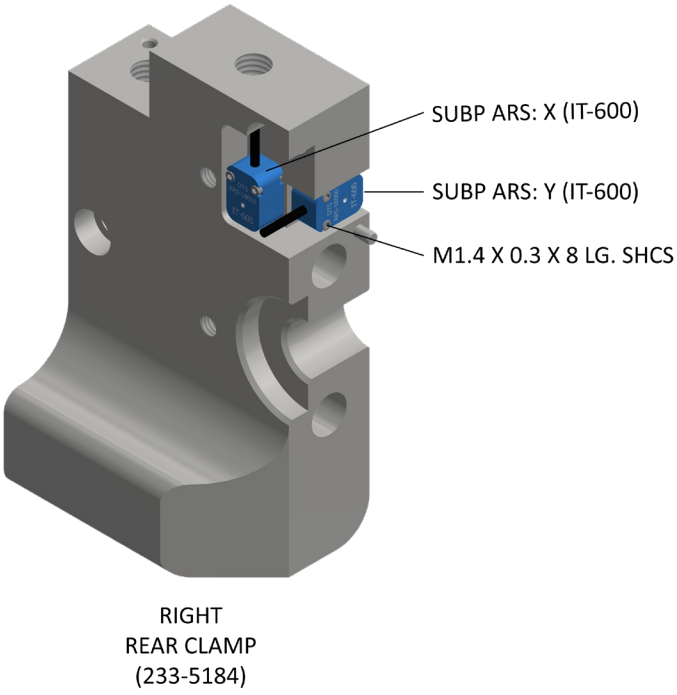


Figure 5.7 Attach the ARS to the Right Rear Clamp

4. **Attach an accelerometer to the left bumper cover assembly (233-5198) using two #0 flat washers and two M1.4 X 0.3 X 4 LG. SHCS.**

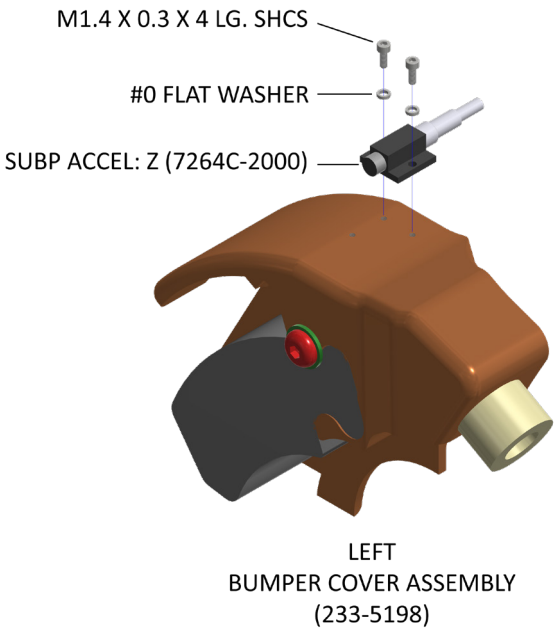


Figure 5.8 Attach an Accel to the Left Bumper Cover Assembly

5. **Attach two accelerometers to the left rear clamp (233-5183) and secure using two #0 flat washers and two M1.4 X 0.3 X 4 LG. SHCS per sensor.**

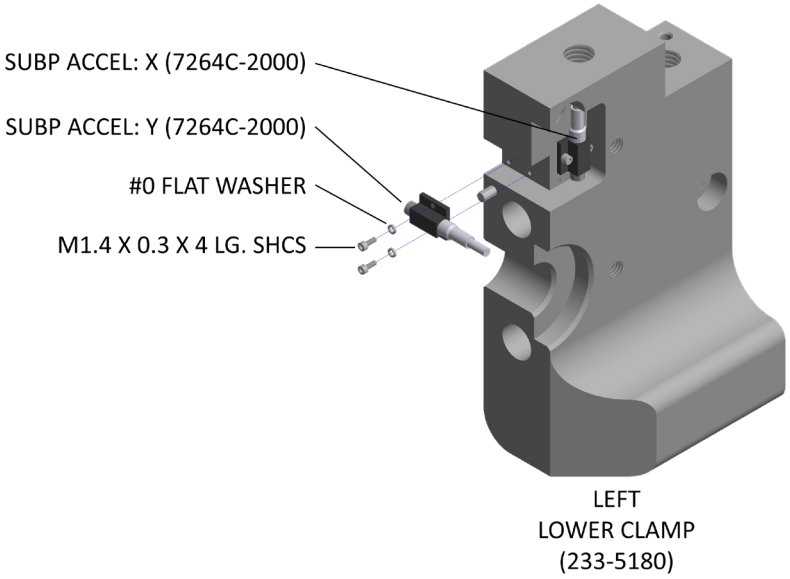


Figure 5.9 Attach the Accels to the Left Lower Clamp

6. **Slide the x-axis shaft (233-5154) into the femur top mounting bracket (233-5192).**

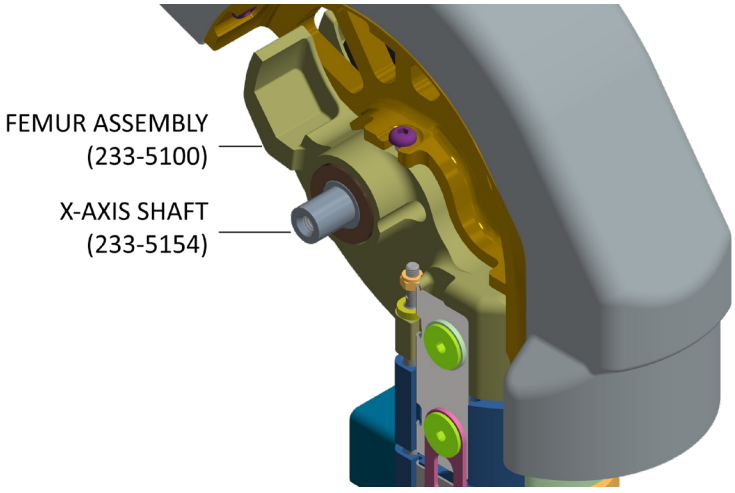


Figure 5.10 Slide the Shaft into the Femur Top Mounting Bracket

7. Place the left and right (shown below) bumper cover assemblies into the curved impact face. Orient them so that the bumpers are facing the inside of the leg. The bumper should rest in the hook area of the femur top mounting bracket.

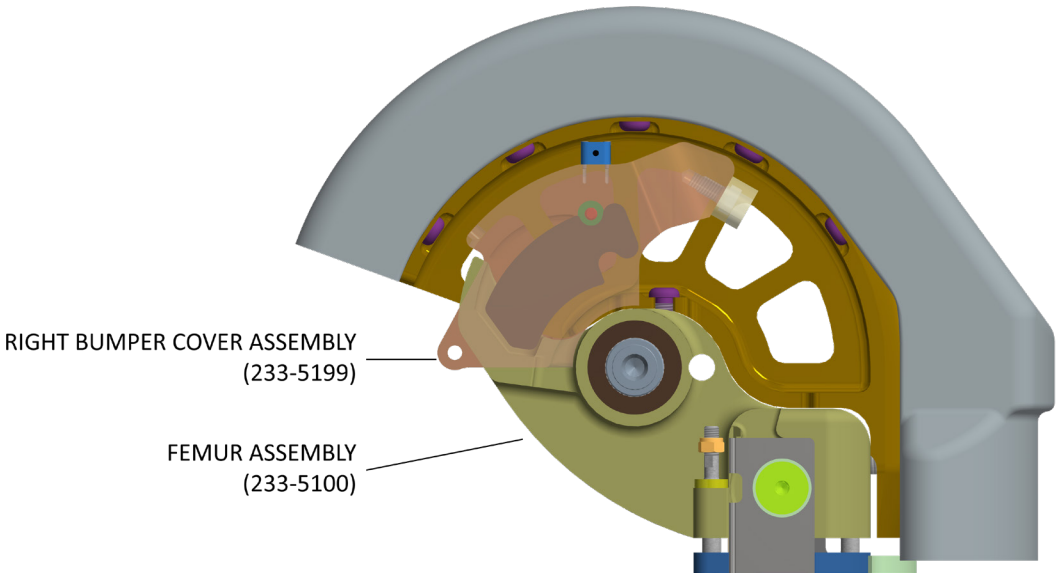


Figure 5.11 Place Bumper Cover Assemblies

8. Route the instrumentation cables through the channel in the bumper cover assemblies.
9. Secure the left and right rear clamps to the bumper covers using one M6 X 1 X 22 LG. SHCS and one M6 X 1 X 18 LG. SHCS per rear clamp as shown below. Ensure that the instrumentation cables are safely routed through the channels in the bumper covers so that they're not being pinched or crushed by the rear clamps before tightening the M6 SHCS.

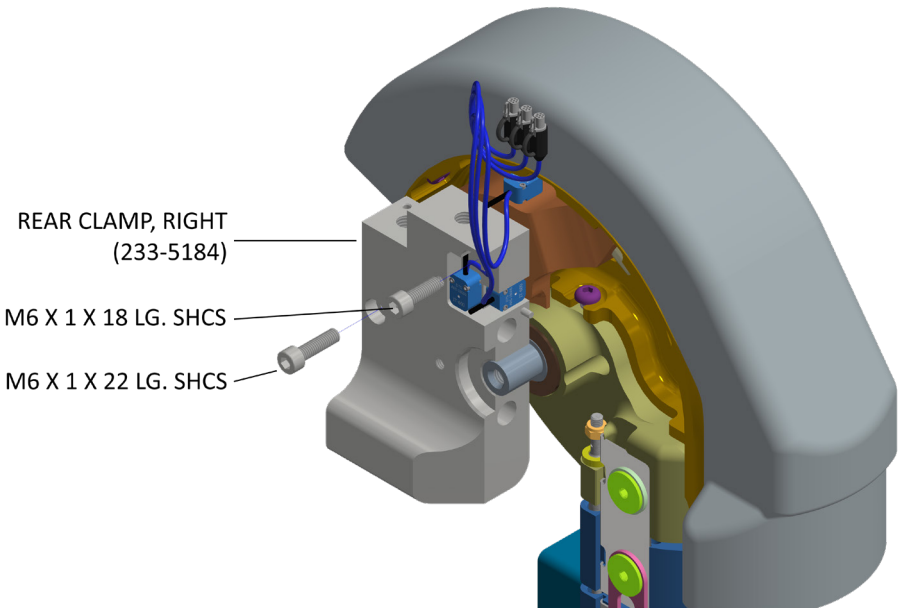


Figure 5.12 Secure Rear Clamps to Bumper Covers

10. Attach the left (233-5220) and right (233-5230) lower buffers to the left (233-5180) and right (233-5181) lower clamps. These are secured with three M6 X 1 X 30 LG. BHCS, one sheet metal clamp (233-5179), and one clamp plate (233-5194) per buffer.

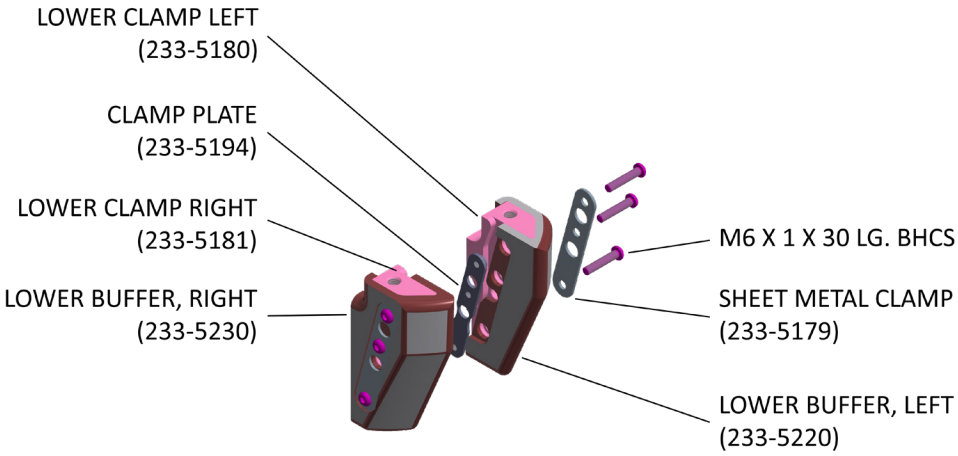


Figure 5.13 Attach Lower Buffers to Lower Clamps

11. Secure the left and right lower clamps to the rear clamps using one M10 X 1.5 X 60 LG. SHCS and one M10 X 1.5 X 30 LG. SHCS per clamp. The M10 X 60 SHCS is secured in the upper counterbore hole, and the M10 X 1.5 X 30 LG. SHCS is secured in the bottom counterbore hole of the rear clamp. Do not torque screws until top housing 233-5166 is fitted.

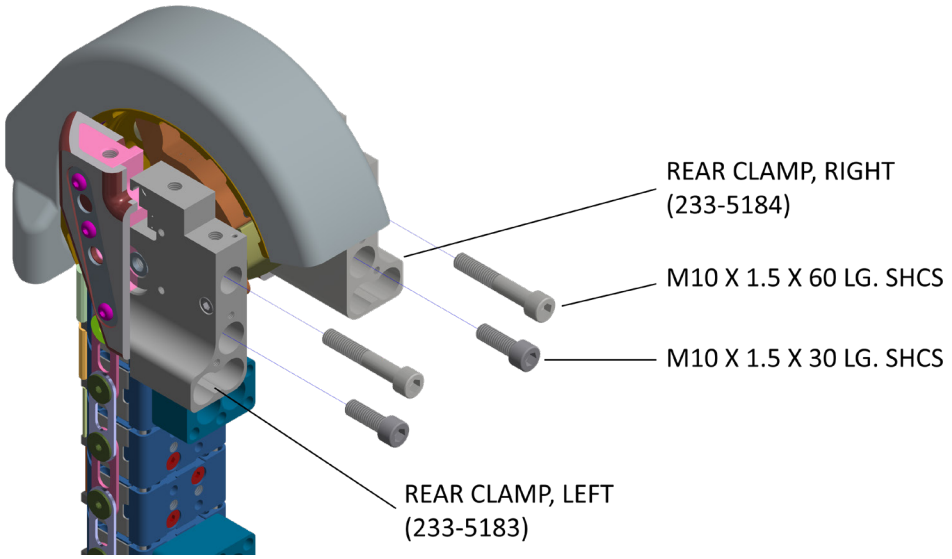


Figure 5.14 Secure Lower Clamps to Rear Clamps

12. Place a pivot clamp washer (233-5164) on both sides of the SUBP and secure with an M8 X 1.25 X 25 LG. FHCS per washer.

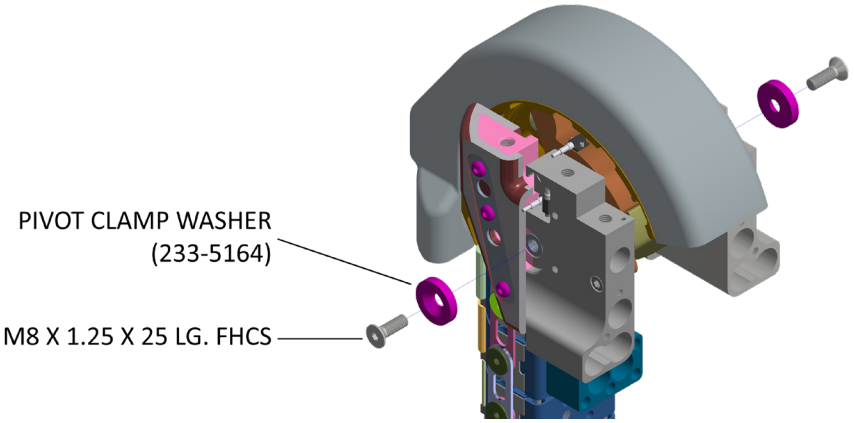


Figure 5.15 Place Pivot Clamp Washer and Secure with M8 X 25 FHCS

13. Attach the rear brace (233-5185) and clamp support (233-5159) to the rear clamps using two M10 X 1.5 X 40 LG. SHCS.

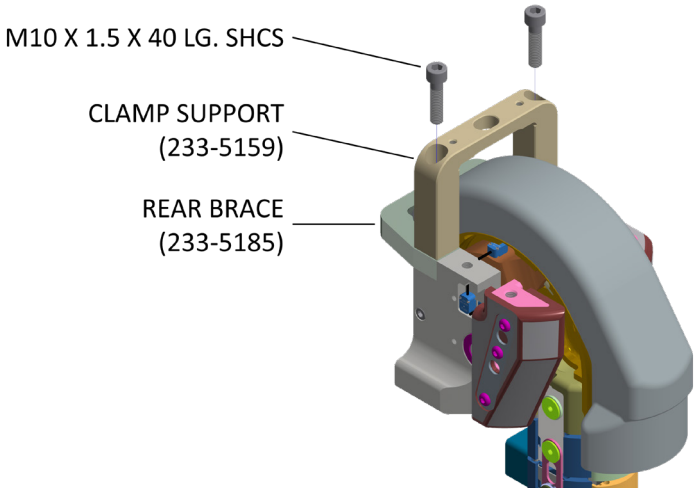


Figure 5.16 Attach Rear Brace and Clamp Support

14. Route the instrumentation cables from the femur, knee, and tibia through the slots in the bottom of the SUBP housing.

15. Attach the SUBP top housing using four M10 X 1.5 X 30 LG. SHCS at the inside of the housing. At this point, torque all bolts as specified.

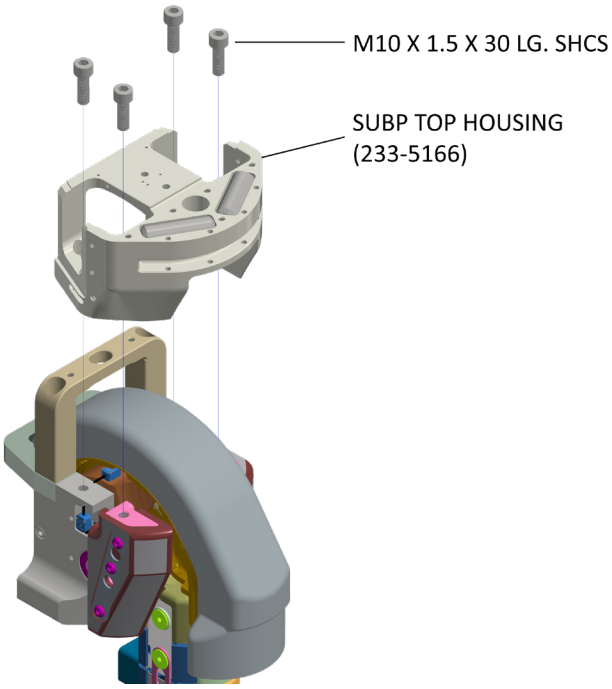


Figure 5.17 Attach the SUBP Top Housing

16. Insert the travel pin so that it goes through the lower clamps and femur top mounting bracket. The SUBP may need to be rotated to align the holes. Secure the travel pin with a 5/16 hairpin cotter on each side.

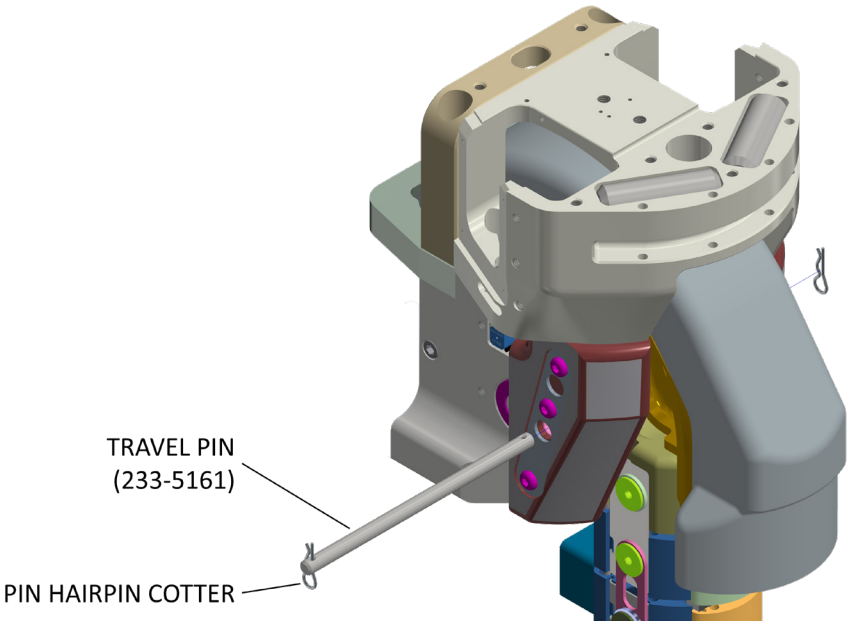


Figure 5.18 Insert Travel Pin

17. Insert three tungsten inserts (233-5155) into both the left and right rear clamps.

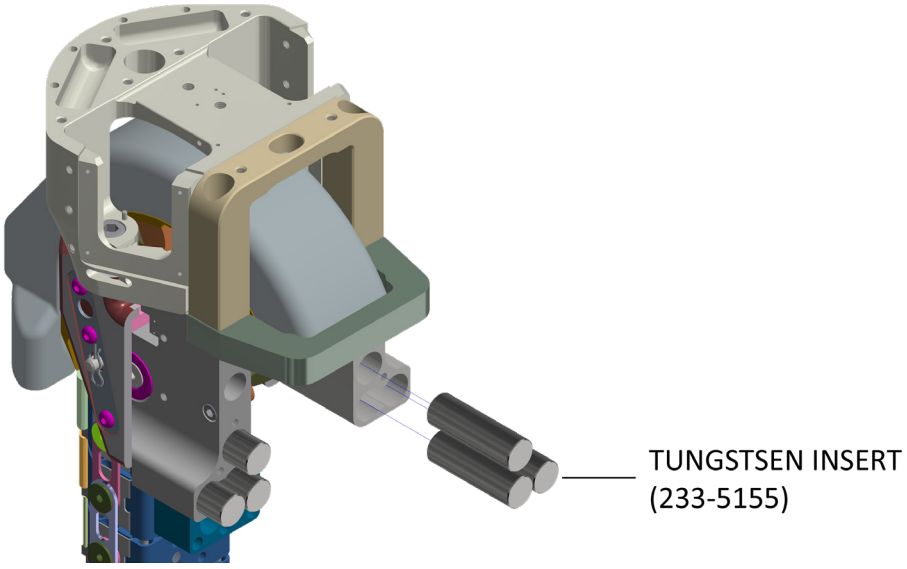


Figure 5.19 Insert Tungsten

18. Attach the left (233-5156) and right (233-5170) rear ballast clamps to the rear clamps using two M6 X 1 X 30 LG. SHCS per clamp.

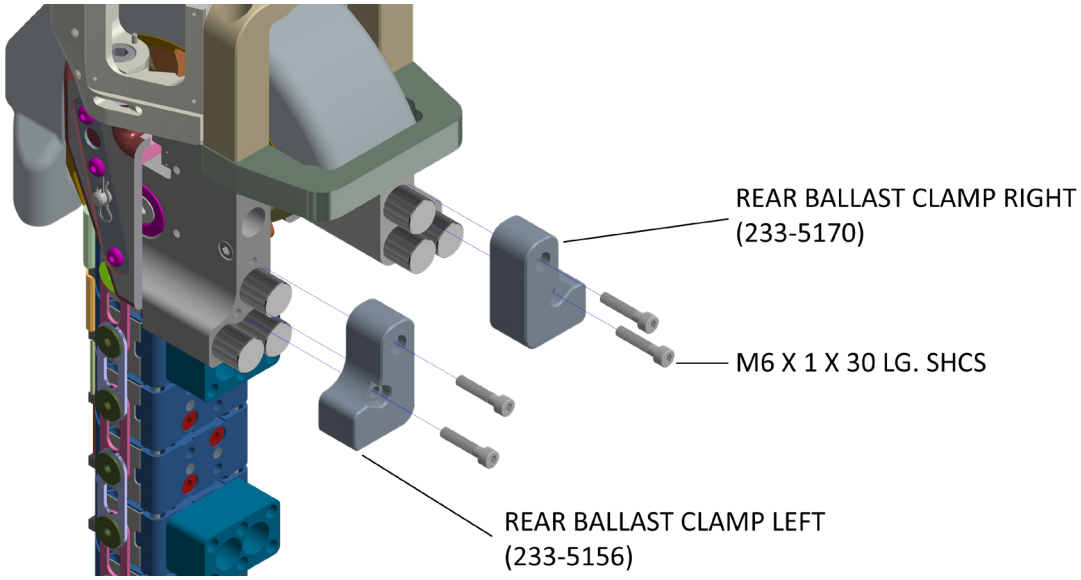


Figure 5.20 Attach Rear Ballast Clamps

19. Place the rear impact protection (233-5204) on the assembly. Secure it at the clamp support using two M6 flat washers and two M6 X 1 X 12 LG. BHCS and at each side with the side clamp plate (233-5162) and two M6 X 1 X 12 LG. BHCS.

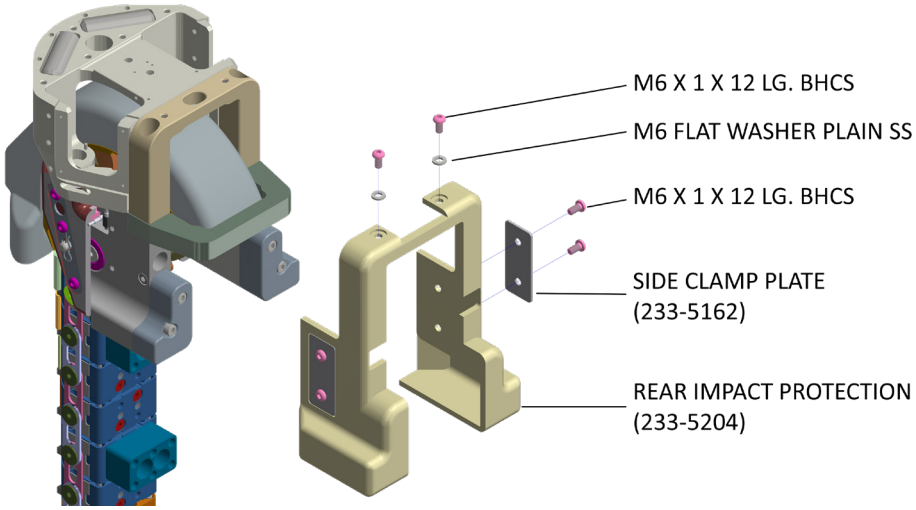


Figure 5.21 Place Rear Impact Protection

20. Secure the DTS SLICE Supercap+ to the right DTS mounting bracket (233-5153) using four M3 X 0.5 X 16 LG. SHCS. Slide this into the right pocket in the SUBP housing and attach it using one M4 X 0.7 12 LG. SHCS. Slide this into the right pocket in the SUBP housing and attach it using one M4 X 0.7 12 LG. SHCS.

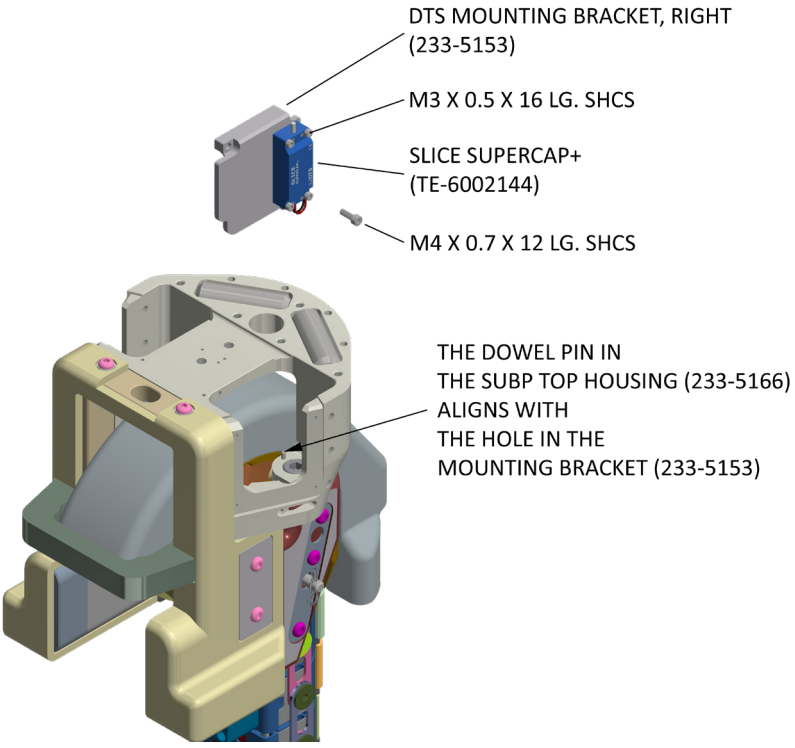


Figure 5.22 Attach the Right DTS Mounting Bracket

21. Secure the DAS to the left DTS mounting bracket (233-5152) using two M3 X 0.5 X 25 LG. SHCS and two M3 X 0.5 X 30 LG. SHCS as shown below.

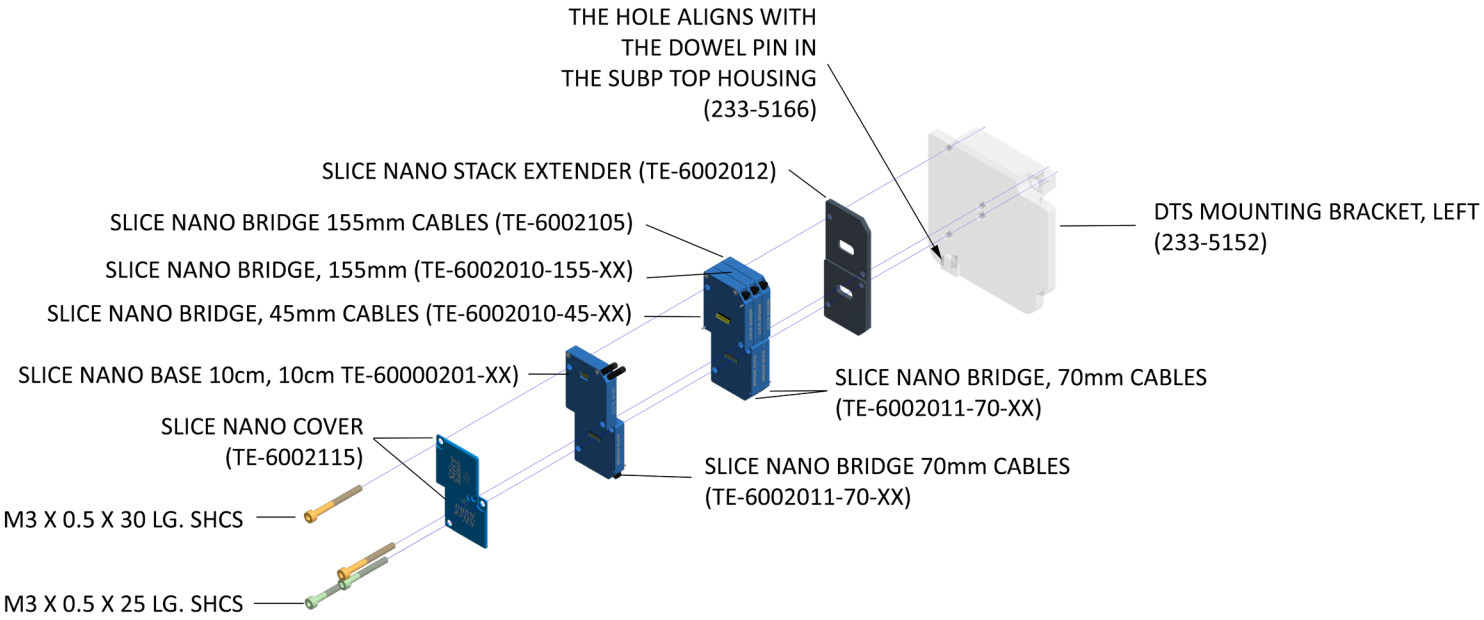


Figure 5.23 Attach the SLICE Nano

22. Slide this into the left pocket in the SUBP housing and attach it using one M4 X 0.7 X 12 LG. SHCS.

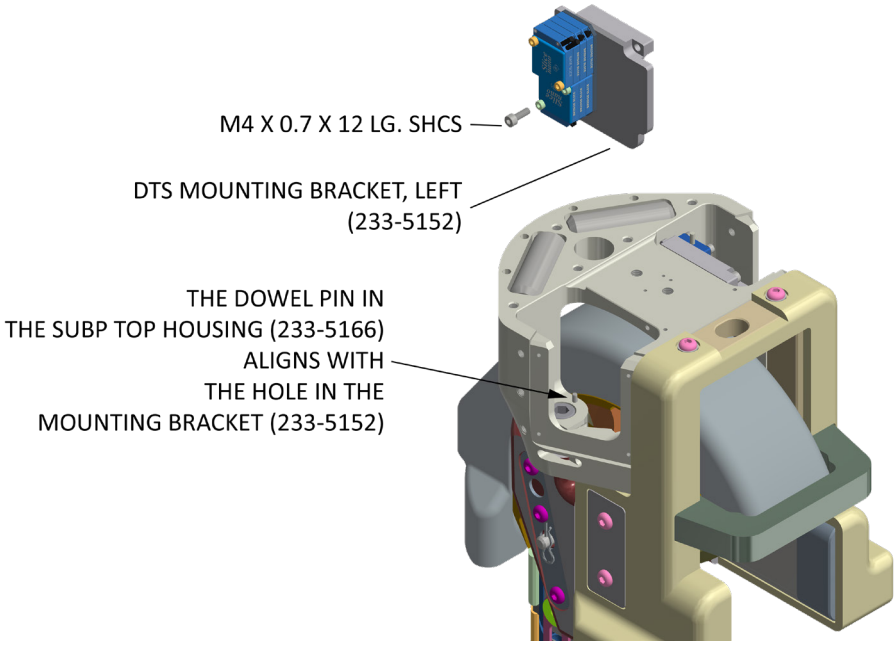


Figure 5.24 Attach the Left DTS Mounting Bracket

23. Secure the exit cable to the SUBP top housing using three M2.5 X 0.4 X 10 LG. SHCS.

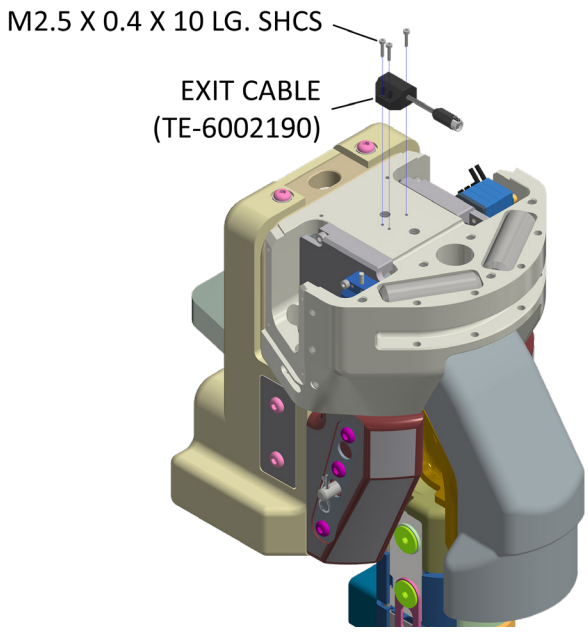


Figure 5.25 Secure the Exit Cable

24. Connect all sensors to the DAS. For the DTS DAS, the sensors can connect to any 7 pin or 16 pin connector as the software identifies the sensor. Refer to Table 3-2 for cable plug-in information.

25. Attach the two DAS covers (233-5172) with four M3 X 0.5 X 6 LG. BHCS per plate.

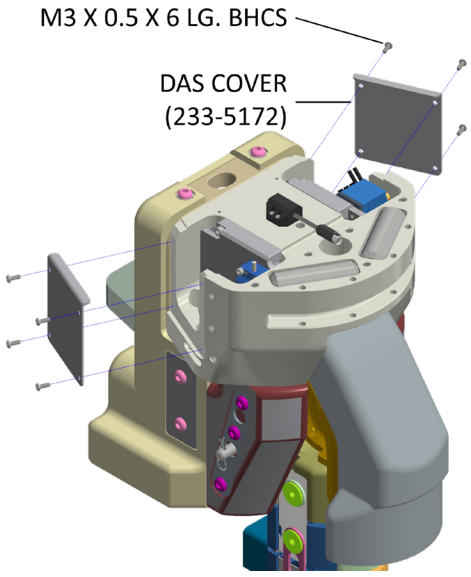


Figure 5.26 Attach the DAS covers

26. Fit the flesh. Then insert four M5 X 40 dowel pins into the SUBP housing thru the top flesh (233-5210) to locate it.

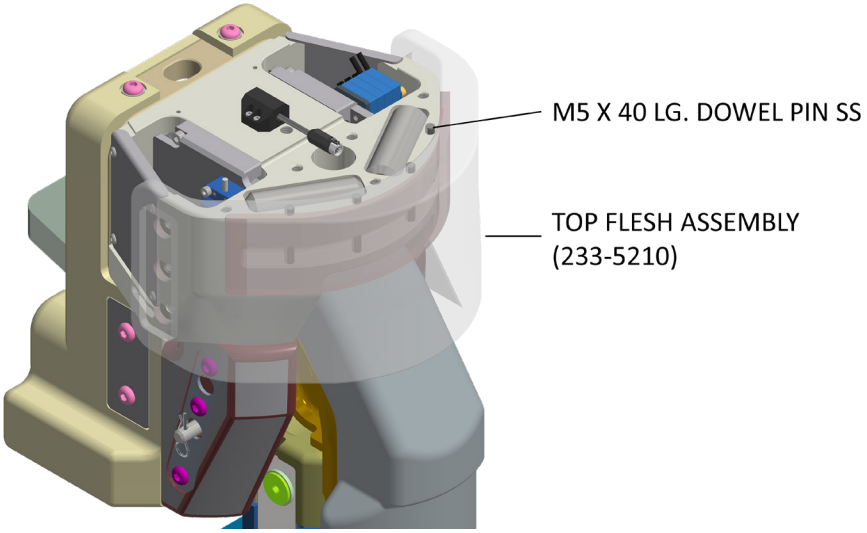


Figure 5.27 Insert Dowel Pins into the SUBP Housing

27. Place the SUBP top flesh (233-5210) onto the top housing. Attach the two flesh clamp plates (233-5186) on both sides of the flesh using three M6 X 1 X 16 LG. FHCS per plate.

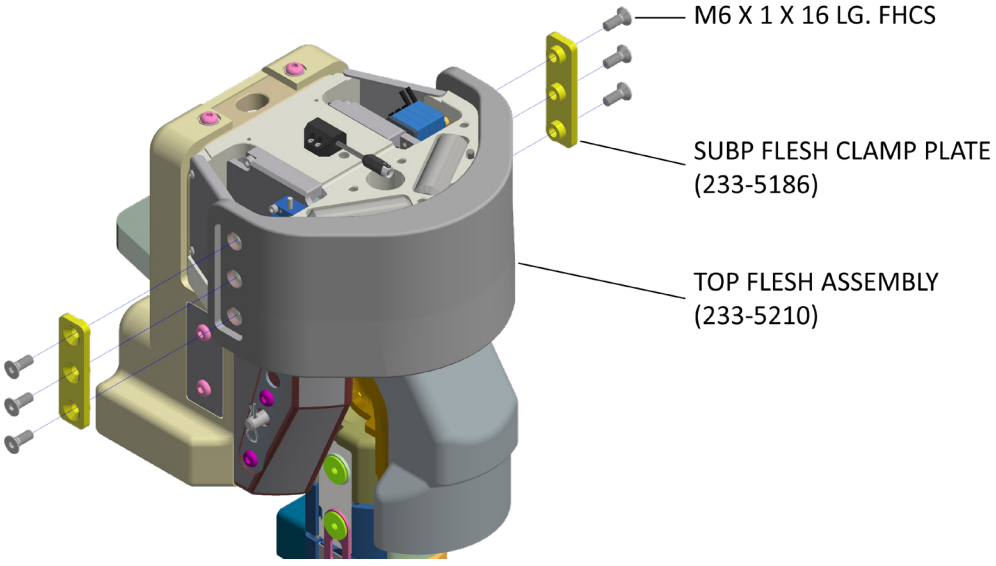


Figure 5.28 Attach the Top Flesh Assembly and Clamp Plate

28. Attach the cover plate (233-5151) using five M6 X 1 X 16 SHCS. Ensure any wires crossing over are not pinched and in the cross grove. Before attaching the cover plate, tape down wires crossing over the SUBP to hold them in place.

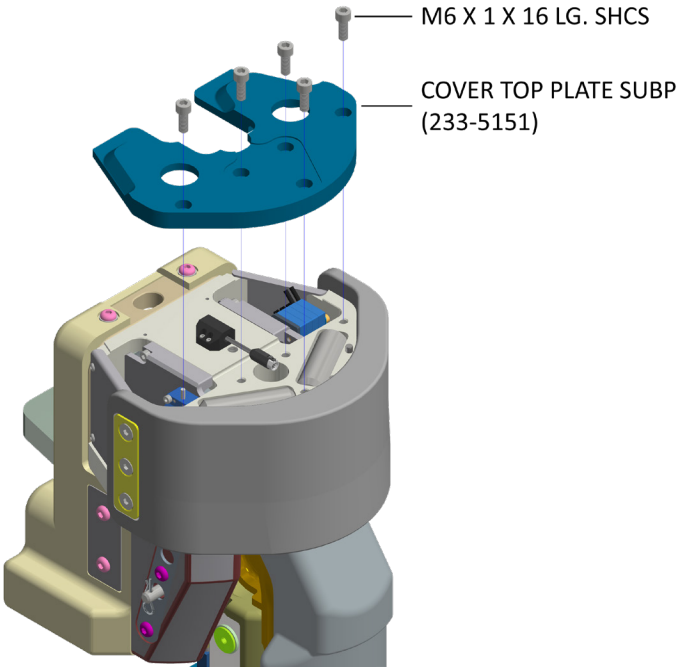


Figure 5.29 Attach the Cover Place

29. The SUBP is now fully assembled on leg.

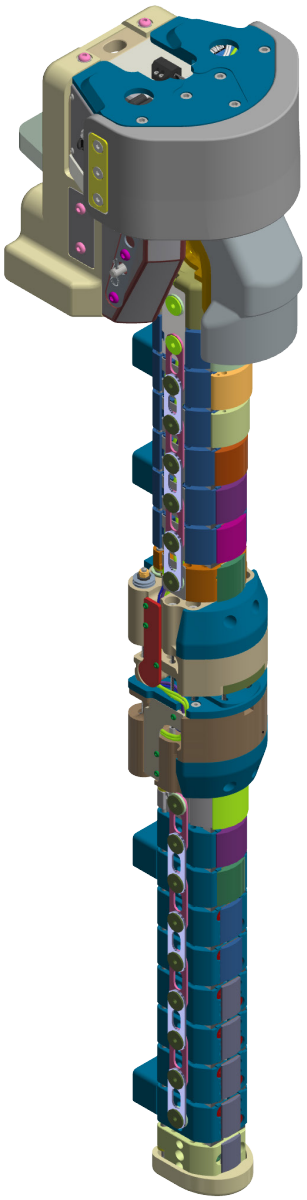


Figure 5.30 SUBP Fully Assembled on Leg

SECTION 6

Femur Assembly

6.1 Description of Femur Assembly and Features

Compared to Flex-PLI, the aPLI is stiffer more biofidelic bone for injury assessment.

6.2 Assembly of Femur

6.2.1 FEMUR ASSEMBLY PARTS LIST

The figures below shows the assembly view and exploded view of the femur assembly, 233-5100 and the table gives a general description of each item.

Figure 6.1 Femur Assembly View

Femur Assembly

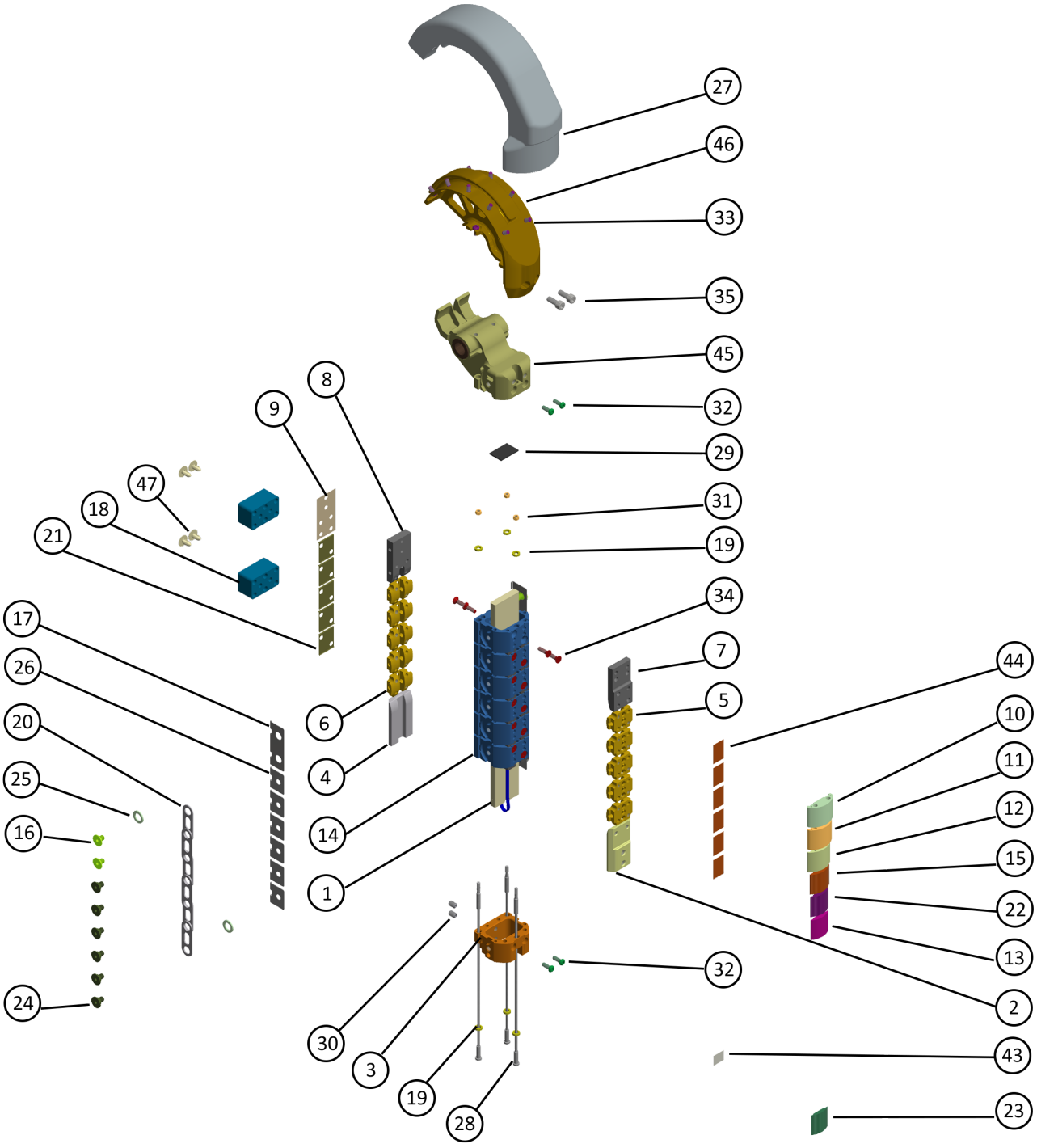


Figure 6.2 Femur Exploded View

Femur Assembly

Table 6-1 aPLI Femur Assembly Parts List

Item	Qty.	Part Number	Description
1	1	233-5165	PCB FEMUR BONE ASSEMBLY, 3 CH
2	1	233-5102	BONE CLAMP THICK, KNEE (FEMUR)
3	1	233-5137	FEMUR SEGMENT LOWER (PT-2)
4	1	233-5508	BONE CLAMP THIN, KNEE (FEMUR)
5	5	233-5125	SPACER, BONE CONTACT, THICK (FEMUR)
6	5	233-5127	SPACER, BONE CONTACT, THIN (FEMUR)
7	1	233-5128	BONE CLAMP THICK, FEMUR TOP
8	1	233-5129	BONE CLAMP THIN, FEMUR TOP
9	1	233-5504	SHIM, BONE CLAMP (T0.4) (OPTIONAL)
10	1	233-5118	IMPACT FACE FEMUR 2
11	1	233-5117	IMPACT FACE FEMUR 3
12	1	233-5116	IMPACT FACE FEMUR 4
13	1	233-5115	IMPACT FACE FEMUR 7
14	6	233-5134	SEGMENT ASSEMBLY FEMUR
15	1	233-5119	IMPACT FACE FEMUR 5
16	4	233-5105	STEPPED BOLT, SHORT
17	2	233-5121	CABLE COVER, FEMUR
18	2	233-5124	LEGFORM PUSH PAD
19	6	233-5521	WASHER, CABLE (OPTIONAL)
20	12	233-5515	LINK
21	5	233-5509	SHIM, TIBIA (T0.4) (OPTIONAL)
22	1	233-5518	IMPACT FACE FEMUR 6
23	1	233-5517	IMPACT FACE TIBIA 3
24	12	233-5106	STEPPED BOLT
25	4	233-5104	WASHER
26	12	233-5528	CABLE COVER
27	1	233-5203	FEMUR HOOK
28	3	133-5110	CABLE ASSEMBLY, FEMUR
29	1	133-5510	RUBBER BUFFER, FEMUR/TIBIA END
30	2	5000796	M8 X 1.25 X 12 LG. SSSCP
31	3	5000522	M5 X 0.8 HEX LOCK NUT ZINC
32	6	5000072	M6 X 1 X 16 LG. BHCS
33	12	5000356	M6 X 1 X 12 LG. BHCS
34	24	5001089	M6 X 1 X 20 LG. FHCS
35	2	5000075	M8 X 1.25 X 20 LG. SHCS
36	2	133-5002	SHIM, BONE CLAMP (T0-05) (OPTIONAL) (NOT SHOWN)
37	2	133-5003	SHIM, BONE CLAMP (T0-5) (OPTIONAL) (NOT SHOWN)
38	2	133-5004	SHIM, BONE CLAMP (T0-6) (OPTIONAL) (NOT SHOWN)
39	15	133-5012	SHIM, .05 (OPTIONAL) (NOT SHOWN)
40	5	133-5029	SHIM, .1 THICK (OPTIONAL) (NOT SHOWN)

Item	Qty.	Part Number	Description
41	5	133-5030	SHIM, .2 THICK (OPTIONAL) (NOT SHOWN)
42	5	133-5031	SHIM, .40 (OPTIONAL) (NOT SHOWN)
43	1	233-5026	TAPE, FEMUR KNEE SEGMENT
44	6	233-5025	TAPE SEGMENT
45	1	233-5192	FEMUR TOP MOUNTING BRACKET
46	1	233-5191	CURVED IMPACT FACE
47	4	6006010	FIR-TREE CLIP 6.5 HOLE X 2-6 THK BLACK

6.2.2 ASSEMBLY OF FEMUR COMPONENTS

Before beginning assembly, inspect the bone for any damage and ensure that all rubber buffers are bonded to the segment assemblies (233-5134). If for any reason a buffer should become dislodged, lost, or damaged it will need replacing or re-bonding. When bonding the buffer ensure surfaces of both parts are cleaned before bonding, degrease then bond with cyano-acrylate adhesive or similar.

The following procedure is a step-by-step description of the assembly procedure for the femur components. The disassembly procedure is the reverse order of the assembly procedure.

1. **Start at the knee end of the femur assembly.**
2. **Orient the lower femur segment with the cutout facing down and the counterbore holes facing the front. Slots on the bone clamp face inwards to prevent the cables from pinching. Attach the thick bone clamp (233-5102) to the lower femur segment (233-5137), on the impact side, using two M6 X 1 X 16 LG. BHCS. Torque to 8 Nm.**

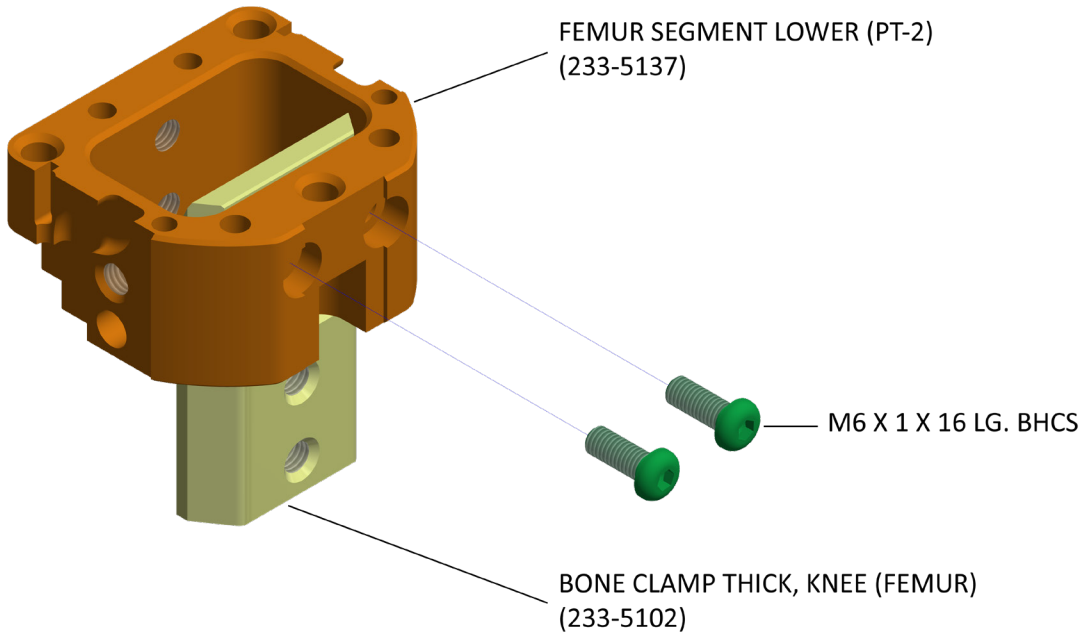


Figure 6.3 Attach Thick Bone Clamp to Lower Femur Segment

3. Slide this with the thin bone clamp (233-5508) over the bone at the knee end with the notch at the bottom and the PC board and cables in the back. The clamps should be flush with the bone.

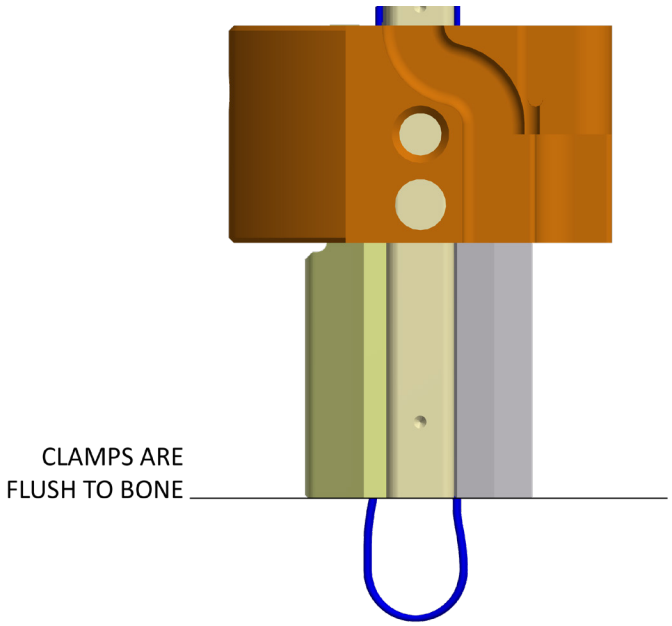


Figure 6.4 Clamps are Flush to Bone

4. Once in place, tighten the two M8 X 1.25 X 12 LG. set screws on the non-impact side of the lower femur segment starting with the screw nearest the knee. Torque to 8 Nm. Route the 3 channel femur bone cable so that it's to the right side of the leg.

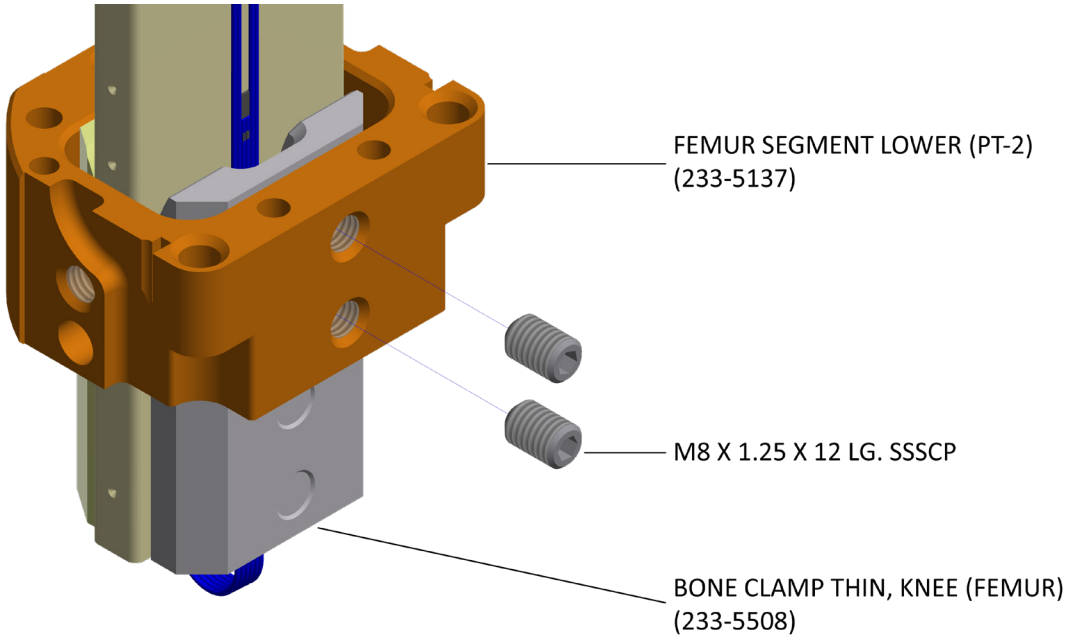


Figure 6.5 Tighten Set Screws on Lower Femur Segment

5. **Orient the femur segment assembly with the curved corners facing front and the thick bone contact spacer facing inwards. Attach a thick bone contact (233-5125) to the impact side of a femur segment assembly (233-5134) using two M6 X 1 X 20 LG. FHCS.**

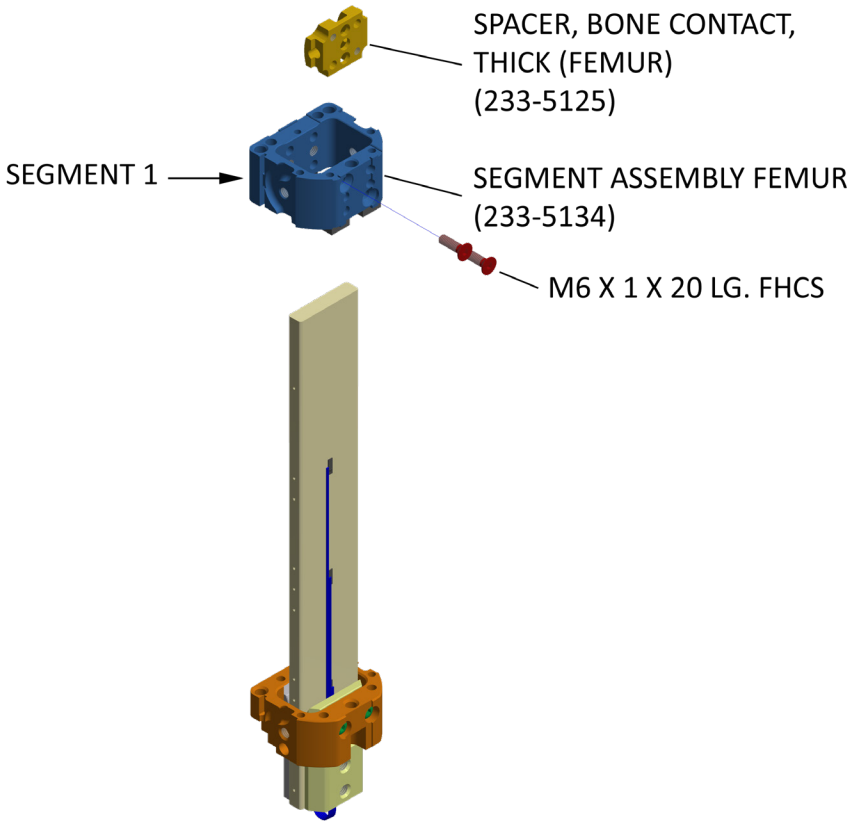


Figure 6.6 Attach Thick Bone Contact to Femur Segment 1

6. **Attach a thin bone contact (233-5127) and shim (233-5509) to the non-impact side of the inner segment using two M6 X 20 FHCS. Torque M6 FHCS to 3 Nm. Slide the segment onto the bone. There should be no play between the inner segment and bone. If there is, add optional shims (133-5012, 133-5029, 133-5030, or 133-5031) between 233-5509 and the segment assembly until a tight fit is reached.**

NOTICE

Be careful when assembling inner segments so that the strain gauges running along the center of the bone are not damaged. When fitting the assembly use thumb force only when pushing down on the segment. Do not force segments into place. There should be resistance when pushing the assemblies in.

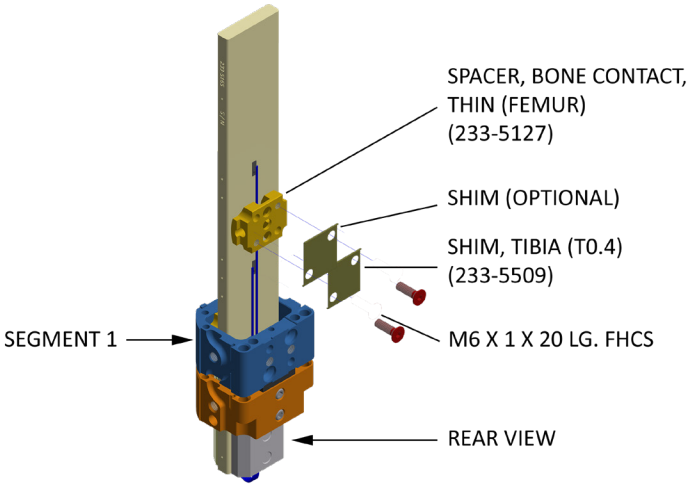


Figure 6.7 Attach the Thin Bone Contact on Non-Impact Side

7. **Repeat steps 5 & 6 for the next four femur segment assemblies.**

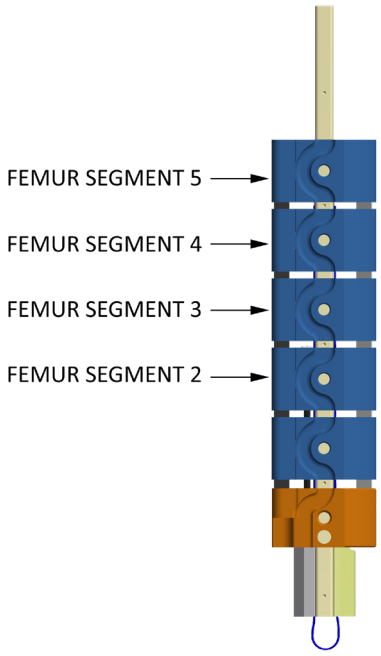


Figure 6.8 Attach Femur Segments 2-5

8. On the last femur segment, attach the thick femur bone clamp (233-5128) to the impact side using two M6 X 20 FHCS. Torque M6 FHCS to 3 Nm. Attach the thin femur bone clamp (233-5129) to the non-impact side using two M6 X 20 FHCS. Slide this over the bone. If the fit is loose, add shims (233-5504, 133-5002, 133-5003, or 133-5004) between the thin bone clamp and segment assembly until a tight fit is achieved.

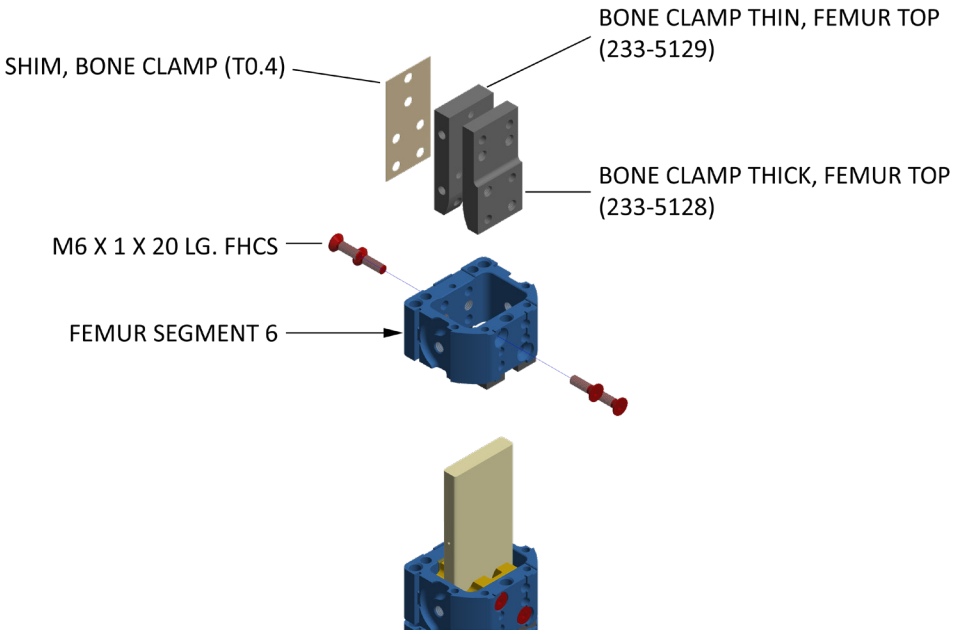


Figure 6.9 Attach Femur Segment 6

9. The clamps should be flush with the bones once assembled.

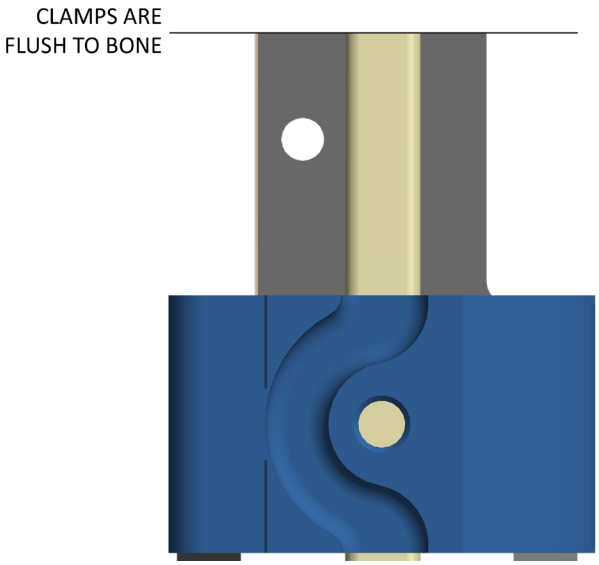


Figure 6.10 Bone Clamps are Flush

10. Place a femur/tibia end rubber buffer (133-5510) on the top bone end. This should be located centrally. Slide the femur top mounting bracket (233-5192) over the rubber buffer. Secure the mounting bracket using two M6 X 1 X 16 LG. BHCS on the impact side and two M6 X 1 X 16 LG. BHCS on the non-impact side. Torque these to 8 Nm. Torque the M6 X 1 X 20 LG. FHCS to 3 Nm.

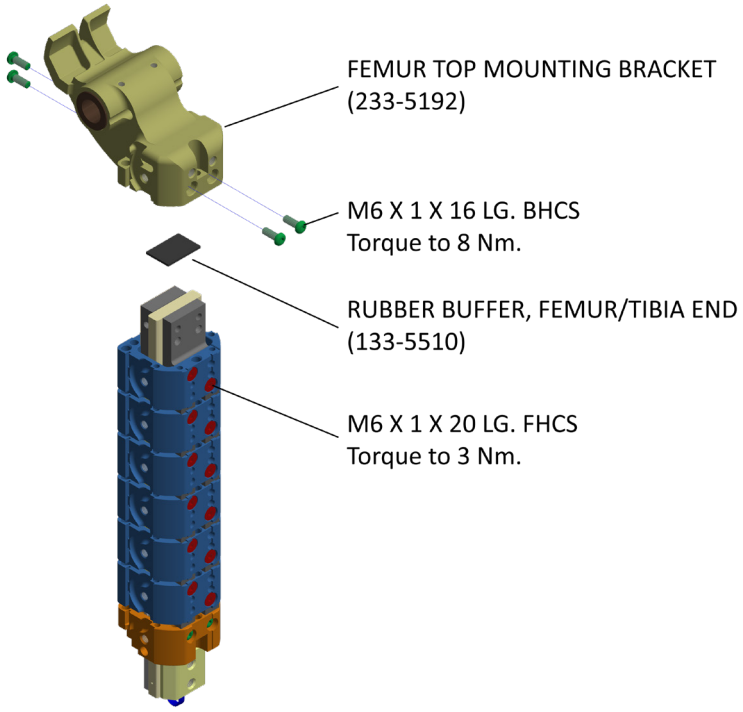


Figure 6.11 Attach Femur Top Mounting Bracket

11. Place a washer (233-5521) over each of the stainless-steel cables (133-5110) and feed the cable through the assembly from the knee end. Place another washer over the threaded fitting. Then attach the three M5 nylock nuts. These can be turned by holding the wire over its 4 mm flats (wrench supplied in the tool kit).

NOTICE
Measure the distance between the nut and washer after using the setting tool (133-5112) provided in the tool kit. There must be a 13.6 mm gap between them.

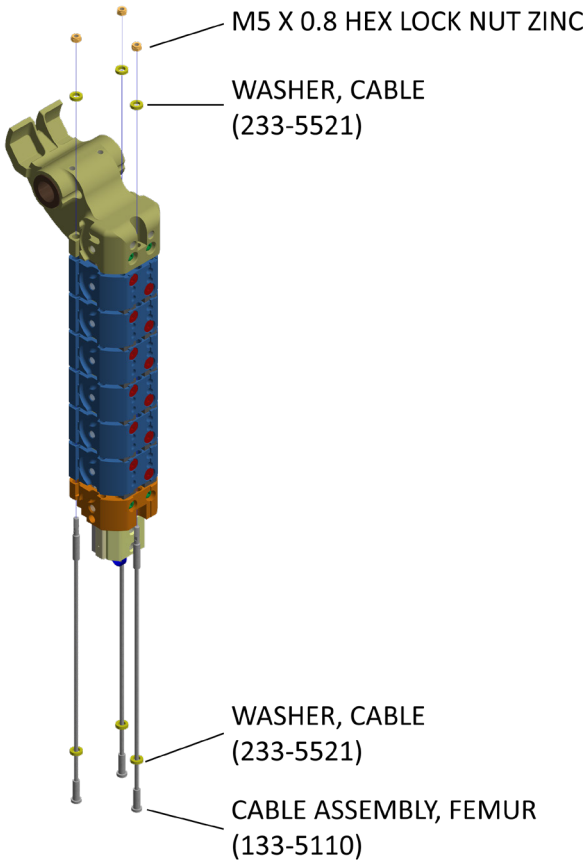


Figure 6.12 Attach Femur Cable Assembly

12. If the femur hook (233-5203) is not already attached to the curved impact face (233-5191), attach it now using ten M6 X 1 X 12 LG. BHCS on the underside of the curved impact face. Torque the screws to 4Nm.

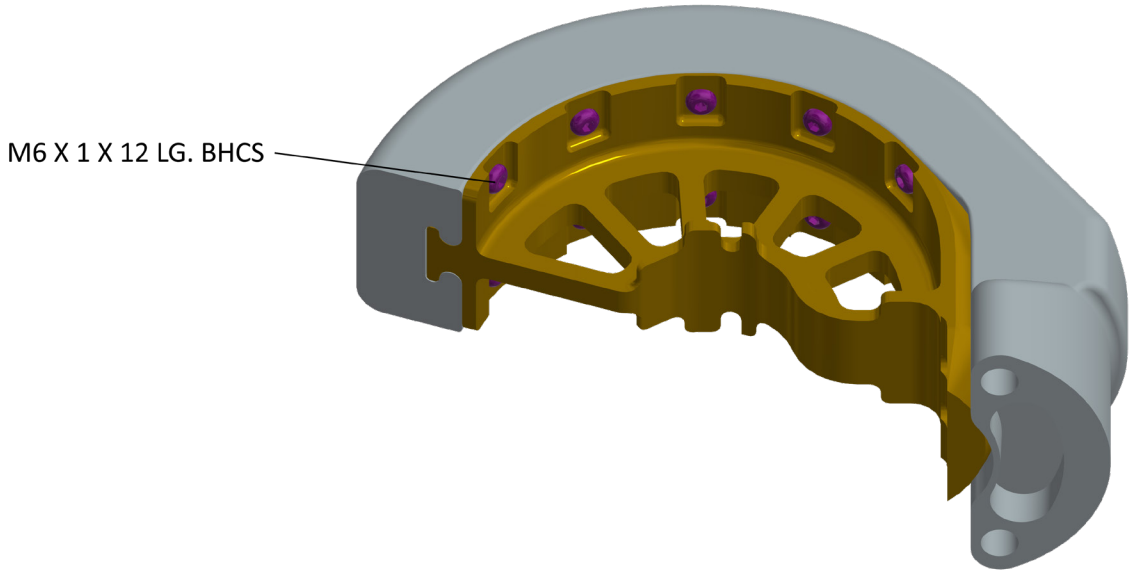


Figure 6.13 Attach Femur Hook with M6X12 BHCS

13. Fit the curved impact face over the femur top mounting bracket and secure it using two M6 X 1 X 12 LG. BHCS at the top of the mounting bracket. Torque to 4Nm.

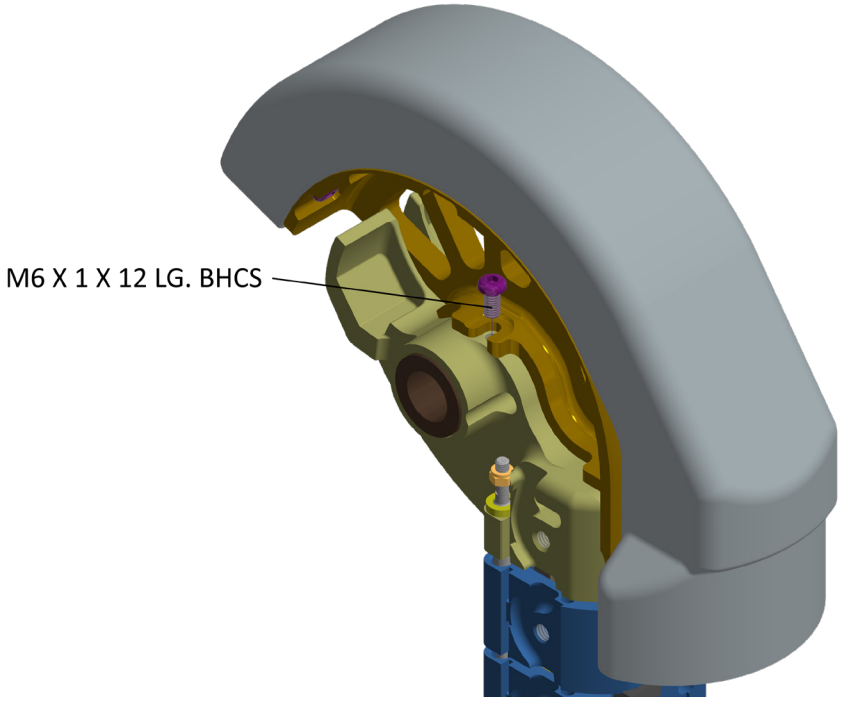


Figure 6.14 Attach Curved Impact Face to Mounting Bracket with M6X12 BHCS

14. Lift the femur hook to access the holes to attach the curved impact face to the mounting bracket. Use two M8 X 1.25 X 20 LG. SHCS and toque to 10 Nm.

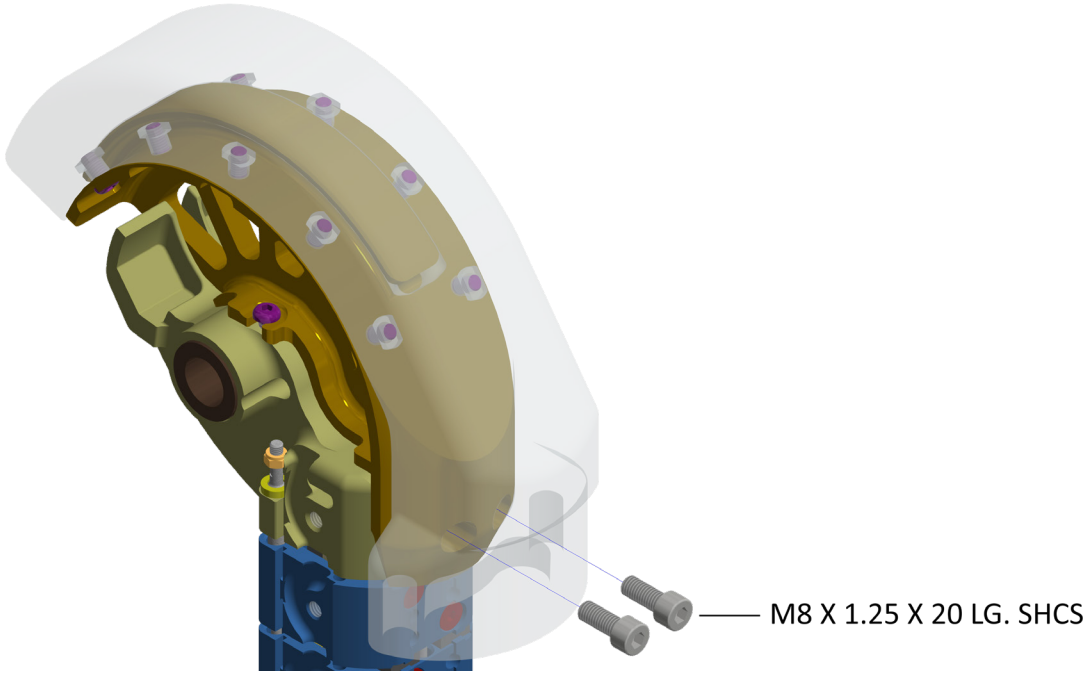


Figure 6.15 Attach Curved Impact Face to Mounting Bracket with M8X20 SHCS

15. Route the instrumentation cables towards the SUBP end through the channels on the right side of the femur. The 3 channel femur cable, knee ARS, ACL and PCL string pot cables are routed up the right side of the femur. The 3 channel and 1 channel tibia cables, MCL, and knee accel are routed up the left side of the femur.

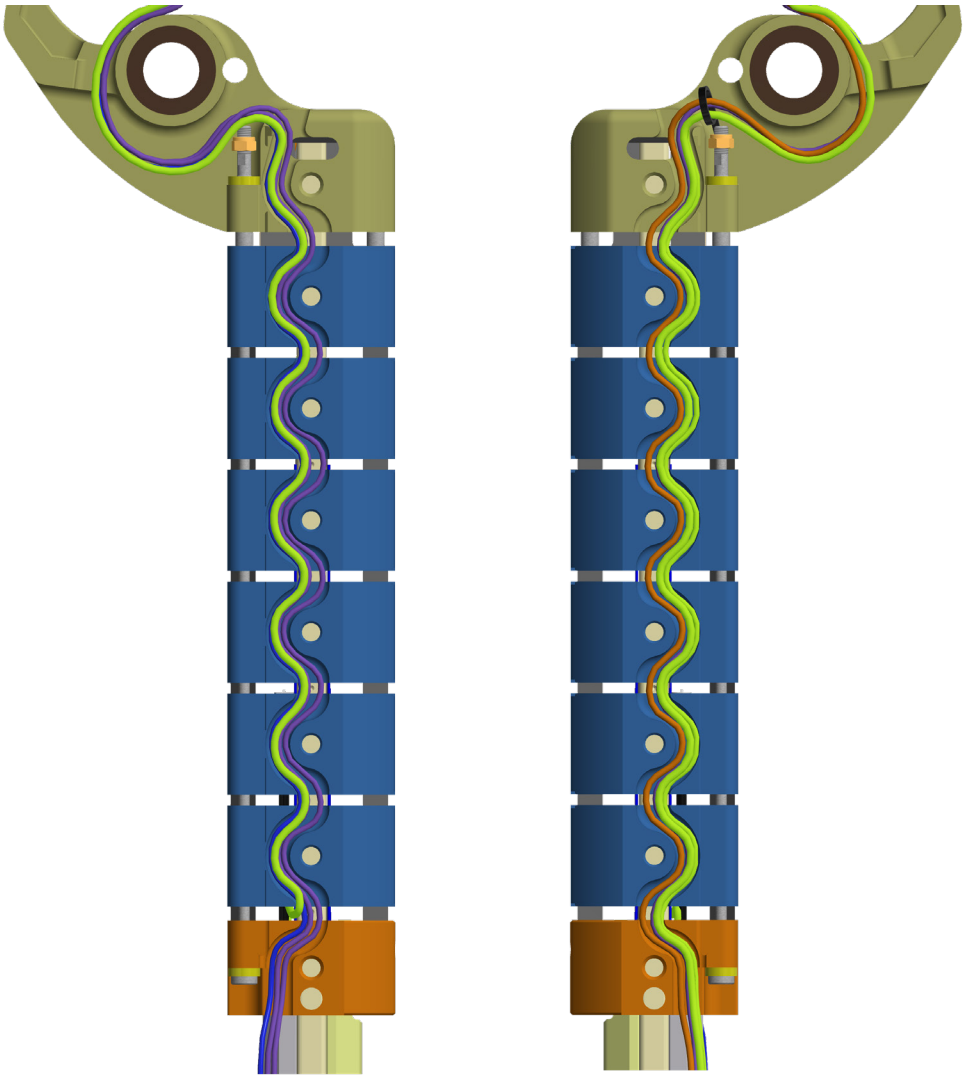


Figure 6.16 Route Cable Towards SUBP

16. Starting at the femur top mounting bracket, place femur cable cover (233-5121) and six cable covers (233-5528) over the channels on the segment assemblies on one side of the legform.

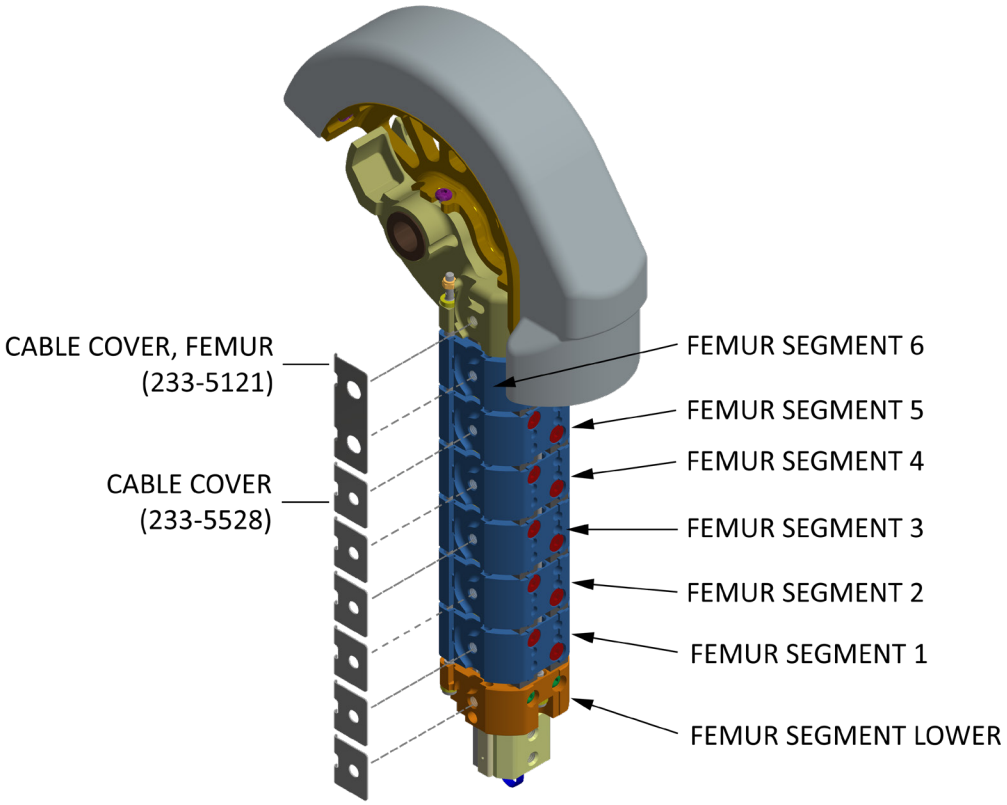


Figure 6.17 Place Cable Covers

17. At the femur cable cover place a washer (233-5104) over the upper hole.

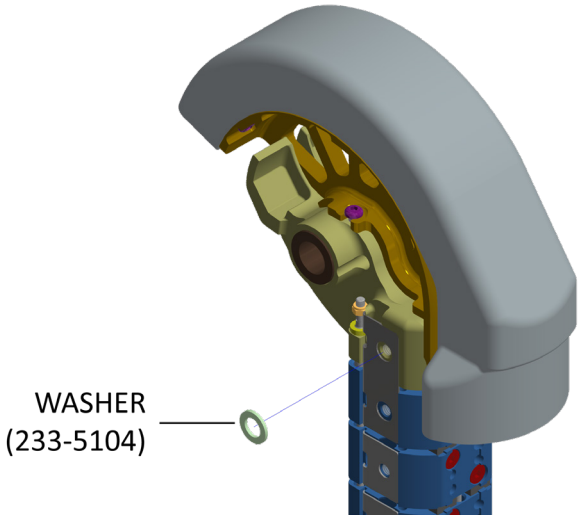


Figure 6.18 Place Washer 233-5104 Over Upper Hole

18. Place a link (233-5515) on the bottom hole of the femur cable cover, so that femur segments 5 and 6 are connected. Place links over the rest of the segments so that segments 3 and 4 are linked, and segments 1 and 2 are linked.

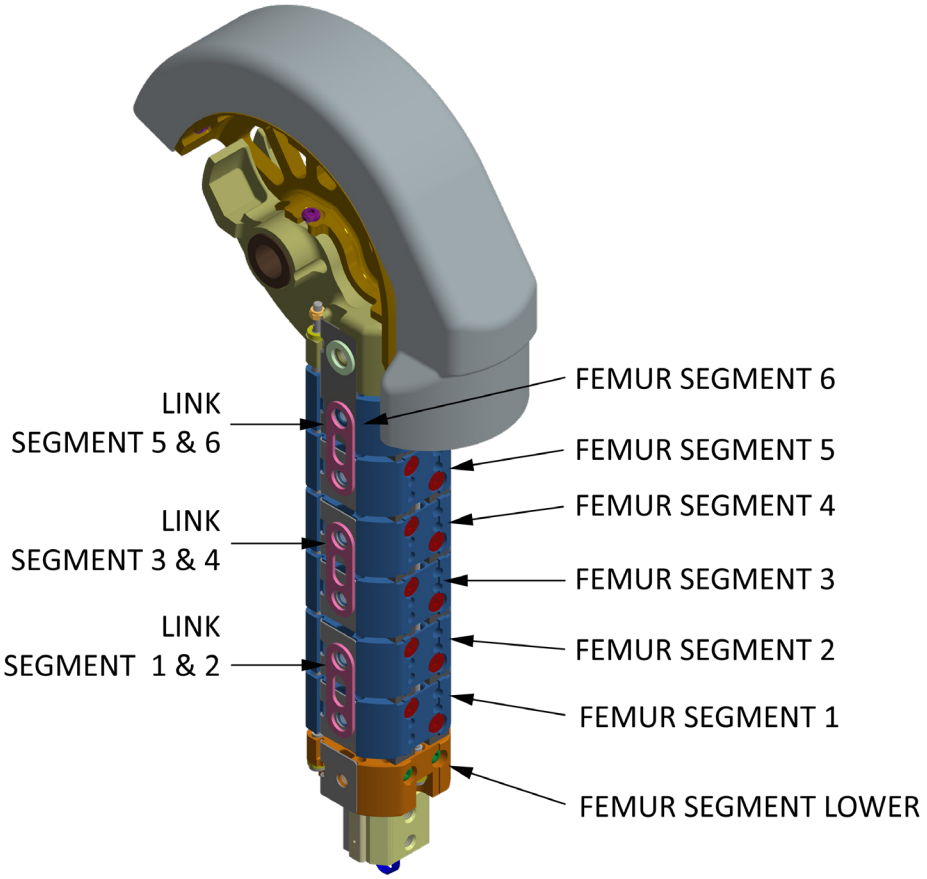


Figure 6.19 Place Links

19. Place a washer over the cable cover on the lower femur segment.

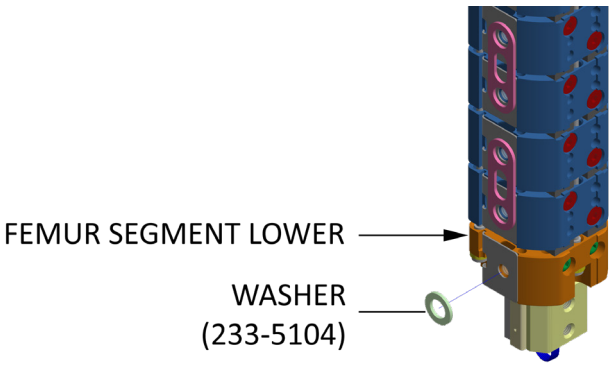


Figure 6.20 Place Washer 233-5104 over Lower Femur Segment

20. Layer links to connect the rest of the segments together such that segment 2 and 3, segments 4 and 5, and segment 1 and the lower femur segment are connected.

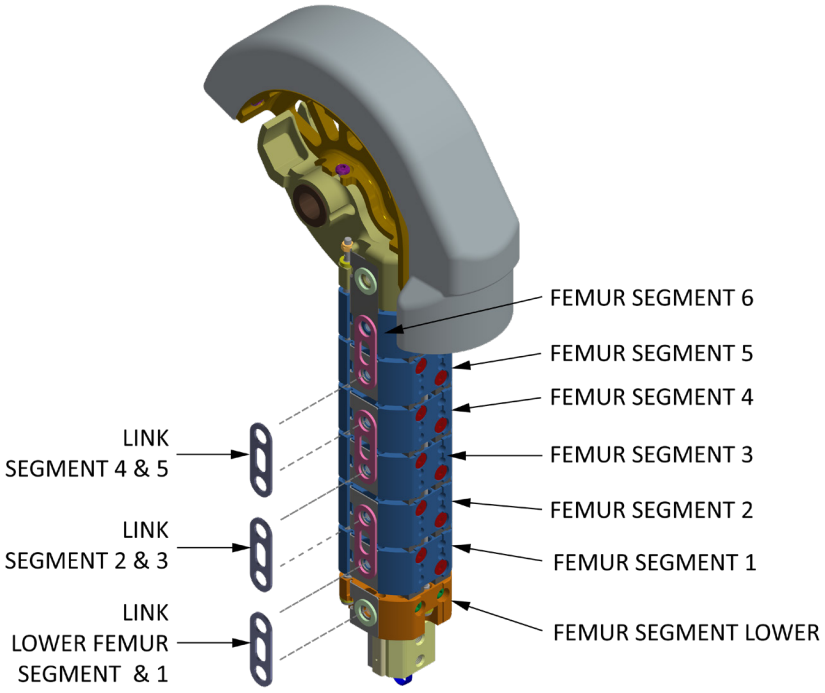


Figure 6.21 Place Links

21. Starting at the top, secure the cable covers and washer with two short stepped bolts (233-5105). Secure the remaining covers and links using six stepped screws (233-5106) as shown. Torque to 3Nm.

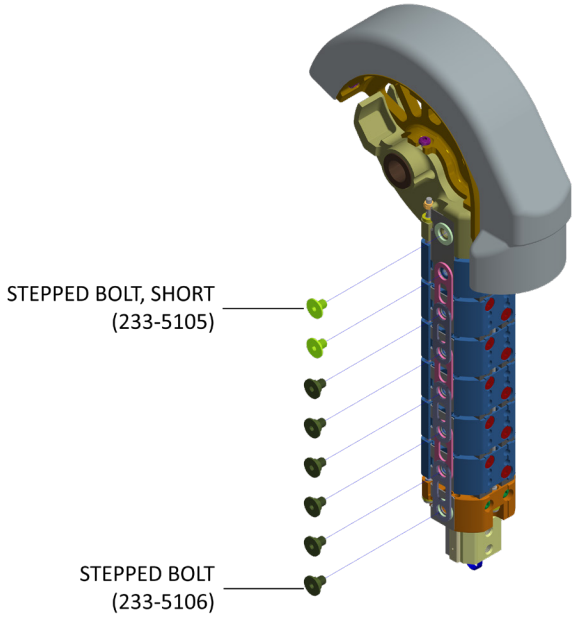


Figure 6.22 Secure Covers with Stepped Bolts

22. Repeat steps 16-21 for other side.
23. Attach the two legform push pads (233-5124), if disassembled, to femur segment 2 and 5 assemblies using two fir-tree clips (6006010) per push pad. The fixings clip into the M8 threaded holes on the non-impact side of the segment assemblies. Clip fixing should be replaced if removed to avoid detachment.

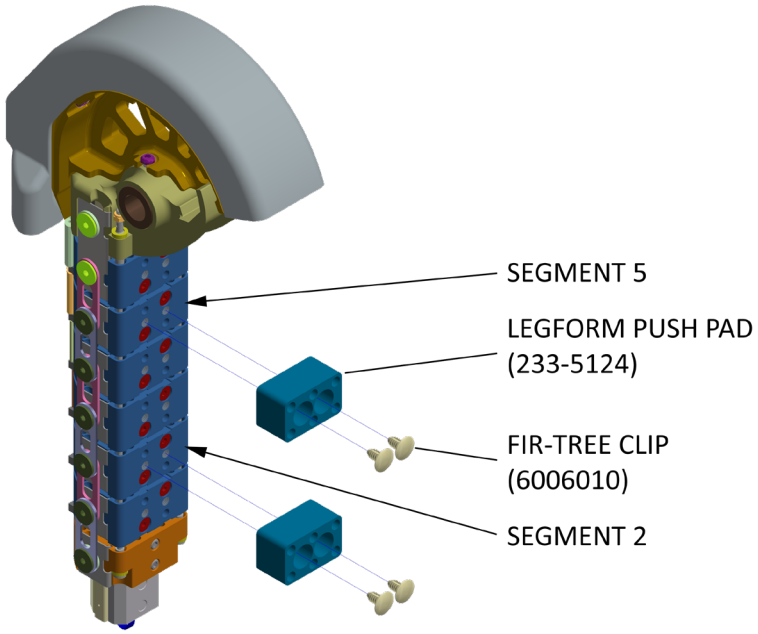


Figure 6.23 Attach the Legform Push Pad

24. If the femur impact segments were removed, reattach these to the impact side of the segment assemblies using double sided tape.

NOTICE

The double-sided tape used to hole the impact segments can be reused if it is still sticky. If it's no longer sticky or is folded over, it needs to be replaced with new pieces of tape.

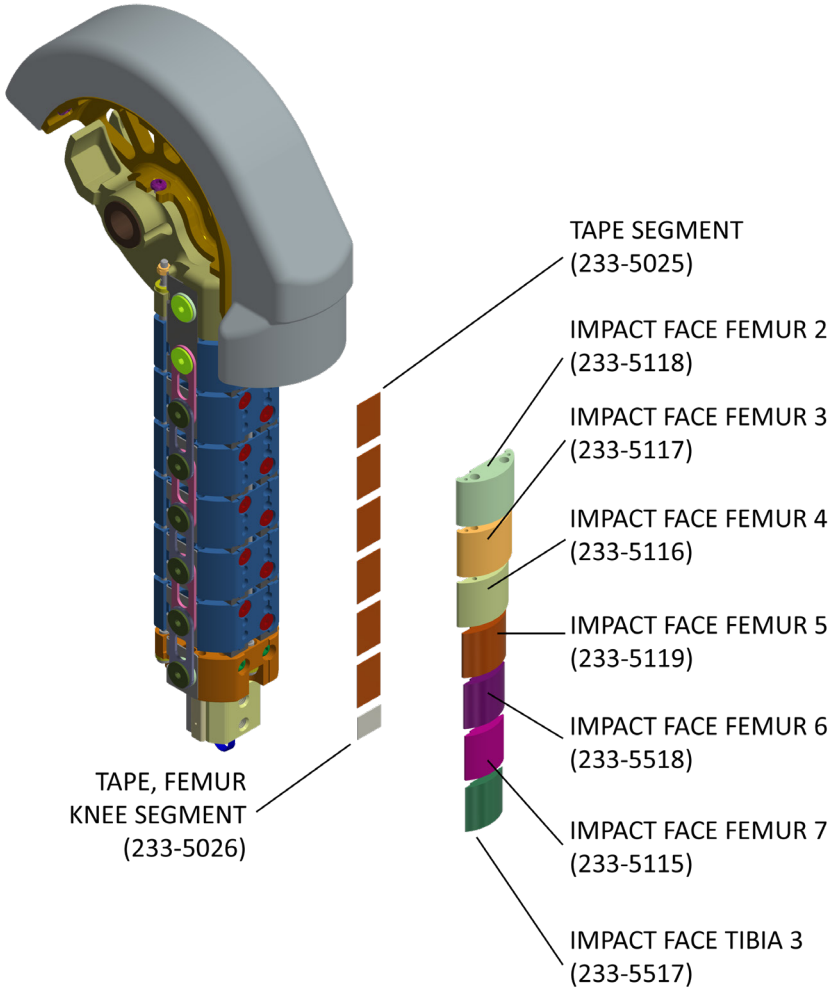


Figure 6.24 Attach the Segment Tape and Impact Face

SECTION 7

Knee Assembly

7.1 Description of Knee Assembly and Features

The knee is a floating joint held together with wires and springs, disc springs are incorporated to save on weight, standard coil springs are used as well. There is a plastic interface (meniscus) to reduce friction. This has a spherical front lobe to help locate the knee and allow 3D rotation.

7.2 Assembly of the Knee

7.2.1 KNEE ASSEMBLY PARTS LIST

The figures below show the assembly view and an exploded view of the Knee Assembly, 233-5300 and the table gives a general description of each item.

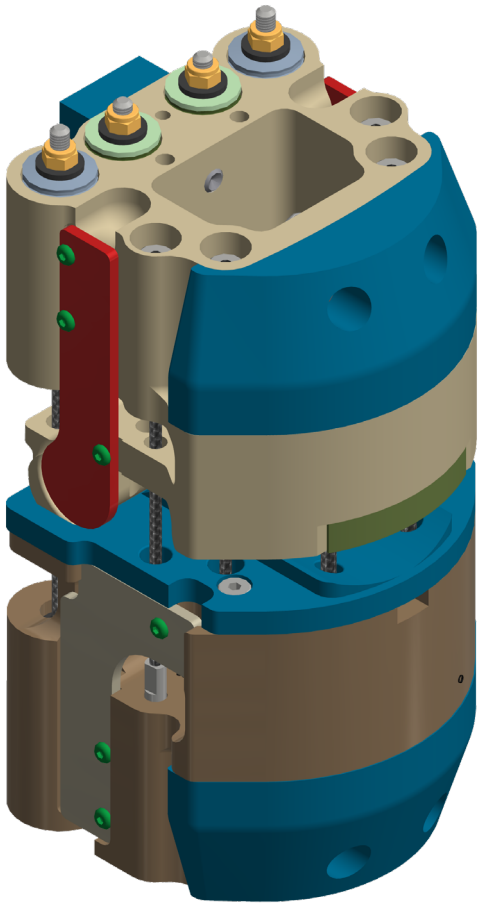


Figure 7.1 Knee Assembly Iso View

Knee Assembly

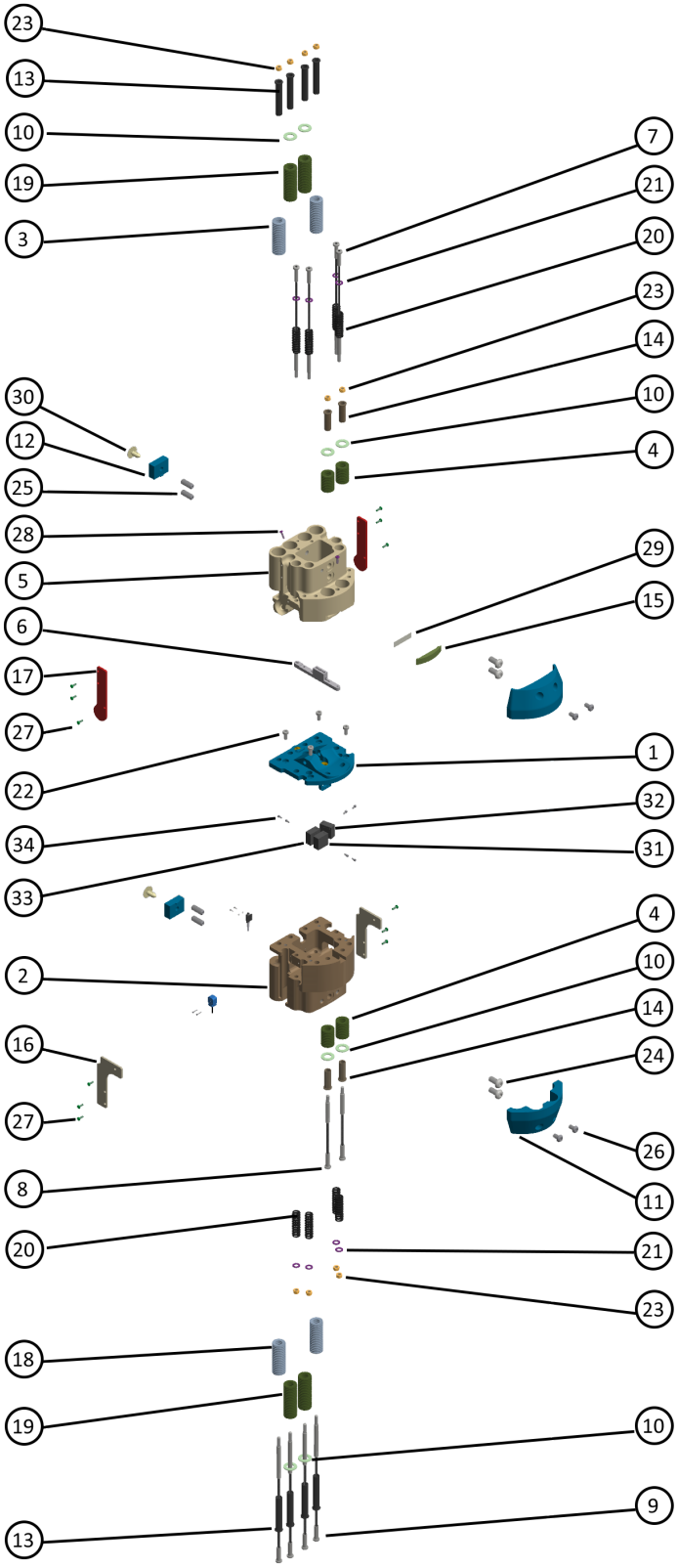


Figure 7.2 Knee Assembly Exploded View

Knee Assembly

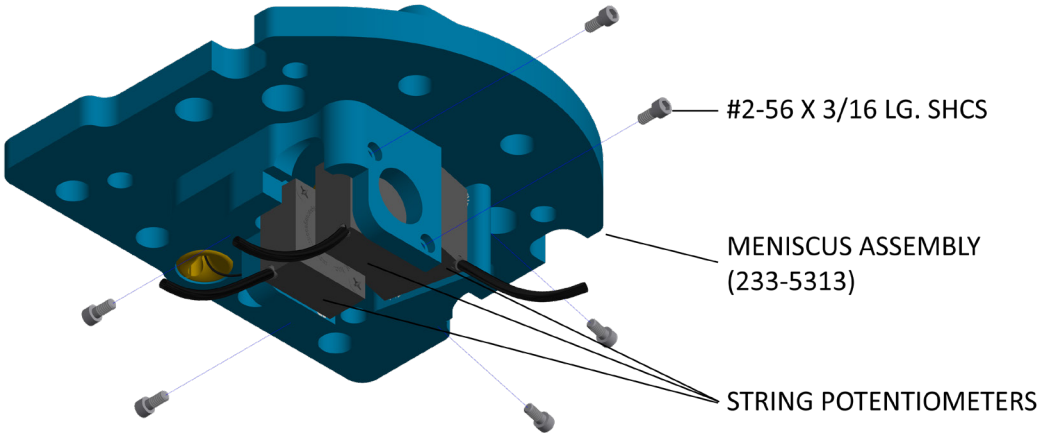
Table 7-1 aPLI Knee Assembly Parts List

Item	Qty.	Part Number	Description
1	1	233-5313	MENISCUS ASSEMBLY
2	1	233-5330	KNEE BLOCK LOWER
3	2	233-5326	OUTSIDE MCL FEMUR STACK THICK (39 WASHERS FOR EACH 233-5326 ASSEMBLY)
4	4	233-5329	LCL FEMUR AND TIBIA STACK THIN (20 WASHERS FOR EACH 233-5329 ASSEMBLY)
5	1	233-5320	KNEE BLOCK UPPER
6	1	233-5302	KNEE STRING ATTACHMENT
7	4	233-5360	CABLE ASSEMBLY, KNEE AP
8	2	233-5370	CABLE ASSEMBLY, LCL
9	4	233-5350	CABLE ASSEMBLY, MCL
10	8	233-5319	BELLEVILLE TOP WASHER
11	2	233-5304	KNEE COVER
12	2	233-5305	KNEE PUSH PAD
13	8	233-5310	GUIDE TUBE, MCL
14	4	233-5311	GUIDE TUBE, LCL
15	1	233-5306	ROUNDING
16	2	233-5314	CABLE CLAMP LOWER
17	2	233-5315	CABLE CLAMP UPPER
18	2	233-5327	OUTSIDE MCL TIBIA STACK THICK (37 WASHERS FOR EACH 233-5327 ASSEMBLY)
19	4	233-5328	INSIDE MCL FEMUR & TIBIA STACK THIN (42 WASHERS FOR EACH 233-5328 ASSEMBLY)
20	8	9003159	SPRING, 12 X 40
21	8	133-5311	CABLE WASHER
22	4	5000774	M5 X 0.8 X 10 LG. LHCS
23	10	5000522	M5 X 0.8 HEX LOCK NUT ZINC
24	4	5001479	M8 X 1.25 X 16 LG. BHCS
25	4	5000006	M8 X 1.25 X 20 LG. SSSCP
26	4	5000891	M6 X 1 X 10 LG. BHCS
27	12	5000410	M3 X 0.5 X 8 LG. BHCS
28	2	5001074	M3 X 0.5 X 10 LG. BHCS
29	1	233-5334	TAPE SEGMENT KNEE
30	2	6006010	FIR-TREE CLIP 6.5 HOLE X 2-6 THK BLACK
31	1	61-503A-05-1150-00-5V	CBL ASSEMBLY STRING POT R, 1150mm CBL, SLICE, ACL
32	1	61-507A-05-950-00-5V	CBL ASSEMBLY STRING POT L, 950mm CBL, SLICE, MCL
33	1	61-507B-05-1150-00-5V	CBL ASSEMBLY STRING POT L, 1150mm CBL, SLICE, PCL
34	6	9003560	#2-56 X 3/16 LG. SHCS

7.2.2 ASSEMBLY OF KNEE COMPONENTS

The following is a step-by-step description of the assembly procedure for the knee components. The disassembly procedure is the reverse order of the assembly procedure.

1. **Attach the 3 knee string potentiometers to the meniscus (233-5313). Each string potentiometer is secured to the meniscus using two #2-56 X 3/16 LG. SHCS. The potentiometers should be returned to the ligament positions they were removed from. When attaching the string pots, the ball crimps of the string potentiometers must be pulled through the bronze bushings. The ball crimps for the ACL and PCL string pots are pulled straight upwards. The ACL and PCL string pots eyelets should be positioned so they're resting above the bronze bushings. Pull the string pot of the of the MCL (mounted diagonally on the plate) towards the non-impact side and through the bronze busing.**



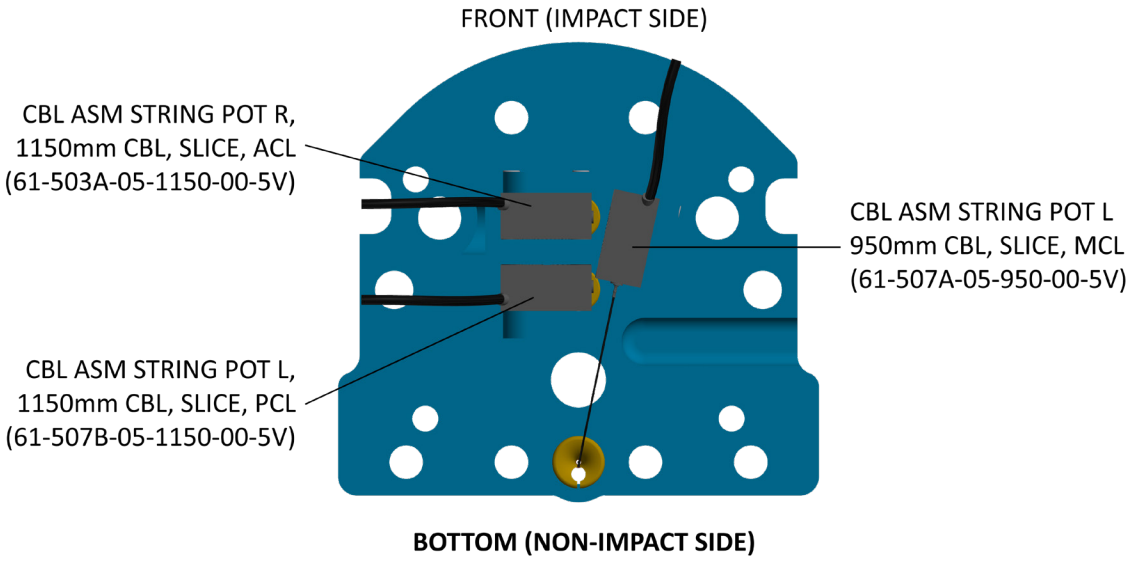


Figure 7.3 Attach the Knee String Potentiometers

2. Pull the ball crimps from the three knee potentiometers upwards and route through the holes on the knee string attachment (233-5302) and locate in the spherical recesses as shown.

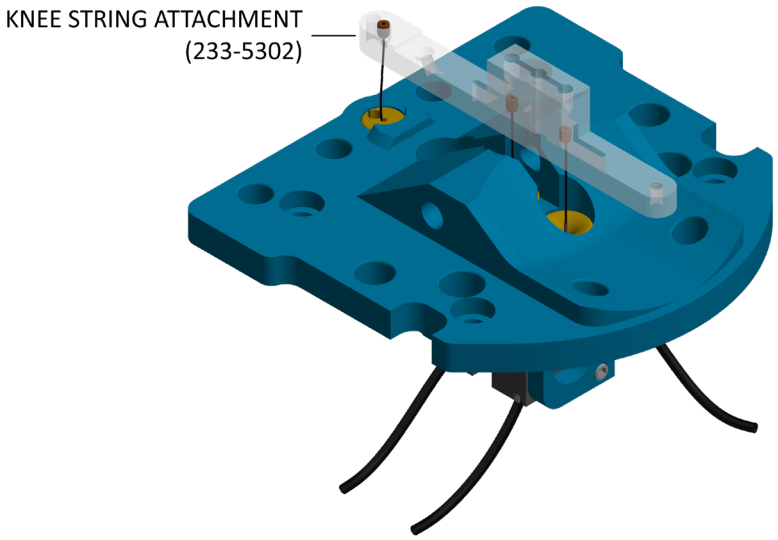


Figure 7.4 Attach Knee String Attachment

3. Route ACL and PCL cables out the right side of the knee and MCL cable out the left side of the knee. Then attach the meniscus assembly to the lower knee block (233-5330) using four M5 X 0.8 X 10 LG. LHCS. Torque to 3 Nm.

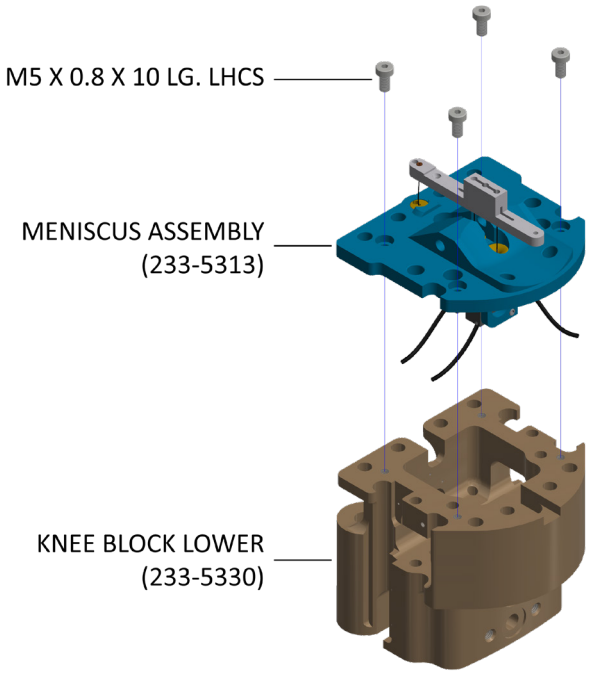


Figure 7.5 Attach the Meniscus Assembly

4. Place the upper knee block (233-5320) onto the meniscus assembly.

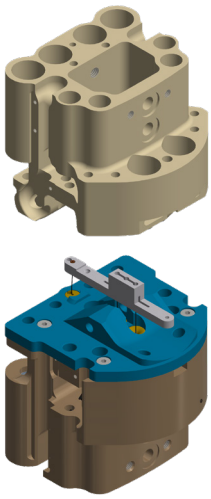


Figure 7.6 Place the Upper Knee Block

5. Route the four ACL/PCL cables through the knee. Place a cable washer (133-5311) and spring (9003159) over each of the four stainless-steel cables (233-5360) as shown and route them through the corresponding ACL/PCL counterbores on the upper knee block. Place another spring and cable washer over the threaded end at the lower knee block, then use a 4mm open ended wrench (provided in the tool kit) to secure the cables on the flats of the end fitting and tighten the M5 lock nuts at the tibia end of the cables.

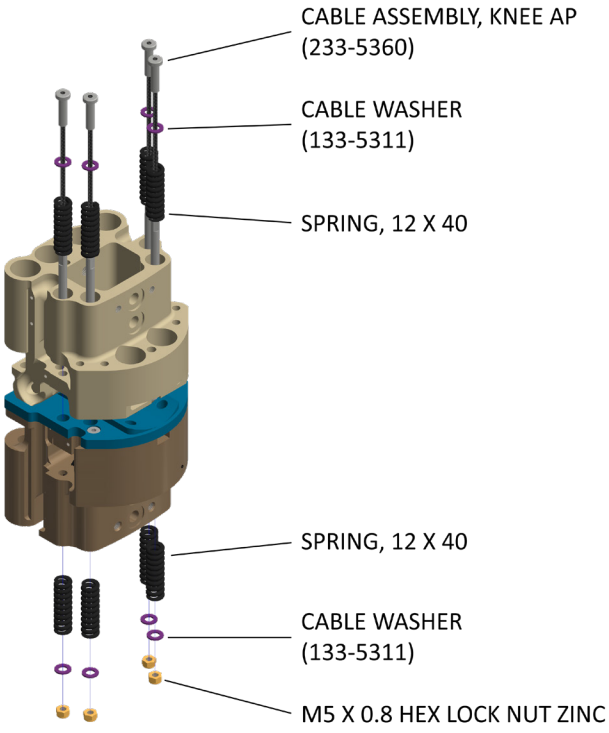


Figure 7.7 Route the ACL/PCL Cables

6. **Route the two LCL cables through the knee. Place an LCL guide tube (233-5311), belleville top washer (233-5319), and LCL femur and tibia washer stack (233-5329) over the stainless-steel cables (233-5370) and route them through the corresponding LCL corridors on the lower knee block. Place another LCL washer stack, belleville top washer, and LCL guide tube over the threaded end of the cable at the upper knee block, then use a 5.5mm open ended wrench (provided in the tool kit) to secure the cables on the flats of the end fitting and tighten the M5 lock nuts at the femur end of the cables.**

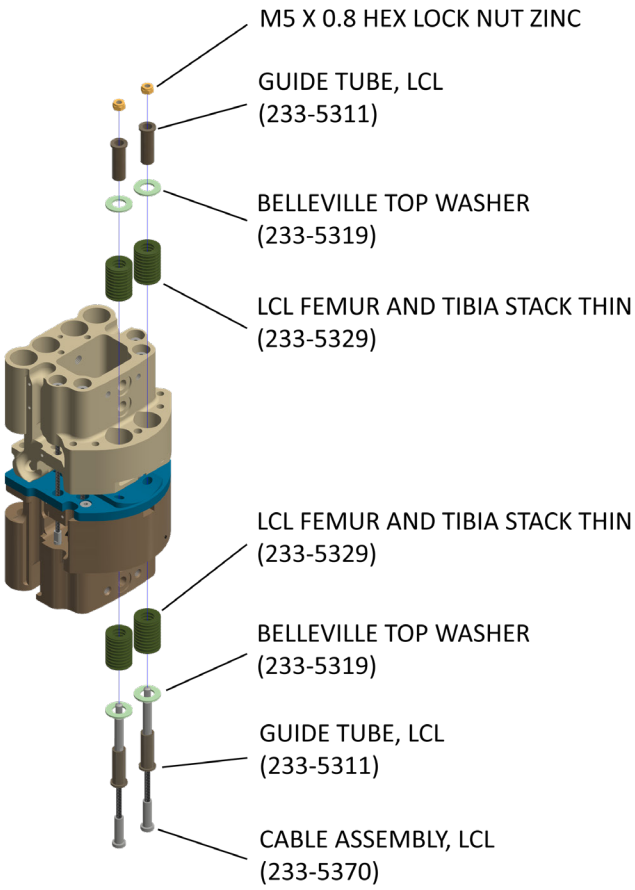


Figure 7.8 Route the LCL Cables

7. **Route the two inside MCL cables through the knee. Place a MCL guide tube (233-5310), belleville top washer (233-5319), and inside MCL stack (233-5328) over the stainless-steel cables (233-5350) and route them through the corresponding counterbores on the lower knee block. Place another inside MCL stack, belleville top washer, and MCL guide tube over the threaded end of the cable at the upper knee block, then use a 5.5mm open ended wrench (provided in the tool kit) to secure the cables on the flats of the end fitting and tighten the M5 lock nuts at the femur end of the cables.**

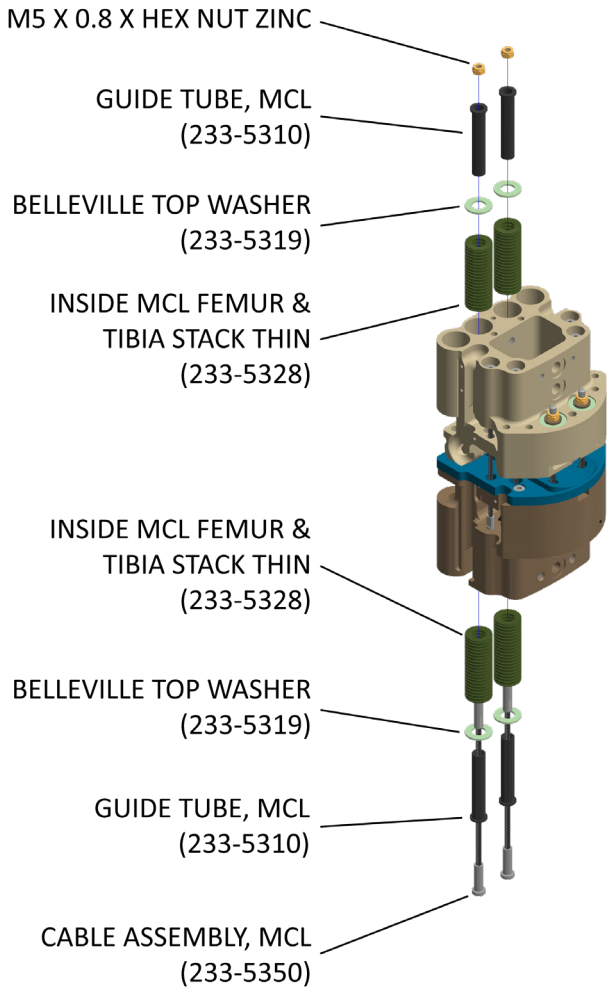


Figure 7.9 Route the Inside MCL Cables

8. **Route the two outside MCL cables through the knee. Place a MCL guide tube (233-5310) and an outside MCL tibia washer stack (233-5327) over the stainless-steel cables (233-5350) and route them through the corresponding counterbores on the lower knee block. Place an outside MCL femur washer stack (233-5326) and MCL guide tube over the threaded end of the cable at the upper knee block, then use a 5.5mm open ended wrench (provided in the tool kit) to secure the cables on the flats of the end fitting and tighten the M5 lock nuts at the femur ends of the cables.**

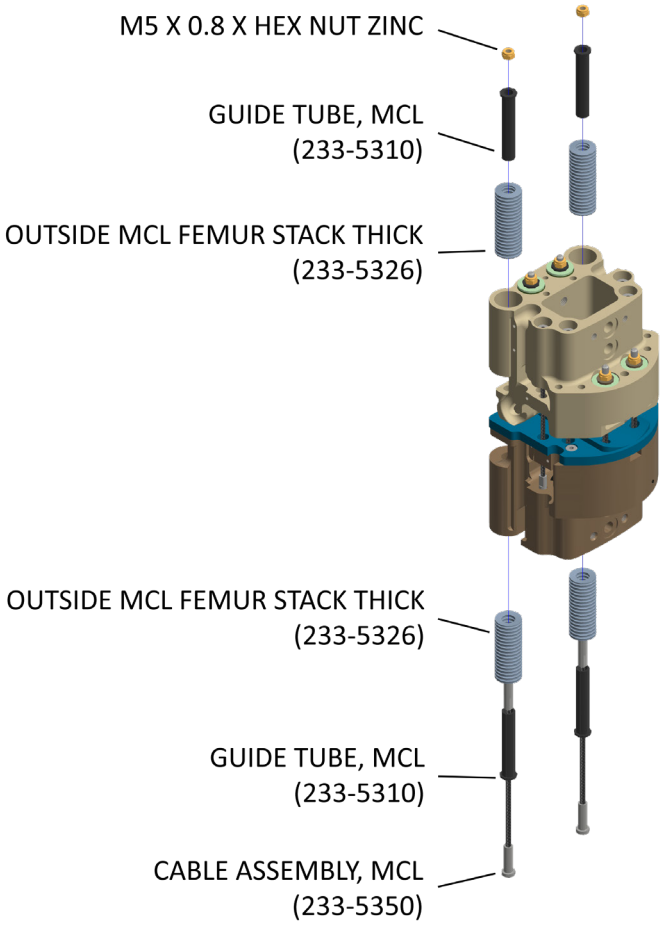


Figure 7.10 Route the Outside MCL Cables

Set the knee cable settings as follows:

- Inside MCL cables (measuring from top of the upper knee block to the top of the guide tube) – 4mm
- Outside MCL cables (measuring from top of the upper knee block to the top of the guide tube) – 4mm
- LCL cables (measuring from the upper knee block to the top of the guide tube) – 1mm

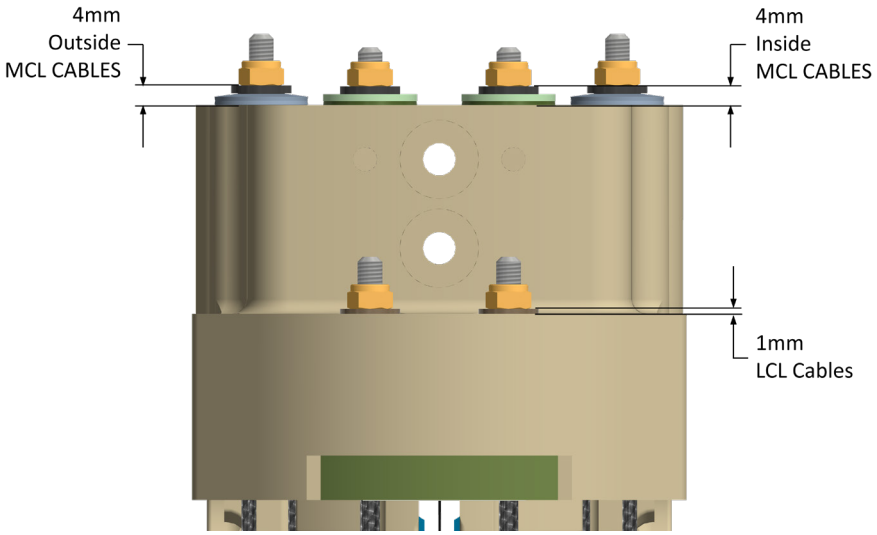


Figure 7.11 Cable Settings for MCL and LCL Cables

- PCL cables (measuring from the top of the upper knee block to the top of the cable) – 5.5mm
- ACL cables (measuring from the top of the upper knee block to the top of the cable) – 6mm

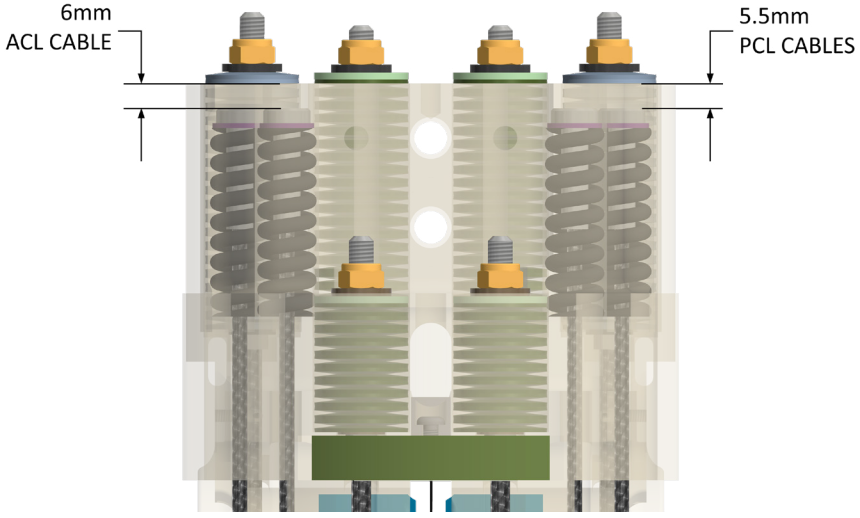


Figure 7.12 Cable Settings for ACL/PCL Cables

9. **Attach the plastic rounding (233-5306) to the impact side of the upper knee block using double sided tape.**

NOTICE

The double-sided tape used to hold the plastic rounding can be reused if it is still sticky. If it's no longer sticky or is folded over, it needs to be replaced with a new piece of tape.

10. **Pull the knee string attachment upwards to the upper knee block. Secure it at the knee block using two M3 X 10 BHCS.**

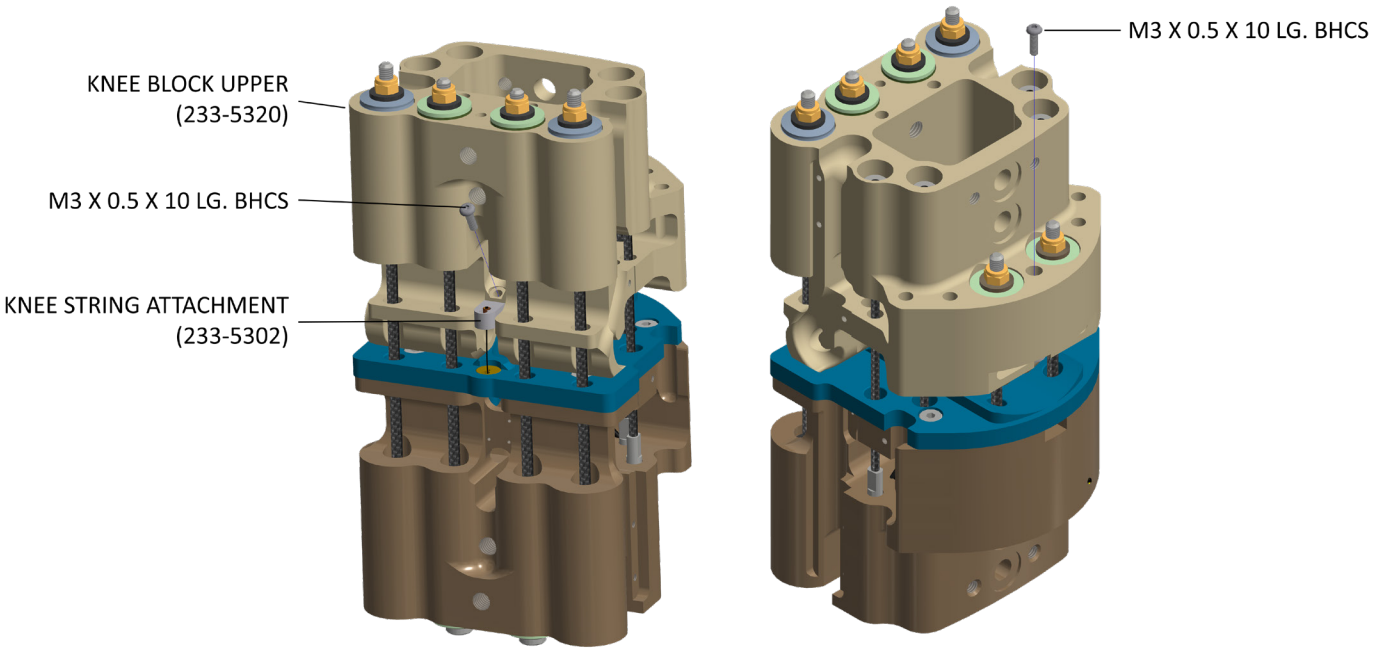


Figure 7.13 Secure the Knee String Attachment

11. Secure the ARS to the right side of the lower knee block with two M1.4 X 0.3 X 8 LG. SHCS. The instrumentation cable is routed up the right side of the knee.

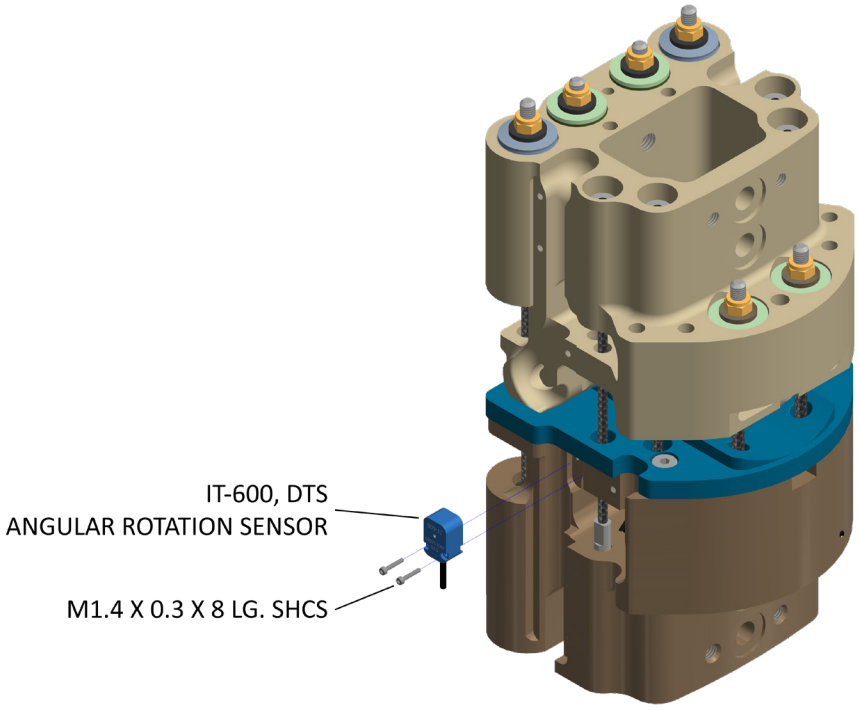


Figure 7.14 Attach the Knee ARS

12. Secure the accelerometer to the non-impact side of the lower knee block with two M1.4 X 0.3 X 4 LG. SHCS and two #0 flat washers. Route the instrumentation cable into the assembly and out the left hand side.

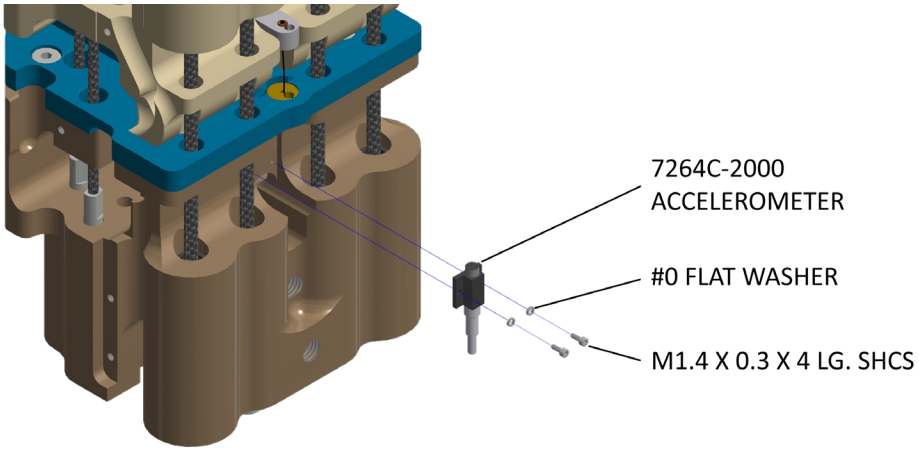


Figure 7.15 Attach the Knee Accelerometer

13. The remaining parts are fitted at the final leg assembly stage (see leg assembly section).

SECTION 8

Tibia Assembly

8.1 Description of Tibia Assembly and Features

The tibia like the femur is a segmented assembly that allows an internal flexible bone to bend. This bone is fitted with 4 sets of strain gages to measure bending moments. Its impact profile is designed to match that of a human tibia bone.

8.2 Assembly of the Tibia

8.2.1 TIBIA ASSEMBLY PARTS LIST

The figure below is the assembly and exploded view of the Tibia Assembly, 233-5500 and the table gives a general description of each item.

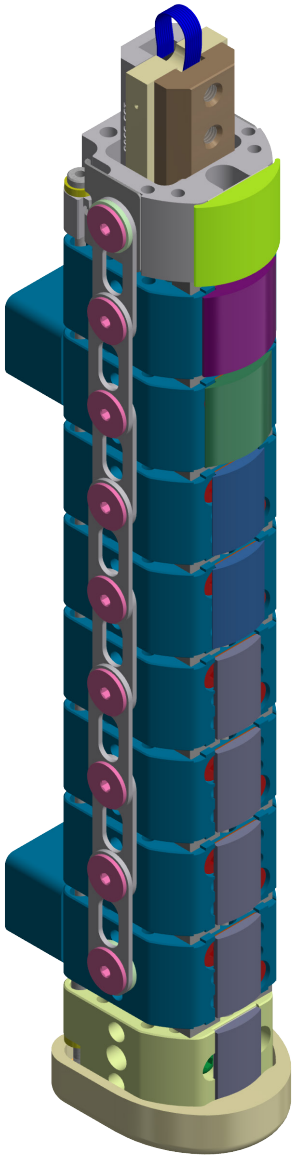


Figure 8.1 Tibia Assembly Iso View

Tibia Assembly

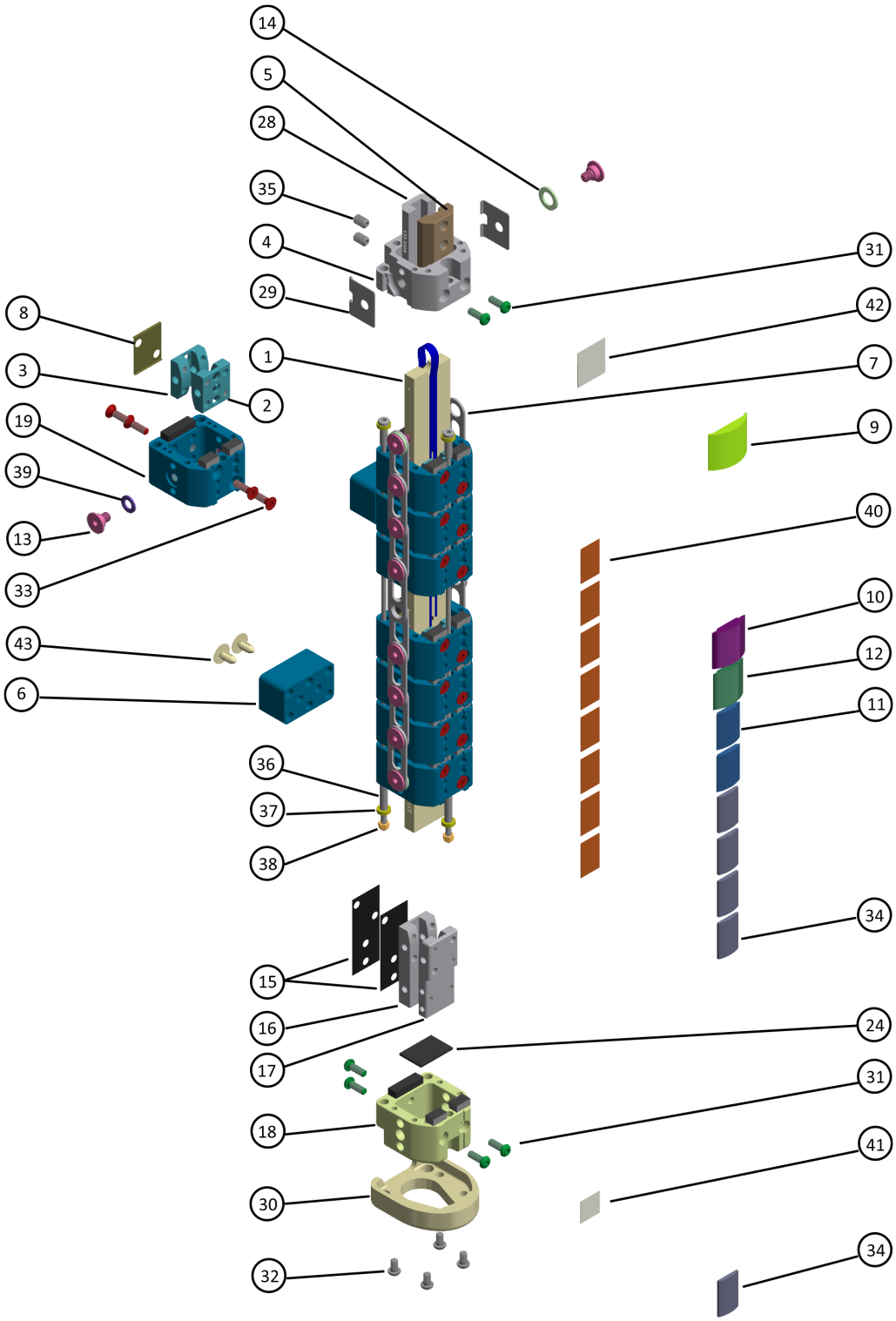


Figure 8.2 Tibia Assembly Exploded View

SECTION 8

Tibia Assembly

Table 8-1 Tibia Assembly Parts List

Item	Qty.	Part Number	Description
1	1	233-5565	PCB BONE ASSEMBLY, 4 CH TIBIA, TESTED/CERTIFIED
2	7	233-5505	SPACER BONE CONTACT, THICK (TIBIA)
3	7	233-5507	SPACER BONE CONTACT, THIN (TIBIA)
4	1	233-5537	TIBIA SEGMENT, KNEE
5	1	233-5506	BONE CLAMP THICK, KNEE (TIBIA)
6	2	233-5124	LEGFORM PUSH PAD
7	16	233-5515	LINK
8	7	233-5509	SHIM, TIBIA (T0.4)
9	1	233-5519	IMPACT SEGMENT TIBIA 1
10	1	233-5518	IMPACT FACE FEMUR 6
11	2	233-5526	IMPACT SEGMENT TIBIA 4&5
12	1	233-5517	IMPACT FACE TIBIA 3
13	18	233-5106	STEPPED BOLT
14	4	233-5104	WASHER
15	2	233-5031	SHIM, BONE CLAMP (T0.4)
16	1	233-5503	BONE CLAMP THIN (TIBIA) BOTTOM
17	1	233-5502	BONE CLAMP THICK (TIBIA)
18	1	233-5531	SEGMENT BOTTOM ASSEMBLY (TIBIA)
19	8	233-5534	INNER SEGMENT ASSEMBLY (TIBIA)
20	7	133-5012	SHIM, .05 (OPTIONAL – NOT SHOWN)
21	7	133-5029	SHIM, .1 THICK (OPTIONAL – NOT SHOWN)
22	7	133-5030	SHIM, .2 THICK (OPTIONAL – NOT SHOWN)
23	7	133-5031	SHIM, .40 (OPTIONAL – NOT SHOWN)
24	1	133-5510	RUBBER BUFFER, FEMUR/TIBIA END
25	1	133-5002	SHIM, BONE CLAMP (T0-05) (OPTIONAL – NOT SHOWN)
26	1	133-5003	SHIM, BONE CLAMP (T0-5) (OPTIONAL – NOT SHOWN)
27	1	133-5004	SHIM, BONE CLAMP (T0-6) (OPTIONAL – NOT SHOWN)
28	1	133-5508	BONE CLAMP THIN, KNEE
29	2	233-5528	CABLE COVER
30	1	233-5205	FOOT
31	6	5000072	M6 X 1 X 16 LG. BHCS
32	4	5000891	M6 X 1 X 10 LG. BHCS
33	32	5001089	M6 X 1 X 20 LG. FHCS
34	5	233-5527	IMPACT FACE TIBIA 6 TO 10
35	2	5000796	M8 X 1.25 X 12 LG. SSSCP
36	3	133-5530	CABLE ASSEMBLY, TIBIA
37	6	233-5521	WASHER, CABLE
38	3	5000522	M5 X 0.8 HEX LOCK NUT ZINC
39	16	233-5523	TIBIA, WASHER
40	8	233-5025	TAPE SEGMENT
41	1	233-5028	TAPE 3, IMPACT SEGMENT
42	1	233-5027	TAPE, TIBIA KNEE SEGMENT
43	4	6006010	FIR-TREE CLIP 6.5 HOLE X 2-6 THK BLACK

8.2.2 ASSEMBLY OF TIBIA COMPONENTS

Before beginning assembly, inspect the bone for any cracks or damage and ensure that all rubber buffers are bonded to the segment assemblies (233-5534). If for any reason a buffer should become dislodged, lost, or damaged it will need replacing or re-bonding. When bonding the buffer ensure surfaces of both parts are clean before bonding, degrease then bond with cyano-acrylate adhesive or similar.

The following procedure is a step-by-step description of the assembly procedure for the tibia components. The process is the same as disassembly, but in reverse.

1. **Start at the knee end of the tibia bone (end with notch).**
2. **Orient the tibia segment with the cutout facing up and the counterbore holes facing front. Attach the thick bone clamp (233-5506) as shown, with the slot facing inwards, to the knee tibia segment (233-5537), on the impact side, using two M6 X 1 X 16 LG. BHCS. Torque to 8 Nm.**

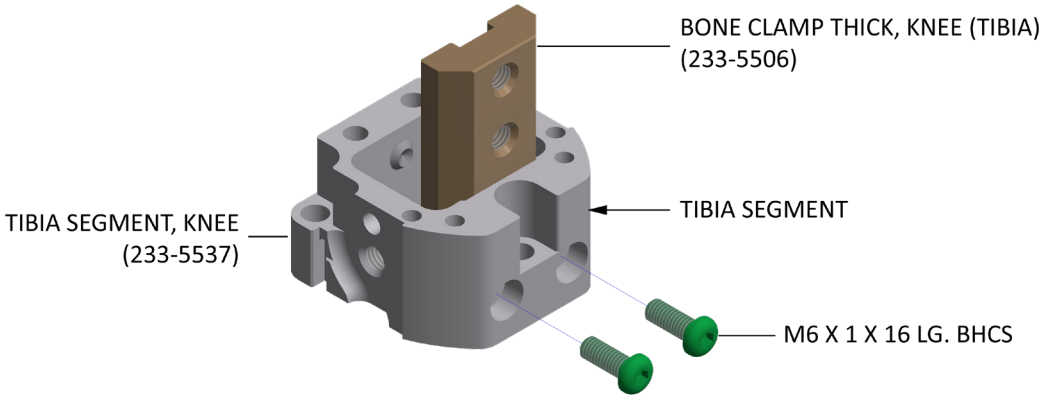


Figure 8.3 Attach the Thick Bone Clamp

3. **Slide this with the thin bone clamp (133-5508) over the bone at the knee end. The PC board and cables from the bone should be in the back. The clamps should be flush with the bone.**

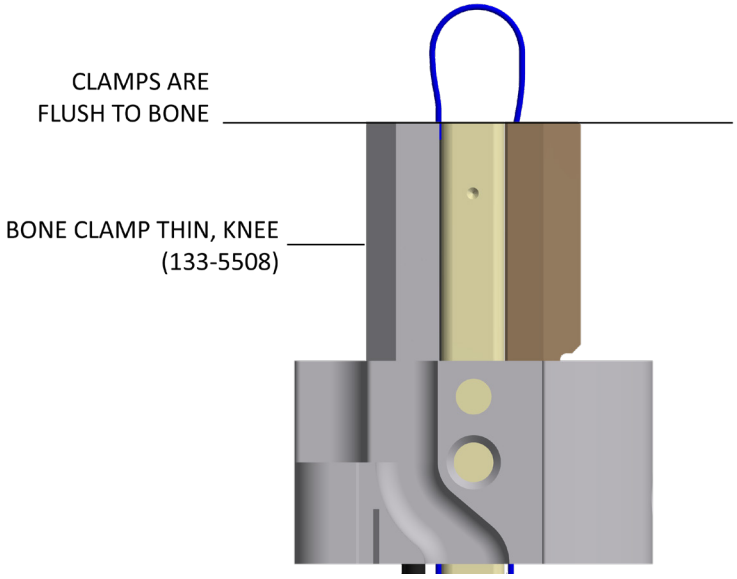


Figure 8.4 Bone Clamps Flush with Bone

4. Once in place, tighten the two M8 X 1.25 X 12 LG. set screws on the non-impact side of the knee tibia segment, fitting the screw nearest the knee first. Route the 3 channel and 1 channel tibia cables towards the left side of the assembly.

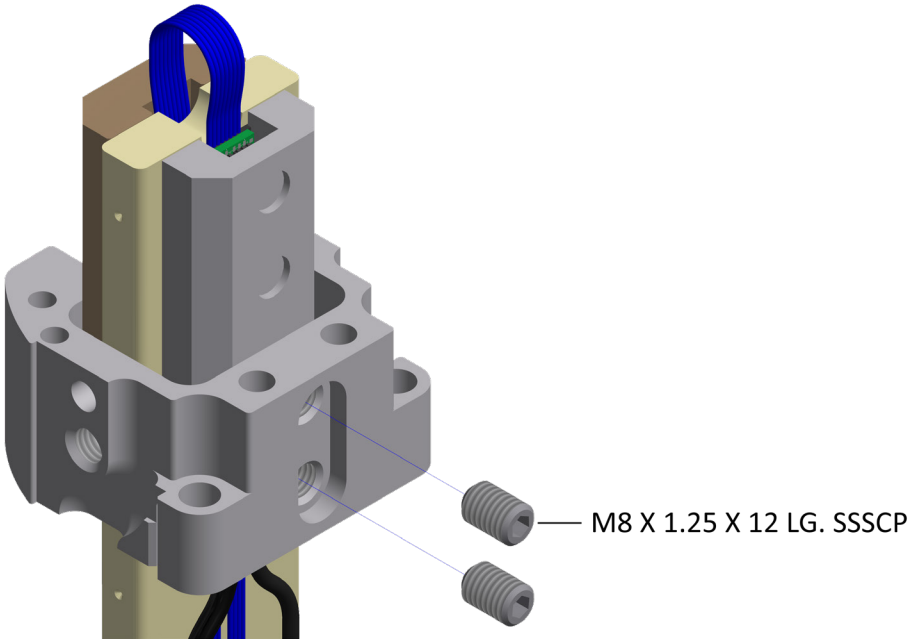


Figure 8.5 Tighten the Set Screw on the Non-Impact Side

5. Attach a thick bone contact (233-5505) to an inner segment assembly (233-5534) on the impact side using two M6 X 1 X 20 LG. FHCS. Torque to 3 Nm.

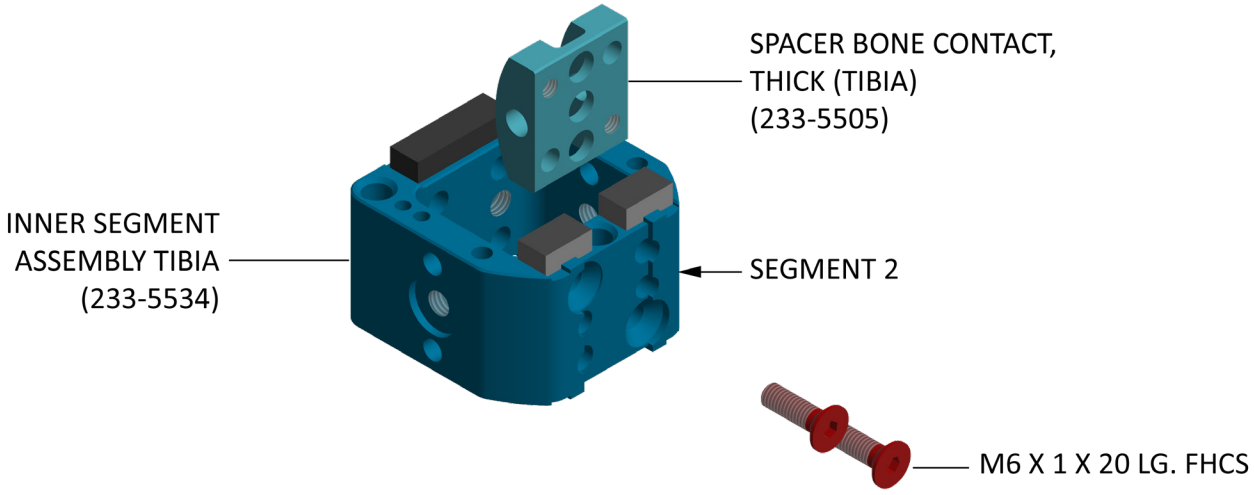


Figure 8.6 Attach the Thick Bone Contact

6. Attach a thin bone contact (233-5507) and shim (233-5509) to the non-impact side of the inner segment using M6 X 1 X 20 LG. FHCS. Torque to 3 Nm. Slide the segment onto the bone. There should be no play between the inner segment and bone. If there is, continue to add optional shims (133-5012, 133-5029, 133-5030, or 133-5031) as required between 233-5509 and the inner segment until a tight fit is reached.

NOTICE

Be careful when assembling inner segments so that the strain gauges running along the center of the bone are not damaged. When fitting the assembly use thumb force only when pushing down on the segment. Do not force segments into place. There should be resistance when pushing the assemblies

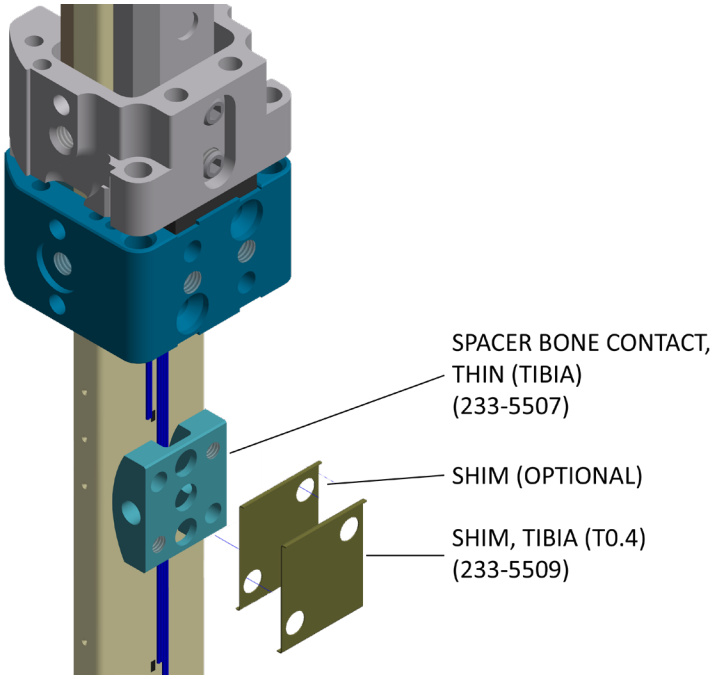


Figure 8.7 Attach the Thin Bone Contact

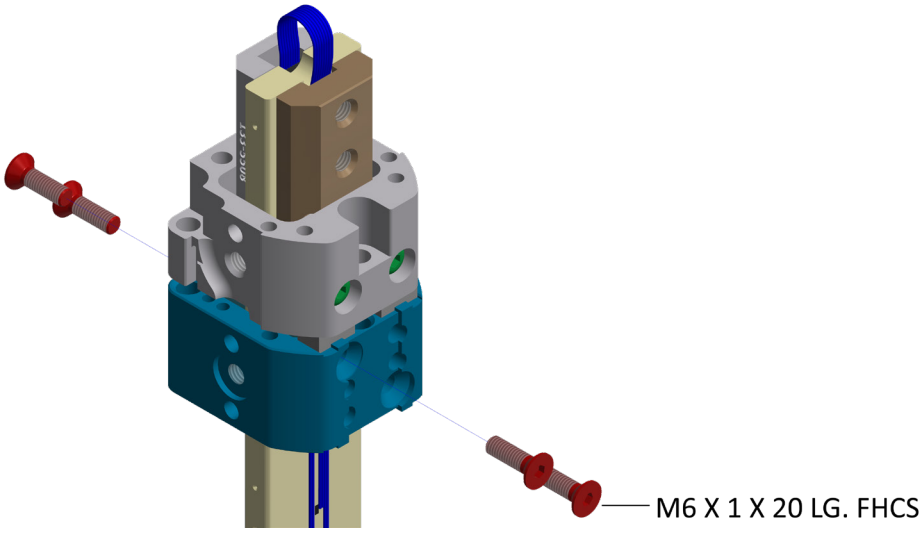


Figure 8.8 Secure the Thick Bone Contact with M6 X 1 X 20 LG. FHCS

7. **Repeat steps 5-6 for the next six inner segment assemblies.**

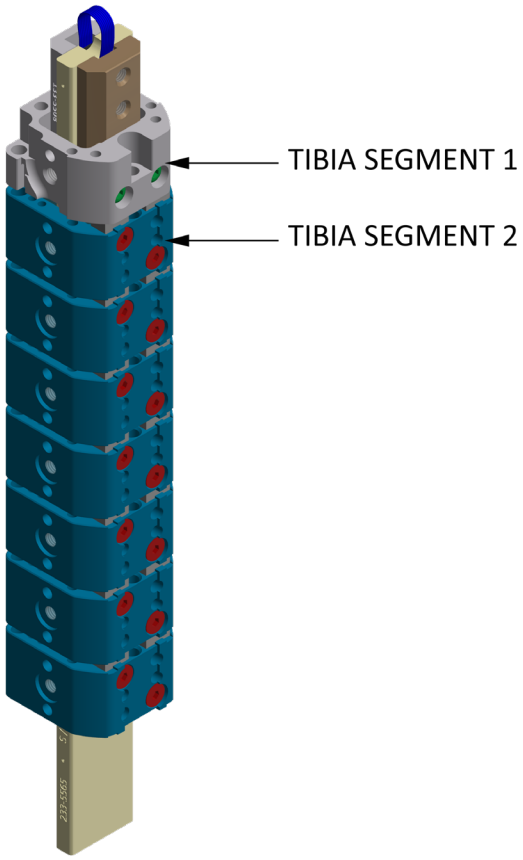


Figure 8.9 Attach Tibia Segments

8. On the last inner segment (9), attach a thick tibia bone clamp (233-5502) to the impact side using two M6 X 1 X 20 LG. FHCS. Attach the thin tibia bone clamp (233-5503) to the non-impact side using two M6 X 1 X 20 LG. FHCS. Slide this over the bone. If the fit is loose, add shims (133-5002, 133-5003, or 133-5004) between the thin bone clamp and inner segment until a tight fit is achieved. The clamps should be flush with the bones once assembled.

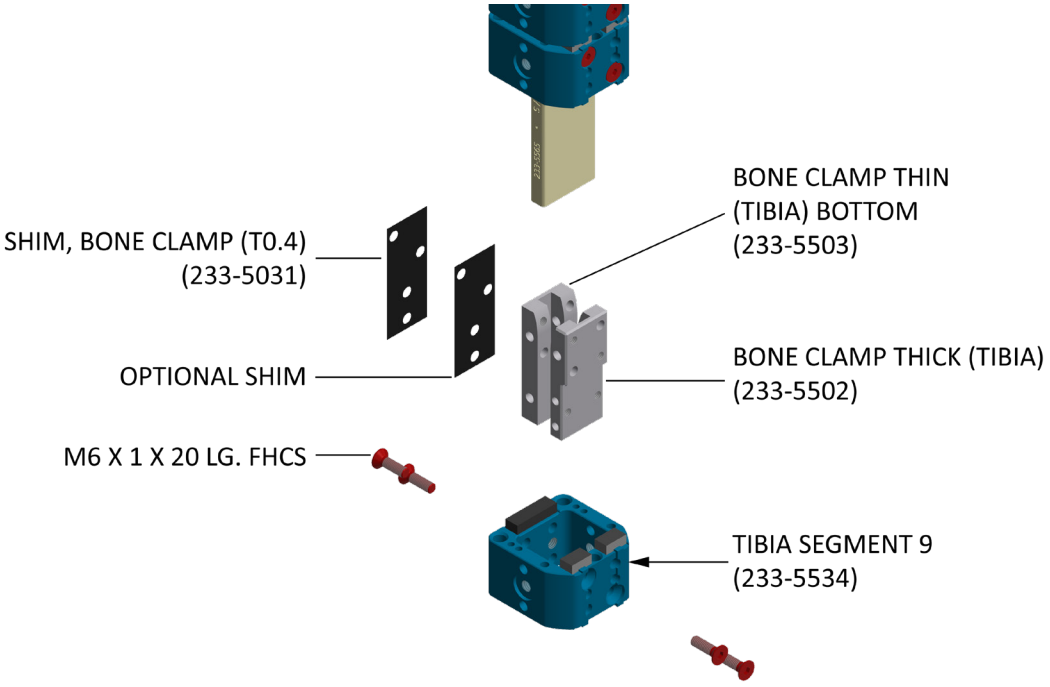


Figure 8.10 Attach the Tibia Bone Clamps

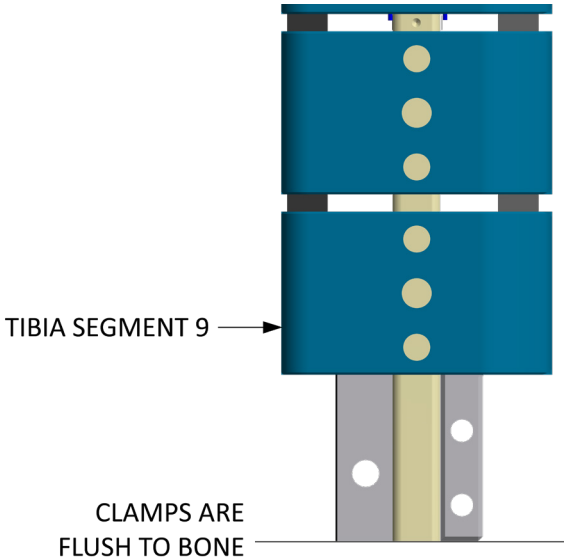


Figure 8.11 Tibia Clamps Flush to Bone

9. Place femur/tibia end rubber buffer (133-5510) centrally inside segment bottom assembly (233-5531). Fit the tibia assembly into the segment bottom ensuring it is the correct way around as shown. Secure the segment using two M6 X 1 X 16 LG. BHCS on the impact side and two M6 X 1 X 16 LG. BHCS on the non-impact side. Torque to 8Nm and torque all the segment screws to 3 Nm.

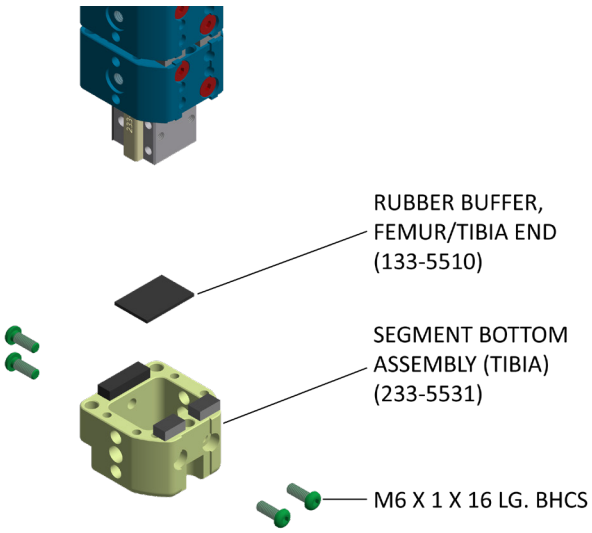


Figure 8.12 Attach the Tibia Bottom Segment

10. Place the tibia washers in the counterbore holes on one side of the eight tibia segment assemblies (233-5531).

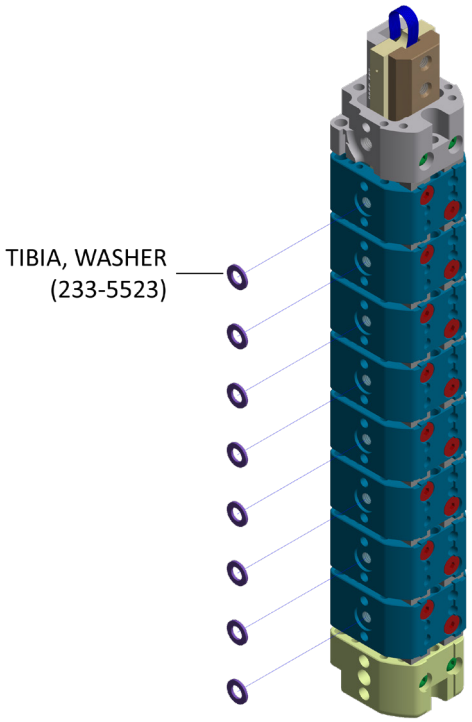


Figure 8.13 Attach the M8 Flat Washers

11. Place the cable covers (233-5528) over the knee tibia segment (233-5537) as shown.

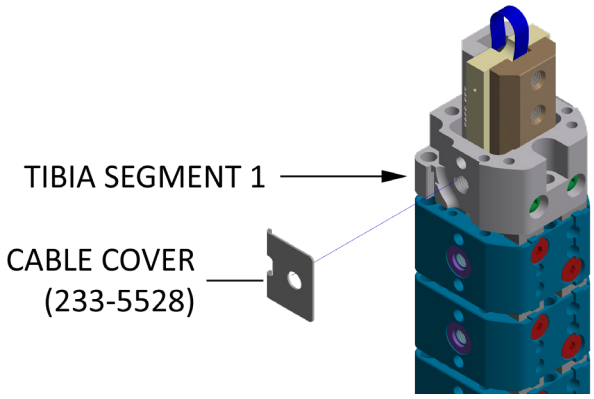


Figure 8.14 Place the Cable Cover

12. Starting at the knee tibia segment place a link one side of the legform such that the tibia segment 1 and segment 2 are linked. Continue placing links such that segments 3 and 4, segments 5 and 6, and segments 7 and 8 are connected. Place a large washer (233-5104) on segment 9.

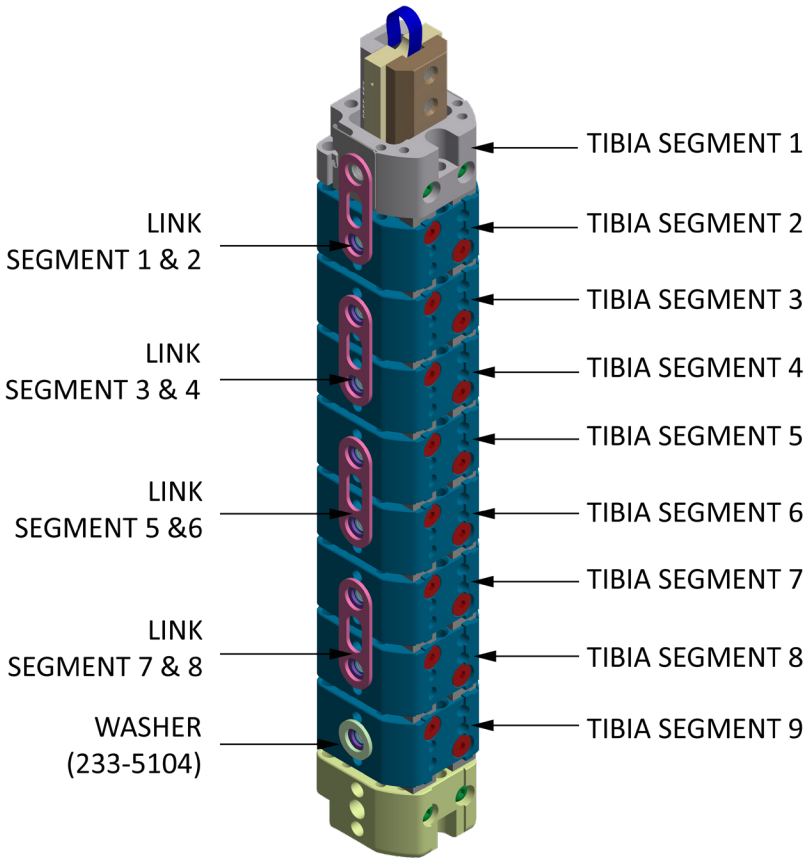


Figure 8.15 Place First Set of Links

13. Layer links to connect the rest of the segments such that segments 2 and 3, segments 4 and 5, segments 6 and 7, and segments 8 and 9 are linked.

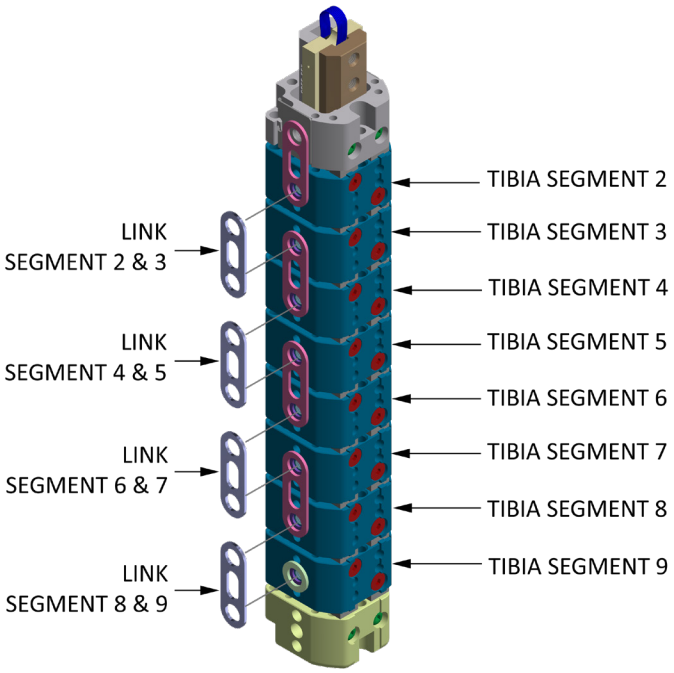


Figure 8.16 Place the Next Set of Links

14. Place a large washer (233-5104) on top of the link at tibia segment 1. Secure the links and washers to the segment assemblies using a stepped bolt (233-5106). Torque to 3Nm.

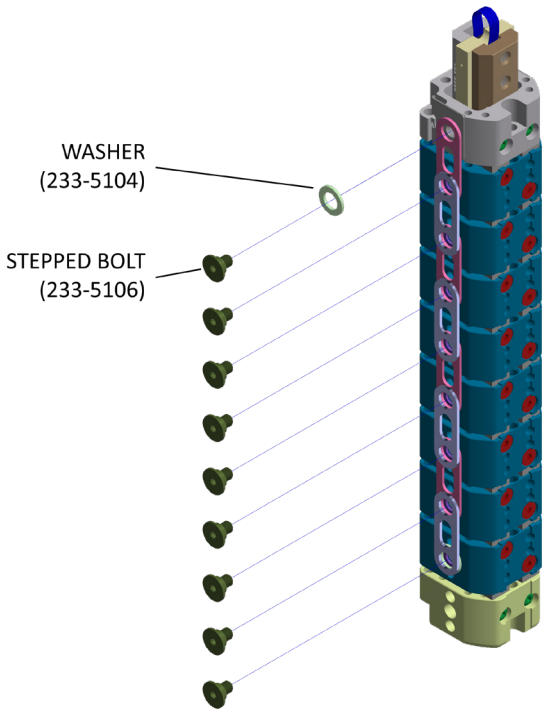


Figure 8.17 Secure with Stepped Bolts

15. Repeat steps 10-14 for other side.
16. Place a washer (233-5521) over each of the stainless-steel cables (133-5530) and feed the cables through the assembly from the knee end. Place a washer over the threaded fitting, then use a 4mm open ended wrench (supplied in the tool kit) to hold the cables over the flats between the nut and washer and tighten the M5 lock nuts at the foot end.

NOTICE

Measure the distance between the nut washer after fitting using the tibia end of the wire setting tool (133-5112). There should be a 11.3mm gap on all three cables.

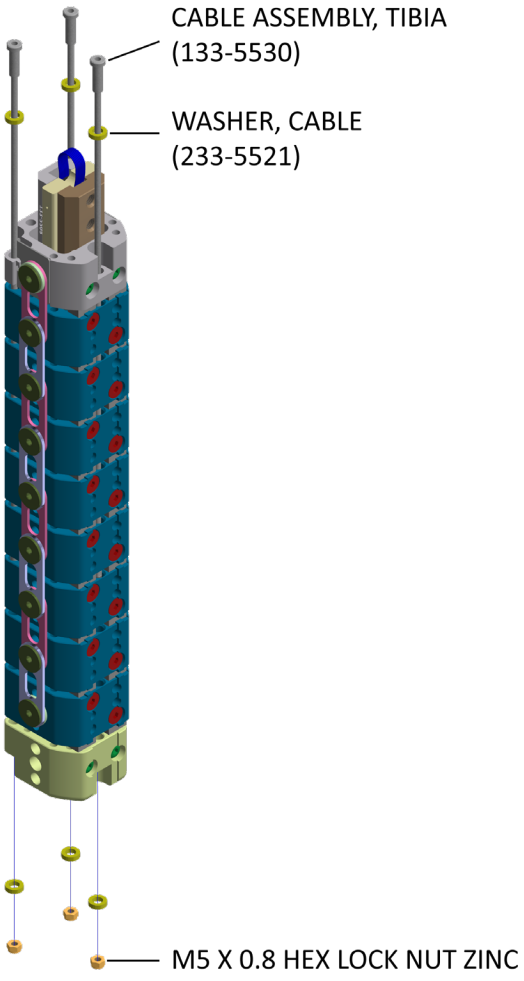


Figure 8.18 Attach the Tibia Cable Assemblies

17. **Reattach the impact segments to the impact side of the segment assemblies using double sided tape as shown. Note: the segments get smaller as they go down.**

NOTICE

The double-sided tape used to hole the impact segments can be reused if it is still sticky. If it's no longer sticky or is folded over, it needs to be replaced with new pieces of tape.

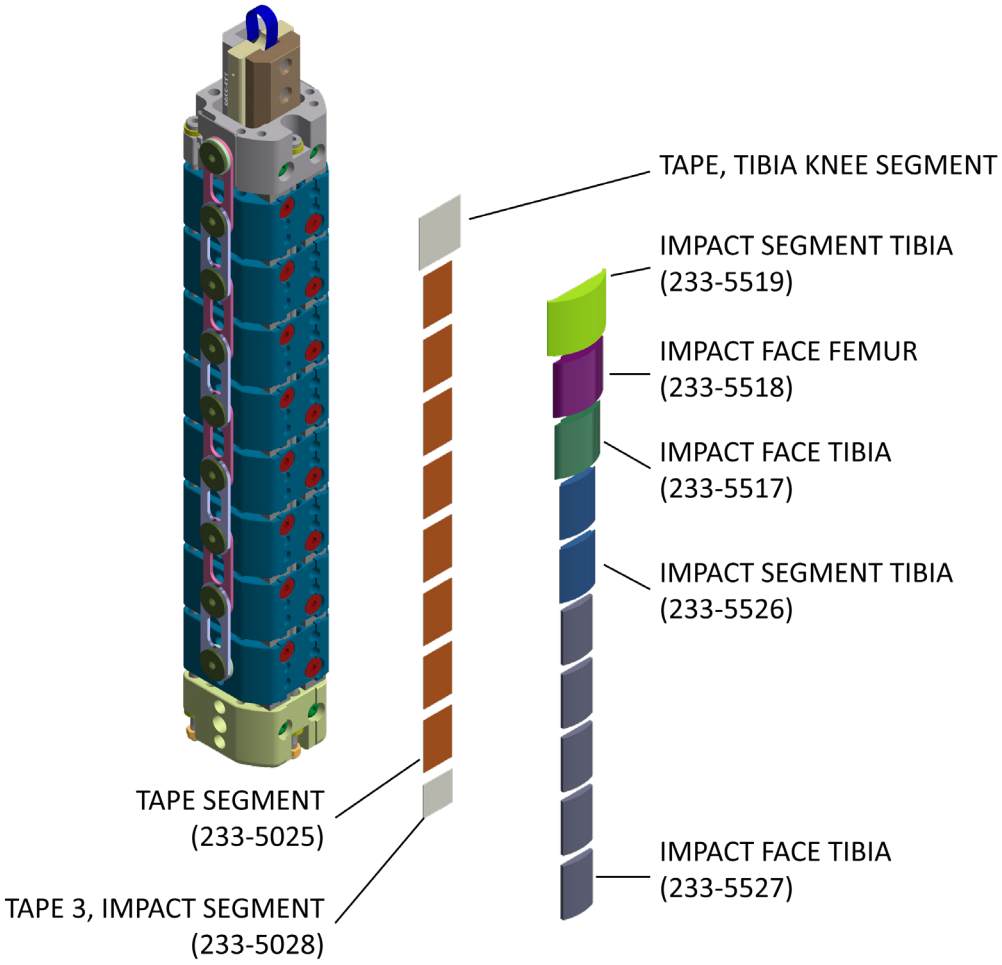


Figure 8.19 Attach the Segment Tapes and Impact Segment

18. Attach the two legform push pads (233-5124) to tibia 3 and 8 segment assemblies using two fir-tree clips (6006010) per push pad. The fixings clip into the M8 threaded holes on the non-impact side of the segment assemblies. Ensure the fir-tree clips are a tight fit.

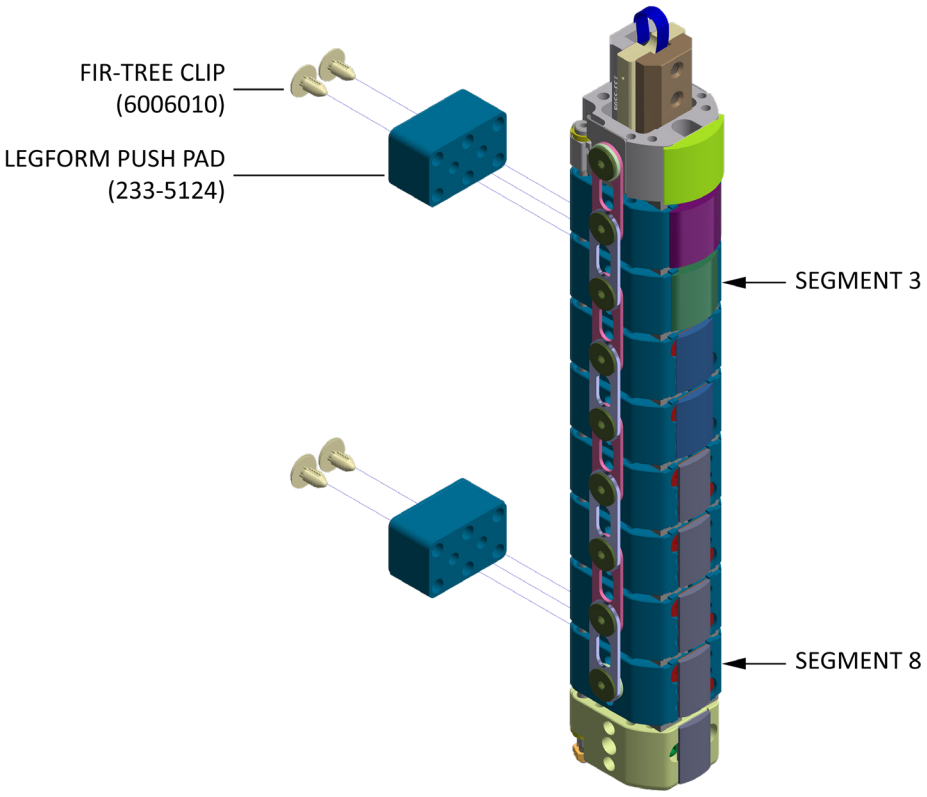


Figure 8.20 Attach the Push Pad and Fir-Tree Clip

19. Attach the foot (233-5205) to the segment bottom using four M6 X 1 X 10 LG. BHCS.

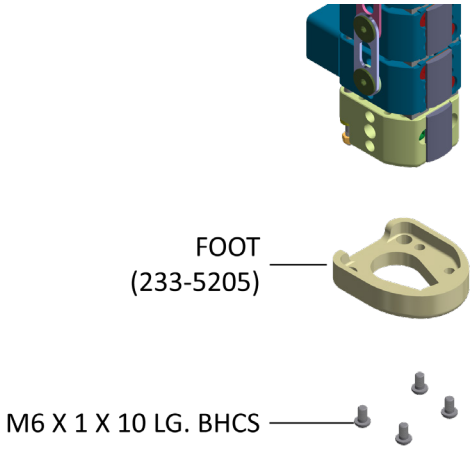


Figure 8.21 Attach the Foot

SECTION 9

Weighted Flesh Assembly

9.1 Description of Weighted Flesh

The molded flesh is a one piece soft urethane part strapped to the leg to simulate the flesh of a human leg. An additional cover goes outside the flesh to protect the soft material.

9.2 Assembly of Weighted Flesh

9.2.1 WEIGHTED FLESH PARTS LIST

The table below gives a description of the molded parts.

Table 9-1 Weighted Flesh Parts List

Item	Qty.	Part Number	Description
1	1	233-5260	WEIGHTED FLESH ASSEMBLY
2	1	233-5250	FLESH COVER ASSEMBLY
3	4	6005983	CABLE TIE HOOK & LOOP 1" X 24" BLACK

9.2.2 WEIGHTED FLESH DISASSEMBLY

The following procedure is a step-by-step description of the disassembly procedure for the molded flesh components.

1. **Undo the Velcro at the back of the flesh cover assembly (233-5250) and remove it from the legform.**
2. **Undo the four cable tie hook & loop straps (6005983) and remove from the legform. The weighted leg flesh (233-5260) can now be pulled off the legform.**

9.2.3 WEIGHTED FLESH ASSEMBLY

The following procedure is a step-by-step description of the assembly procedure for the molded flesh components.

1. **Place the weighted flesh assembly (233-5260) on the legform and secure it using four cable tie hook & loop straps (6005983). The weighted flesh has indentations where the loop straps are to be secured. The buckles of the two straps at the femur should align with the corners of the molded flesh on the non-impact side. The buckles of the two straps at the tibia should align with the center of the non-impact side of the leg. Straps need to be tight.**
2. **Place the flesh cover assembly over the weighted leg flesh. The top loop of the cover should be routed between the curved impact face and femur top mounting bracket (233-5192). The flesh cover should not cover the legform push pads. Try to get as tight of a fit as possible.**

SECTION 10

Pretest Checks

10.1 Recommended Spare Parts

During operation dummy parts can fail. Normally, however, an early warning for a part that may fail is noticed during the certification procedures. To safeguard continuous operation with the aPLI it is recommended to have the following spare parts in stock:

Table 10-1 Recommended Spare Parts List

Item	Qty.	Part Number	Description
1	1	233-5165	PCB FEMUR BONE ASSEMBLY, 3 CH
2	1	233-5565	PCB BONE ASSEMBLY, 4 CH TIBIA, TESTED/CERTIFIED
3	1	233-5210	SUBP TOP FLESH
4	1	233-5260	WEIGHTED LEG FLESH ASSEMBLY
5	2	233-5250	FLESH COVER ASSEMBLY
6	4	6005983	CABLE TIE HOOK & LOOP 1” X 24” BLACK
7	1	61-507A-05-950-00-5V	CABLE ASSEMBLY STRING POT L, 950mm CBL, SLICE, MCL
8	1	61-503A-05-1150-00-5V	CABLE ASSEMBLY STRING POT R, 1150mm CBL, SLICE, ACL
9	1	61-507B-05-1150-00-5V	CABLE ASSEMBLY STRING POT L, 1150mm CBL, SLICE, PCL
10	2	233-5187	SUBP BUMPER

10.2 General External Damage Inspection

It is recommended that the legform is inspected as described in the following sections and certify as required. If the leg is passing inverse tests that is the main indicator that the leg is suitable to continue testing. If the leg is not passing, this could indicate wear or damage has taken place and the problem needs to be investigated and corrected. The first indication of a problem would appear with unexpected output of the leg after a vehicle test. After exceeding injury criteria it would be advised to inspect and re-certify the leg. This section gives a systematic checking procedure and guidance on when parts require inspection, adjustment, replacement, reassembly, or recalibration.

It is recommended that a visual inspection is carried out after every test when the cover and flesh is removed and the knee re-aligned.

- ✓ **Inspect and check the cover for wear and tears. Minor defects will not affect performance.**
- ✓ **Check for cracks, nicks, or tears.**

Roller (233-5196)

- ✓ **Before certification testing, check the blue polymer roller (233-5196) on the hanger assembly (233-5103) is not damaged or worn. This check is not applicable before vehicle testing.**

Molded SUBP Flesh

- ✓ **Check molded flesh parts for any tears or cuts. Any minor damage should not affect performance.**

Pretest Checks

Weighted Leg Flesh Assembly

- ✓ Inspect the weighted leg flesh assembly (233-5260) for any tears or cuts.
- ✓ Inspect the foam inserts (233-5201 and 233-5202) for any tears or cuts and ensure that these are properly fitted into the cavities of the weighted leg flesh (233-5621).
- ✓ Check that the 4x tie hook & loops (6005983) are intact.

Flesh Cover Assembly

- ✓ Check the flesh cover assembly (233-5250) for large cuts or tears. It may be prone to damage as it is the soft contact surface to the vehicle bumper. Small cuts and tears are not a problem, but large tears or damage to the Velcro straps will require the cover to be replaced. The Velcro straps maintain the fit of the cover and this tight fit should always be maintained.
- ✓ If the leg is not in use or being transported, the cover should be fitted loose or removed to avoid stretching.

Impact Segments

- ✓ Inspect the impact segments for any damage that could prevent it from protecting the inner instrumentation. If these should appear cracked or worn, they should be replaced.
- ✓ If the double-sided tape used to hold the impact segments in place is no longer sticky or is folded over, it should be replaced.

Inner Segments

- ✓ Check if the inner segments on the femur and tibia are loose. The inner segments can become loose with use due to small indentations to the bone and light wear to the curved contacts that interfaces with the bone. If there is concern with the amount of play on the femur or tibia assemblies, they should be re-shimmed and statically re-certified. The femur and tibia inner segments should always be reassembled as tight as possible. There is no specific play limit to when the bone requires re-shimming. If the bone is passing dynamic testing, it can continue to be used as is.
- ✓ Check the rubber buffers between segments are bonded to the inner segments. If one should become dislodged or damaged the bone must be disassembled and a new rubber buffer should be attached.
- ✓ Check segment screws are tightened to 3 Nm.

Knee Blocks

- ✓ Inspect the knee blocks (233-5320 and 233-5330) for any type of damage.
- ✓ Check bone attachment screws are tightened to 8 Nm.

Knee Meniscus

- ✓ Inspect the meniscus assembly (233-5313) for cracks or wear due to contact with the upper knee block (233-5320). If this wear has created a significant groove in the plate this could affect the knee motion in the knee and should be replaced.
- ✓ The bronze sleeves (233-5303) in the plate may also be subject to wear, which is normal after many tests. The meniscus plate will likely need to be replaced before the wear on the sleeves becomes a concern. All the bronze sleeves are bonded in the plate. If one should become loose then it must be bonded in.

10.3 Sensor and Electrical Maintenance

10.3.1 GENERAL ELECTRICAL MAINTENANCE

- ✓ **Check electrical cables and connectors for damage and wear. Cables should have sufficient slack to allow full range of motion in the knee joint and upper body when flexed in testing. Broken cables or connectors should be repaired or replaced, as necessary.**

10.3.2 FEMUR AND TIBIA BONE MAINTENANCE

The timing for gage calibration certification is stated in Table 13-1.

- ✓ **Check the bones for cracking. The bone will see localized small indents at the curved interface of the segments after some use. This is expected and should not greatly affect the performance of the bone. If there is severe cracking the bone should be replaced, however, if the leg is passing dynamic certification this would be at the discretion of the user. Whenever the bone is disassembled it should be checked for wear or damage to electrical components and should be repaired if necessary.**

10.3.3 STRING POTENTIOMETER MAINTENANCE

The timing for sensor recalibration is stated in Table 13-1.

- ✓ **Check the string potentiometer pull cables are tight when the knee is assembled and not loose or deformed. If they are loose, the potentiometers will need to be replaced.**
- ✓ **When disassembling the knee, the string crimps should be checked for possible slippage, the dimension from the crimp to the pot is 60.5 ±1mm for the MCL and 21.5 ±0.5mm for the ACL and PCL string pots. Also check the string pull by gently pulling on the pot wires, they should all have the same resistance, but do not exceed the 38mm travel. Check the cables and connectors for any wear or damage and repair or replace if necessary.**

SECTION 11

Storage

The plastic material used to make many of the leg parts can absorb moisture in high humidity environments. The water absorption can weaken these parts and make them expand a little. This weakness should not affect the function of the legform, but as a precaution, the leg should be stored in a humidity-controlled room or chamber or placed in an air sealed container or bag to prevent water absorption if the leg is being used in extreme environmental conditions.

The neoprene flesh cover assembly (233-5250) should be removed or fitted loosely when not in use to prevent stretching.

All leg components should be stored as close to the test temperature conditions (16 to 24°C) as possible to allow for the leg to reach the required temperature during its 4-hour soak time.

SECTION 12

Weight Specification

The aPLI assembly mass and tolerances are given below. For dynamic certification tests (inverse type 1 and 2) as well as regulatory vehicle tests, the leg must comply with the given limits.

Table 12-1 aPLI Weight Specifications

Segment Assembly	Mass (kg)	Tolerance ±
SUBP (233-5150)	11.8	0.3
FEMUR (233-5100)	4.3	0.2
KNEE (233-5300)	2.8	0.1
TIBIA (233-5500)	2.3	0.1
Leg Assembly without SUBP (233-5100, 233-5300, 233-5500, 233-5260, 233-5250, four 6005983)	12.9	0.3
TOP ASSEMBLY (233-5000-S18)	24.7	0.3

SECTION 13

Static Certification and Procedures

Certification of the aPLI requires 6 procedures to ensure certified performance of all components. All steps that may be performed by the user are described in this section.

Calibration of string potentiometers, accelerometers, angular rate sensors, and bending moment strain gages are not presented in this user manual, as they require operations only to be carried out by experienced and trained lab personnel.

The legform and leg parts should be kept in the test environment at least 4 hours prior to the use in a test. The testing laboratory environment should be controlled to have:

- **A temperature of 20 ±2°C**
- **A relative humidity of 40 ±30%**

When conducting certification tests a time interval of at least 30 minutes should be observed between two consecutive tests.

To perform the static certification testing, a material testing load frame machine with a high-definition load cell is required. The FLEX STATIC, a Frontone calibration fixture, can be upgraded to be used for testing the aPLI. This fixture can automatically carry out femur, knee, and tibia using the appropriate fixtures. It can also be used to perform bone gage calibration.

Table 13-1 aPLI Calibration

Step	Description	When Required	Pass-Fail Requirement
0A	Femur Gauge Calibration	**1. Recommended annually** **2. Recommended after exceeding injury thresholds +10% for aPLI in an application test**	**1. ±1.0% linearity full scale all gages** **2. ±2.0% hysteresis full scale all gages**
0B	Tibia Gauge Calibration	**1. Recommended annually** **2. Recommended after exceeding injury thresholds +10% for aPLI in an application test**	**1. ±1.0% linearity full scale all gages** **2. ±2.0% hysteresis full scale all gages**
0C	String Potentiometer Calibration	**1. Annually**	**1. ±1.0% (VRCI-P-100A1)**
0D	Accelerometer Calibration	**1. Annually**	**1. ±1.0% linearity full scale**
0E	ARS Calibration	**1. Annually**	**1. ±1.0% linearity full**

Table 13-2 aPLI Certification

Step	Description	When Required	Pass-Fail Requirement
1	Femur Static Assembly Certification	1. Recommended annually 2. Recommended after exceeding injury thresholds +10% 3. Recommended after maintenance and/or component exchange	1. Femur bending moment-deflection corridor
2	Tibia Static Assembly Certification	1. Recommended annually 2. Recommended after exceeding injury thresholds +10% for aPLI in an application	1. Tibia bending moment-deflection corridor
3	Knee Static Assembly Certification	1. Recommended annually 2. Recommended after exceeding injury thresholds +10% 3. Recommended after maintenance and/or component exchange	1. MCL moment-elongation corridor 2. ACL moment-elongation corridor 3. PCL moment-elongation corridor
4	Hip Adduction Test (SUBP Bumpers)	1. Recommended annually 2. Recommended after exceeding injury thresholds +10% for aPLI in an application	1. SUBP bumper torque-angle corridor
5	Type 1 Inverse Test	1. Annually 2. After at least 30 vehicle tests 3. After exceeding injury thresholds +10% 4. After maintenance and/or component exchange	1. Peak bending moment tibia 1, 2, 3, and 4 2. Peak bending moment femur 1, 2, and 3 3. Peak elongation MCL, PCL, and ACL
6	Type 2 Inverse Test	1. Annually 2. After at least 30 vehicle tests 3. After exceeding injury thresholds +10% 4. After maintenance and/or component exchange	1. Peak bending moment tibia 1, 2, 3, and 4 2. Peak bending moment femur 1, 2, and 3 3. Peak elongation MCL, PCL, and ACL

Static Certification and Procedures

The Frontone Flex Static machine is available and programmed to certify the aPLI leg.

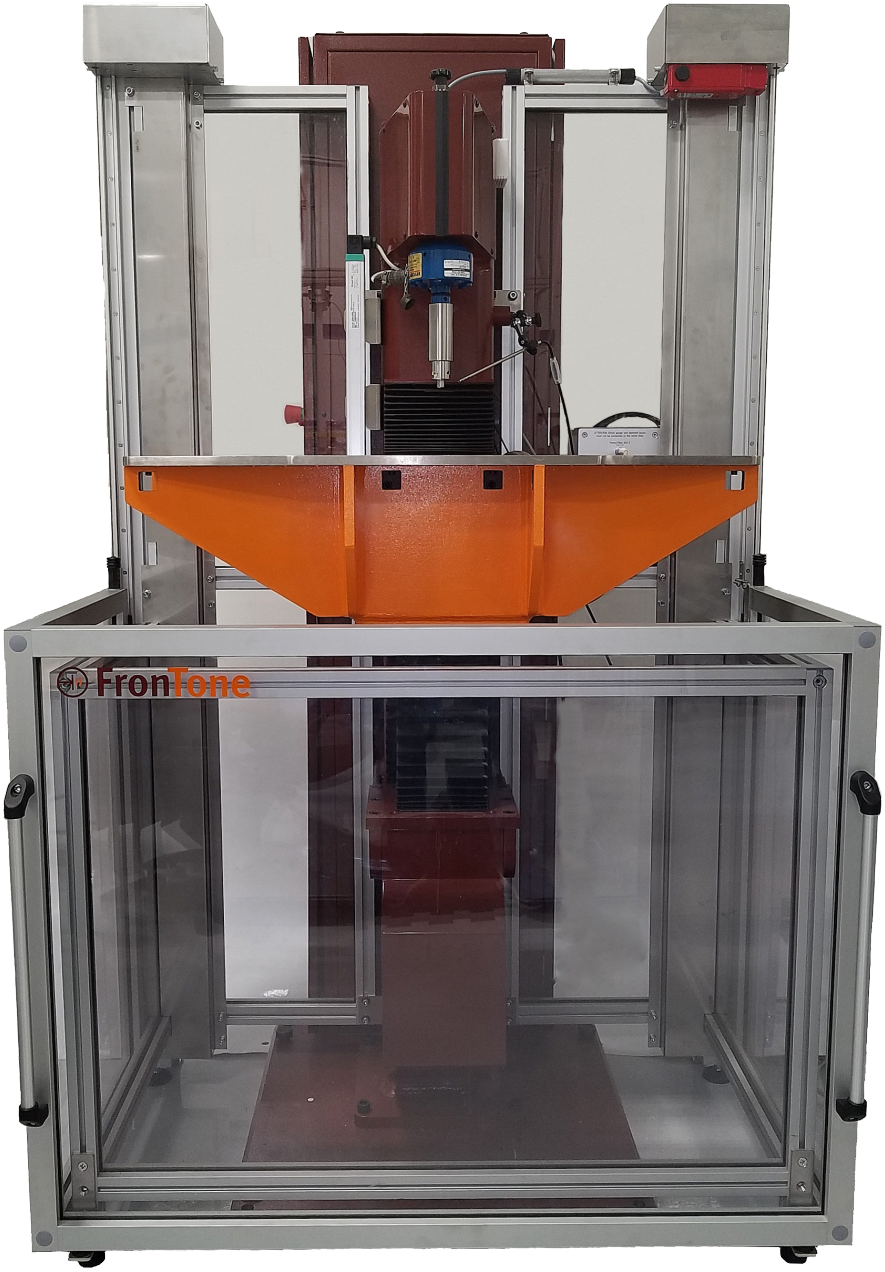


Figure 13.1 Flex Static Machine

SECTION 14

Dynamic Inverse Certification and Procedures

The aPLI is required to pass two dynamic inverse certification tests. The type 1 inverse test is a central knee impact test, and the type 2 inverse test is a lower femur impact test. The output from the femur and tibia strain gages, as well as the string potentiometers, must all fall within the certification corridors. The tests are performed on the full leg assembly. The travel pin (233-5161) must be removed prior to performing the test and the hanger assembly (233-5103) must be attached to the top of the SUBP.

The legform and leg parts should be kept in the test environment at least 4 hours prior to the use in a test. The testing laboratory environment should be controlled to have:

- **A temperature of 20 ±2°C**
- **A relative humidity of 40 ±30%**

When conducting certification tests a time interval of at least 30 minutes should be observed between two consecutive tests.

Humanetics dynamic certification is performed on Frontone's E-linear FLEX ZERT machine. The FLEX ZERT has an upgrade available to customers who previously used it for the Flex-PLI. The upgrade still allows the certification of the FlexPLI.

Before performing any test, the following procedure should be followed

1. **Check the M8 BHCS that attach the femur and tibia to the knee are tightened to 8Nm**
2. **Check that the stop cable clearances on the three cables in the femur assembly are set to 13.6mm and 11.3mm in the tibia assembly. Use the cable setting tool provided in the tool kit.**
3. **Check that the knee blocks are aligned to ensure the knee is not twisted or in a shear condition before the test. For forward impact alignment this can be done by laying the leg on its push pads on a flat surface with the SUBP over hanging the surface. For side alignment the same can be done but clearance would be required for the knee, so that the leg only lays on the femur and tibia.**
4. **Check that the shoulder bolts along the sides of the femur and tibia are tightened to 3Nm.**
5. **Check the push pads are secure. If they are loose, remove them by pulling away from the assembly, and replace the fir-tree clips (6006010) used to attach them.**
6. **Inspect the femur and tibia impact segment caps are attached and in the correct position. These can be adjusted as necessary. The caps are attached using double-sided tape. If the tape is no longer sticky or is folded over, it needs to be replaced with a new piece.**
7. **Check that the SUBP (Simplified Upper Body Part) rotates freely.**
8. **Inspect parts for damage, see section 5.2 for a full inspection checklist.**

14.1 Type 1 Inverse Testing

14.1.1 TEST PROCEDURE

1. Remove the travel pin (233-5161) from the SUBP.
2. Secure the hanger assembly (233-5103) to the SUBP cover plate (233-5151) using three M6 X 25 SHCS. Toque to 8Nm. The hanger assembly should be 25 ±5 degrees from vertical.
3. Wrap a 5052 aluminum honeycomb segment with a crush strength of 75 PSI ±10 in a paper cloth that is less than 1mm thick. The size of the honeycomb is width 200 ±5mm, length 160 ±5mm, and depth 60 ±2mm. To ensure repeatability the honeycomb should either have a 3/16 or 1/4 inch cell size. The honeycomb should have a density of 2.0 pounds per cubic foot for honeycomb with a 3/16 inch cell size or a density of 2.3 pounds per cubic foot for honeycomb with a 1/4 inch cell size. Pre-crushed honeycomb is recommended. The paper cloth is taped at the back of the honeycomb to secure it. The paper cloth is intended to protect the leg cover.

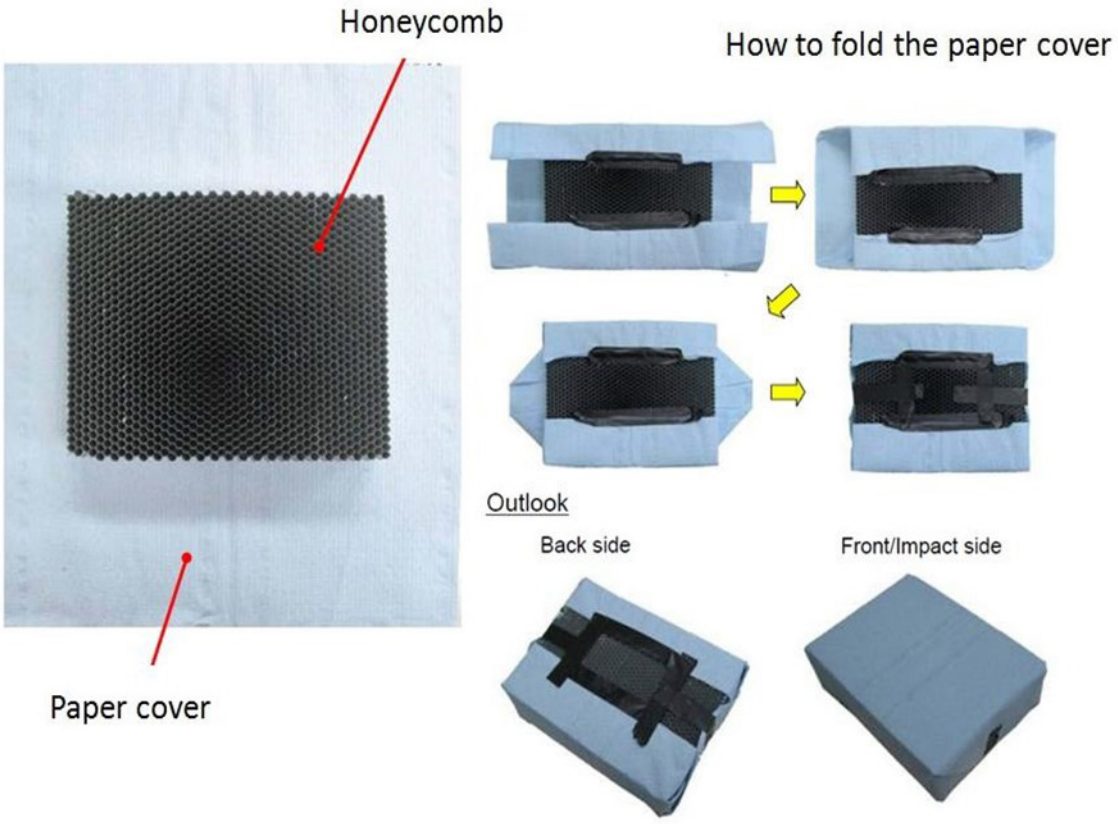


Figure 14.1 Paper Cloth Wrapping of Honeycomb

4. Attach the honeycomb with paper cloth to the impact block using tape. The top of the honeycomb and impactor are to be flush.
5. Hang the leg on the quick release hook on the FLEX ZERT machine.
6. Connect the DAS to the machine via the quick-release connector.

7. **Initiate the DAS while the leg is in a vertical orientation. Set the DAS such that the sensors are zeroed to zero sensor output in the vertical position.**
8. **Align the impactor such that the aluminum honeycomb is even with the top of the meniscus assembly (233-5313).**
9. **Arm the DAS.**
10. **Release the impact block at a rate of 11.1 ±0.2m/s. The leg should have a free travel of 70mm prior to impact and 190-220mm after initial contact.**
11. **If the quick-release connector disconnects during testing, it must be reconnected to download the data.**

WARNING

After impact, the leg is thrown violently away from the test rig and can seriously injure anyone standing in the flight area. It is highly recommended that a safety barrier is erected in the flight area ensuring no one is inside this danger zone during the test to avoid any injury.

14.1.2 DATA PROCESSING

All data shall be filtered at CFC180. Peak values shall be within 40ms after impact. The inverse certification corridors set by Euro NCAP for type 1 inverse testing are given in Table 14-1.

Table 14-1 Type 1 (Knee Impact) Inverse Testing Euro NCAP Certification Corridors

Description	Lower Limit	Upper Limit
Peak moment tibia gage 1 (Nm)	291	334
Peak moment tibia gage 2 (Nm)	238	272
Peak moment tibia gage 3 (Nm)	160	193
Peak moment tibia gage 4 (Nm)	92	116
Peak ACL elongation (mm)	3	4
Peak MCL elongation (mm)	12	16
Peak PCL elongation (mm)	6	8
Peak moment femur gage 1 (Nm)	162	208
Peak moment femur gage 1 (Nm)	133	178
Peak moment femur gage 1 (Nm)	101	134

14.2 Type 2 (Femur Impact) Inverse Testing

14.2.1 TEST PROCEDURE

1. Remove the travel pin (233-5161) from the SUBP.
2. Secure the hanger assembly (233-5103) to the SUBP cover plate (233-5151) using three M6 X 25 SHCS. Toque to 8Nm. The hanger assembly should be 25 ±5 degrees from vertical.
3. Wrap a 5052 aluminum honeycomb segment with a crush strength of 75 PSI ±10 in a paper cloth that is less than 1mm thick. The size of the honeycomb is width 200 ±5mm, length 160 ±5mm, and depth 60 ±2mm. To ensure repeatability the honeycomb should either have a 3/16 or 1/4 inch cell size. The honeycomb should have a density of 2.0 pounds per cubic foot for honeycomb with a 3/16 inch cell size or a density of 2.3 pounds per cubic foot for honeycomb with a 1/4 inch cell size. Pre-crushed honeycomb is recommended. The paper cloth is taped at the back of the honeycomb to secure it. The paper cloth is intended to protect the leg cover.
4. Attach the honeycomb paper cloth to the impactor block using tape. The top of the honeycomb and the impactor are to be flush.
5. Hang the leg on the quick release hook on the FLEX ZERT machine fitting it into its lower locator ±0.5° from vertical.
6. Connect the DAS to the machine via the quick-release connector.
7. Initiate the DAS while the leg is in a vertical orientation. Set the DAS such that the sensors are zeroed to zero sensor output in the vertical position.
8. Position the leg so that the top of the impactor block is above the top of the knee (the impact point is 120mm ±2mm above the meniscus).
9. Arm the DAS.
10. Release the impact block at a rate of 11.1 ±0.2m/s. The leg should have a free travel of 70mm prior to impact and 190-220mm after initial contact.
11. If the quick-release connector disconnects during testing, it must be reconnected to download the data.

WARNING

After impact, the leg is thrown violently away from the test rig and can seriously injure anyone standing in the flight area. It is highly recommended that a safety barrier is erected in the flight area ensuring no one is inside this danger zone during the test to avoid any injury.

14.2.2 DATA PROCESSING

All data shall be filtered at CFC180. Peak values shall be within 40ms after impact. The inverse certification corridors set by Euro NCAP for type 2 inverse testing are given in Table 14-2.

Table 14-2 Type 2 (Femur Impact) Inverse Testing Euro NCAP Certification Corridors

Description	Lower Limit	Upper Limit
Peak moment tibia gage 1 (Nm)	206	251
Peak moment tibia gage 2 (Nm)	182	228
Peak moment tibia gage 3 (Nm)	132	164
Peak moment tibia gage 4 (Nm)	63	83
Peak ACL elongation (mm)	3	4
Peak MCL elongation (mm)	20	24
Peak PCL elongation (mm)	8	10
Peak moment femur gage 1 (Nm)	233	293
Peak moment femur gage 1 (Nm)	189	238
Peak moment femur gage 1 (Nm)	147	190

Dynamic Inverse Certification and Procedures

The Dynamic FlexZert machine can be upgraded to include the aPLI certification.

Figure 14.2 Dynamic FlexZert Machine

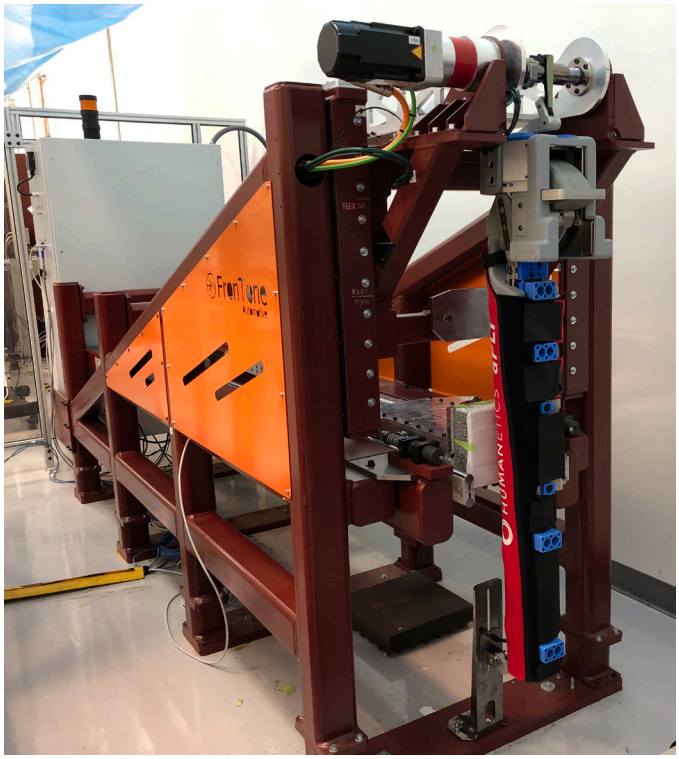


Figure 14.3 Dynamic FlexZert with aPLI Leg

SECTION 15

Disclaimer

15.1 Disclaimer

The information in this manual is furnished for informational use only and is subject to change without notice. Humanetics Innovative Solutions, Inc. assumes no responsibility for liability on errors or inaccuracies that may appear in this manual.

15.2 Proprietary Statement

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15.3 Notice of Lead Content in Product

The product referred to in this manual may contain lead. A list of components that may contain lead is being maintained on the Humanetics website by ATD (test dummy) type and subcomponents. The list includes items that may currently or in the past have contained or a lead-based alloy. Please refer to our Lead Disclosure for information regarding possible lead content in this product.

15.4 About Humanetics

Humanetics Innovative Solutions, Inc. is a global company whose strategy is to harness the best of today's technologies for the creation of high-quality products which play an important role in improving safety, comfort, and protection of people and their environment. Humanetics is the world's leading supplier in the design and manufacture of sophisticated crash test dummies, associated technical support, and laboratory services and load cell crash wall systems. Furthermore, Humanetics develops and supplies finite element software-based dummy models for computerized crash test simulations and specializes in static and dynamic strain measurements.

For additional information on Humanetics and its products and services, please refer to our website or contact:

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SECTION 16

Update Log

Table 16-1 Update Log

Revision Level	Revision Date	Revision Author	Revision Description
1	MAR2022	MGT, MB, IH	Initial Release


HUMANETICS