

This tutorial has been updated to match the naming convention used in the IOR foot paper. The original tutorial can be found [here](#).

In 2014, updates to the IOR foot model were published. The updated tutorial can be found [here](#).

Sample Data

Sample data can be downloaded [here](#).

Once the zip file has been downloaded, you can find a static C3D and three dynamic trials in the SampleFiles folder. These files will be used to complete the tutorial.

The model, planar angles and joint angles for the right side were defined and plotted in the Leardini_2007_Angles.cmo. Once the left side angles have been defined, the report template will graph both the left and right angles.

Introduction

Visual3D is a general tool capable of implementing many different foot models.

This tutorial focuses on the multi-segment foot model as described in the following article:

[Leardini2007articleheader.jpg](#)

Multi-Segment Foot Marker Set

Foot Targets

[foot_markersIOR.png](#)

CA^[1] (FCC) ^[2] : p. 162 = Posterior Surface of Calcaneus **ST^[1] (FST) ^[2]** : p.164 = Sustentaculum Tali of Calcaneus **PT^[1] (FPT) ^[2]** : p.171 = Lateral apex of the peroneal tubercle **TN^[1] (FNT) ^[2]** : p.165 = Medial apex of the tuberosity navicular. **FMH^[1] (FM1) ^[2]** : p.173 = Head of 1st Metatarsus **SMH^[1] (FM2) ^[2]** : p.173 = Head of 2nd Metatarsus **VMH^[1] (FM5) ^[2]** : p.173 = Head of 5th Metatarsus **VMB^[1] (FMT) ^[2]** : p.172 = Tuberosity of 5th Metatarsal **PM^[1] (PD6) ^[2]** : p.175 = Proximal Distal Phalanx. * **FMB^[1]** = Base of First Metatarsal. ** **SMB^[1]** = Base of Second Metatarsal. **

* Serge Van Sint Jan describes palpation for the mediolateral borders of this landmark (PM6/PL6), the target should be placed at the midpoint.

** There is no reference for this landmark in Serge Van Sint Jan text, please see the IOR Foot paper for further clarification

Shank Targets

HF^[1] (FAX)^[2] : p.154 = Apex of the styloid process	
TT^[1] (TTC)^[2] : p.144 = Tibial tuberosity	
LM^[1] (FAL)^[2] : p.158 = Apex of the Lateral malleolus	IORShank_targets.png{/images/thumb/9/99/IORShank_targets.png/300px-IORShank_targets.png}
MM^[1] (TAM)^[2] : p.148 = Apex of the Medial malleolus	

NOTE: This tutorial follows the naming convention presented in the IOR Foot paper.

Metatarsus (Met)

Landmarks

1. Create RMET_DIST: • Click Landmarks button • Click Add New Landmark button • Create Landmark: <i>RMET_DIST</i>	Landmark Name: <i>RMET_DIST</i> Define Orientation Using: Starting Point: <i>RFMH</i> Ending Point: <i>RVMH</i> Lateral Object: <i>RSMB</i> Project From: <i>RSMH</i>	 • Do NOT Check: <i>Offset by Percent (1.0 = 100%)</i> • Check: <i>Calibration Only Landmark</i>	IOR_Landmark_RMET_DIST.png{/images/thumb/b/b8/IOR_Landmark_RMET_DIST.png/275px-IOR_Landmark_RMET_DIST.png}
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Segment Definition

1. Create RMet Segment: • In the Segments tab, select <i>RMet</i> in the Segment Name box. • Select Kinematic Only • Click on the Create Segment button. • In the RMet tab, enter these values:	Define Proximal Joint and Radius Lateral: <i>None</i> Joint: <i>RSMB</i> Medial: <i>None</i> Radius: <i>0.1</i> Define Distal Joint and Radius Lateral: <i>None</i> Joint: <i>RMET_DIST</i> Medial: <i>None</i> Radius: <i>0.1</i> Extra Target to Define Orientation Location: <i>Medial</i> <i>RFMH</i> Select Tracking Targets: <i>RFMB, RFMH, RSMB, RSMH, RVMB, RVMH</i>	• Click on Build Model. • Click on Close Tab before proceeding.	
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2. Modify the Segment Coordinate System: • Define the Segment Orientation as:	A/P Axis: +Y Distal to Proximal: -X	
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The image to the right (and all other images in this tutorial) show a mediolateral view of the segment coordinate system after it has been modified.

Mid-foot (Mid)

Landmarks

1. Create RID Joint Center: • Click Landmarks button • Click Add New Landmark button • Create Landmark: RID	Landmark Name: RID Define Orientation Using: Starting Point: RTN Ending Point: RVMB	• Offset Using the Following AXIAL Offset: 0.5 • Check: Offset by Percent (1.0 = 100%) • Check: Calibration Only Landmark	IOR_Landmark_RID.png{/images/thumb/8/85/IOR_Landmark_RID.png/275px-IOR_Landmark_RID.png}
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Segment Definition

1. Create RMid Segment: • In the Segments tab, select RMid in the Segment Name box. • Select Kinematic Only. • Click on the Create Segment button. • In the RMid tab, enter these values:	Define Proximal Joint and Radius Lateral: None Joint: RID Medial: None Radius: 0.1 Define Distal Joint and Radius Lateral: None Joint: RSMB Medial: None Radius: 0.1 Extra Target to Define Orientation Location: Medial RTN Select Tracking Targets: RSMB, RTN, RVMB	• Click on Build Model. • Click on Close Tab before proceeding.	IOR_Segment_RMID.png{/images/thumb/3/3d/IOR_Segment_RMID.png/275px-IOR_Segment_RMID.png}
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2. Modify the Segment Coordinate System: • Define the Segment Orientation as:	A/P Axis: +Y Distal to Proximal: -X	IOR_Seg_RMID_SCS.png{/images/thumb/2/26/IOR_Seg_RMID_SCS.png/275px-IOR_Seg_RMID_SCS.png}
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Calcaneus (Cal)

Landmarks

1. Create RIC Joint Center: - Click Landmarks button - Click Add New Landmark button - Create Landmark: <i>RIC</i>	Landmark Name: <i>RIC</i> Define Orientation Using: Starting Point: <i>RST</i> Ending Point: <i>RPT</i>	- Offset Using the Following AXIAL Offset: <i>0.5</i> Check: Offset by Percent (<i>1.0 = 100%</i>) Check: Calibration Only Landmark	
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Segment Definition

1. Create RCal Segment: - In the Segments tab, select <i>RCal</i> in the Segment Name box. - Click on the Create Segment button. - In the RCal tab, enter these values:	Define Proximal Joint and Radius Lateral: <i>None</i> Joint: <i>RCA</i> Medial: <i>None</i> Radius: <i>0.1</i> Define Distal Joint and Radius Lateral: <i>None</i> Joint: <i>RIC</i> Medial: <i>None</i> Radius: <i>0.1</i> Extra Target to Define Orientation Location: <i>Medial</i> <i>RST</i> Select Tracking Targets: <i>RCA, RPT, RST</i>	• Click on Build Model. • Click on Close Tab before proceeding. IOR_Segment_RCAL.png { {/images/thumb/4/4e/IOR_Segment_RCAL.png/275px-IOR_Segment_RCAL.png
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2. Modify the Segment Coordinate System: Define the Segment Orientation as:	A/P Axis: +Y Distal to Proximal: -X	
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Foot (Foo)

Landmarks

1. Create RFT_DIST: - Click Landmarks button - Click Add New Landmark button - Create Landmark: <i>RFT_DIST</i>	Landmark Name: <i>RFT_DIST</i> Define Orientation Using: Starting Point: <i>RCA</i> Ending Point: <i>RFMH</i> Lateral Object: <i>RVMH</i> Project From: <i>RSMH</i>	Do NOT Check: <i>Offset by Percent (1.0 = 100%)</i> Check: <i>Calibration Only Landmark</i> 
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Segment Definition

1. Create Right Foot Segment: - In the Segments tab, select <i>Right Foot</i> in the Segment Name box. - Click on the Create Segment button. - In the Right Foot tab, enter these values:	Define Proximal Joint and Radius Lateral: <i>None</i> Joint: <i>RCA</i> Medial: <i>None</i> Radius: <i>0.5*DISTANCE(RST,RPT)</i> Define Distal Joint and Radius Lateral: <i>None</i> Joint: <i>RFT_DIST</i> Medial: <i>None</i> Radius: <i>0.5*DISTANCE(RFMH,RVMH)</i> Extra Target to Define Orientation Location: <i>Medial RFMH</i> Select Tracking Targets: <i>RCA, RFMH, RVMH</i>	- Click on Build Model. - Click on Close Tab before proceeding. 
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2. Modify the Segment Coordinate System: • Define the Segment Orientation as:	A/P Axis: +Y Distal to Proximal: -X	
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Shank (Sha)

Landmarks

1. Create RIM: • Click Landmarks button • Click Add New Landmark button • Create Landmark: RIM	Landmark Name: RIM Define Orientation Using: Starting Point: RLM Ending Point: RMM	• Offset Using the Following AXIAL Offset: 0.5 • Check: Offset by Percent (1.0 = 100%) • Check: Calibration Only Landmark	
2. Create RSK_PROX: • Click Landmarks button • Click Add New Landmark button • Create Landmark: RSK_PROX	Landmark Name: RSK_PROX Define Orientation Using: Starting Point: RIM Ending Point: RLM Lateral Object: RHF Project From: RTT	• Do NOT Check: Offset by Percent (1.0 = 100%) • Check: Calibration Only Landmark	

Segment Definition

1. Create Right Shank Segment: - In the Segments tab, select <i>Right Shank</i> in the Segment Name box. - Click on the Create Segment button. - In the Right Shank tab, enter these values:	Define Proximal Joint and Radius Lateral: <i>None</i> Joint: <i>RSK_PROX</i> Medial: <i>None</i> Radius: <i>DISTANCE(RSK_PROX,RHF)</i> Define Distal Joint and Radius Lateral: <i>None</i> Joint: <i>RIM</i> Medial: <i>None</i> Radius: <i>0.5*DISTANCE(RLM,RMM)</i> Extra Target to Define Orientation Location: <i>Lateral RLM</i> Select Tracking Targets: <i>RHF, RLM, RMM, RTT</i>	- Click on Build Model. - Click on Close Tab before proceeding. IOR_Segment_RSK.png{/images/thumb/8/88/IOR_Segment_RSK.png/275px-IOR_Segment_RSK.png}
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2. Modify the Segment Coordinate System: Define the Segment Orientation as:	A/P Axis: +X Distal to Proximal: +Y	
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Angles

Landmarks

The F2Pt and F2Ps planar angles are calculated as the angle between the lines created by the targets FMB-FMH and FMH-PM. To calculate this angle using the Compute Planar Angle command, an offset along the line between FMB and FMH is created to define the 3 point angle.

1. Create RF2P_Offset: • Click Landmarks button • Click Add New Landmark button • Create Landmark: RF2P_Offset	Landmark Name: RF2P_Offset Define Orientation Using: Starting Point: RFMB Ending Point: RFMH	• Offset Using the Following AXIAL Offset: 1.5 • Check: Offset by Percent (1.0 = 100%) • Do NOT Check: Calibration Only Landmark LandmarkImage_RF2P_Offset.png{{/images/thumb/e/e8/LandmarkImage_RF2P_Offset.png/275px-LandmarkImage_RF2P_Offset.png
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2. Create LF2P_Offset:

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When defining the left signal, use same definitions as for the RF2P_Offset landmark

The F2G, S2G and V2G angles are calculated in the plane orthogonal to the ground. These landmarks will need to be projected onto the ground. To project landmarks onto the ground, the Lab_O, Lab_X and Lab_Y landmarks will need to be created to identify the plane of the ground.

3. Create Lab_O: • Click Landmarks button • Click Add New Landmark button • Create Landmark: Lab_O

4. Create Lab_X: • Click Landmarks button • Click Add New Landmark button • Create Landmark: <i>Lab_X</i>	Landmark Name: <i>Lab_X</i>	• Offset Using the Following ML/AP/AXIAL Offsets: X: <i>0.05</i> Y: <i>0.0</i> Z: <i>0.0</i> • Do NOT Check: <i>Offset by Percent (1.0 = 100%) (Meters when not checked)</i> • Do NOT Check: <i>Calibration Only Landmark (Not generated for assigned motion file(s))</i>	IORFoot_Lab_X.png { {/images/thumb/a/ad/ IORFoot_Lab_X.png/275px- IORFoot_Lab_X.png
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5. Create Lab_Y: • Click Landmarks button • Click Add New Landmark button • Create Landmark: <i>Lab_Y</i>	Landmark Name: <i>Lab_Y</i>	• Offset Using the Following ML/AP/AXIAL Offsets: X: <i>0.0</i> Y: <i>0.05</i> Z: <i>0.0</i> • Do NOT Check: <i>Offset by Percent (1.0 = 100%) (Meters when not checked)</i> • Do NOT Check: <i>Calibration Only Landmark (Not generated for assigned motion file(s))</i>	IORFoot_Lab_Y.png { {/images/thumb/9/95/ IORFoot_Lab_Y.png/275px- IORFoot_Lab_Y.png
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6. Create RFMH_proj: - Click Landmarks button - Click Add New Landmark button - Create Landmark: <i>RFMH_proj</i>	Landmark Name: <i>RFMH_proj</i> Define Orientation Using: Starting Point: <i>LAB_O</i> Ending Point: <i>LAB_X</i> Lateral Object: <i>LAB_Y</i> Project From: <i>RFMH</i>	Do NOT Check: <i>Offset by Percent (1.0 = 100%)</i> Do NOT Check: <i>Calibration Only Landmark</i>	
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Create landmarks 7-17 by following the same format as the RFMH_proj landmark for: ****

7. RFMB	12. LFMH
8. RSMH	13. LFMB
9. RSMB	14. LSMH
10. RVMH	15. LSMB
11. RVMB	16. LVMH
	17. LVMB

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Planar Angles

F2Pt

F2Pt - the angle between the lines FMH-PM and FMB-FMH projected onto the transverse plane of the metatarsus

Represents - valgus of the first metatarsophalangeal joint

1. Create RF2Pt planar angle: - Define Resulting Signal Name: <i>RF2Pt</i> - Calculate a 3 point angle between the following targets:	1 - <i>LANDMARK::ORIGINAL::RF2P_offset</i> 2 - <i>TARGET::ORIGINAL::RFMH</i> 3 - <i>TARGET::ORIGINAL::RPM</i> Angle Direction: <i>Left Hand Rule</i> Use Range: <i>-180 to 180 degrees</i> Projected onto Plane: <i>XZ</i> Note: The reference segment will need to be changed to <i>RMet</i> within the text option.	
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2. Create LF2Pt planar angle: When defining the left signal, use same definitions except set:	Angle Direction: <i>Right Hand Rule</i> Note: The reference segment will need to be changed to <i>LMet</i> within the text option.
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S2F

S2F - the angle between the lines FMB-FMH and SMB-SMH projected onto the transverse plane of the metatarsus

1. Create RS2F planar angle: - Define Resulting Signal Name: RS2F - Calculate a 4 point angle between the following targets:	1 - TARGET::ORIGINAL::RSMH 2 - TARGET::ORIGINAL::RSMB 3 - TARGET::ORIGINAL::RFMB 4 - TARGET::ORIGINAL::RFMH Angle Direction: <i>Right Hand Rule</i> Use Range: -180 to 180 degrees Projected onto Plane: XZ Note: The reference segment will need to be changed to <i>RMet</i> within the text option.	PlanarAngle_RS2F.png
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2. Create LS2F planar angle: When defining the left signal, use same definitions except set:	Angle Direction: <i>Left Hand Rule</i> Note: The reference segment will need to be changed to <i>LMet</i> within the text option.
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S2V

S2V - the angle between the lines VMB-VMH and SMB-SMH projected onto the transverse plane of the metatarsus

1. Create RS2V planar angle: - Define Resulting Signal Name: RS2V - Calculate a 4 point angle between the following targets:	1 - TARGET::ORIGINAL::RSMH 2 - TARGET::ORIGINAL::RSMB 3 - TARGET::ORIGINAL::RVMB 4 - TARGET::ORIGINAL::RVMH Angle Direction: <i>Left Hand Rule</i> Use Range: -180 to 180 degrees Projected onto Plane: XZ Note: The reference segment will need to be changed to <i>RMet</i> within the text option.	PlanarAngle_RS2V.png
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2. Create LS2V planar angle: When defining the left signal, use same definitions except set:	Angle Direction: <i>Right Hand Rule</i> Note: The reference segment will need to be changed to LMet within the text option.
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F2G

F2G - the angle between the lines FMB-FMH and the ground, plane orthogonal to the ground (3D angle relative to the ground)

The **FMH_proj** and **FMB_proj** landmarks will be used to calculate the **F2G** planar angle which are described in the [landmarks](#) section.

1. Create RF2G planar angle: - Define Resulting Signal Name: <i>RF2G</i> - Calculate a 4 point angle between the following targets:	1 - <i>TARGET::ORIGINAL::RFMB</i> 2 - <i>TARGET::ORIGINAL::RFMH</i> 3 - <i>TARGET::ORIGINAL::RFMH_proj</i> 4 - <i>TARGET::ORIGINAL::RFMB_proj</i> Angle Direction: <i>Right Hand Rule</i> 3D Space: <i>Always 0 to 180 degrees</i>	PlanarAngle_RF2G.png
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2. Create LF2G planar angle: When defining the left signal, use same definitions as for the right angle
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S2G

S2G - the angle between the lines SMB-SMH and the ground, plane orthogonal to the ground (3D angle relative to the ground)

The **SMH_proj** and **SMB_proj** landmarks will be used to calculate the **S2G** planar angle which are described in the [landmarks](#) section.

1. Create RS2G planar angle: - Define Resulting Signal Name: <i>RS2G</i> - Calculate a 4 point angle between the following targets:	1 - <i>TARGET::ORIGINAL::RSMB</i> 2 - <i>TARGET::ORIGINAL::RSMH</i> 3 - <i>TARGET::ORIGINAL::RSMH_proj</i> 4 - <i>TARGET::ORIGINAL::RSMB_proj</i> Angle Direction: <i>Right Hand Rule</i> 3D Space: <i>Always 0 to 180 degrees</i>	PlanarAngle_RS2G.png
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2. Create LS2G planar angle:

- When defining the left signal, use same definitions as for the right angle

V2G

V2G - the angle between the lines VMB-VMH and the ground, plane orthogonal to the ground (3D angle relative to the ground)

The **VMH_proj** and **VMB_proj** landmarks will be used to calculate the **V2G** planar angle which are described in the [landmarks](#) section.

1. Create RV2G planar angle: - Define Resulting Signal Name: RV2G - Calculate a 4 point angle between the following targets:	1 - TARGET::ORIGINAL::RVMB 2 - TARGET::ORIGINAL::RVMH 3 - TARGET::ORIGINAL::RVMH_proj 4 - TARGET::ORIGINAL::RVMB_proj Angle Direction: Right Hand Rule 3D Space: Always 0 to 180 degrees	PlanarAngle_RV2G.png
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2. Create LV2G planar angle:

- When defining the left signal, use same definitions as for the right angle

F2Ps

F2Ps - the angle between the lines FMH-PM and FMB-FMH projected onto the sagittal plane of the metatarsus

Represents - dorsiflexion of the first metatarso-phalangeal joint

1. Create RF2Ps planar angle: - Define Resulting Signal Name: RF2Ps - Calculate a 3 point angle between the following targets:	1 - LANDMARK::ORIGINAL::RF2P_offset 2 - TARGET::ORIGINAL::RFMH 3 - TARGET::ORIGINAL::RPM Angle Direction: Right Hand Rule Use Range: -180 to 180 degrees Projected onto Plane: XY Note: The reference segment will need to be changed to RMet within the text option.	PlanarAngle_RF2Ps.png
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2. Create LF2Ps planar angle: When defining the left signal, use same definitions except set:	Angle Direction: <i>Right Hand Rule</i> Note: The reference segment will need to be changed to <i>LMet</i> within the text option.
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MLA

MLA - the angle between the lines CA-ST and ST-FMH projected onto the sagittal plane of the foot
Represents - navicular drop

1. Create RMLA planar angle: - Define Resulting Signal Name: <i>RMLA</i> - Calculate a 3 point angle between the following targets:	1 - <i>TARGET::ORIGINAL::RCA</i> 2 - <i>TARGET::ORIGINAL::RST</i> 3 - <i>TARGET::ORIGINAL::RFMH</i> Angle Direction: <i>Right Hand Rule</i> Use Range: <i>-180 to 180 degrees</i> Projected onto Plane: <i>XY</i> Note: The reference segment will need to be changed to <i>RMet</i> within the text option.	PlanarAngle_RMLA.png
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2. Create LMLA planar angle: When defining the left signal, use same definitions except set:	Angle Direction: <i>Right Hand Rule</i> Note: The reference segment will need to be changed to <i>LMet</i> within the text option.
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Joint Angles

Sha_Foo_Angle

1. Define the RSha_Foo_Angle: - Open the Compute Model Based dialog - Select JOINT_ANGLE from drop down list	Data Name: <i>RSha_Foo_Angle</i> Segment: <i>Right Foot Reference Segment: Right Shank Cardan Sequence: Z-X-Y</i>	Use Negative: <i>X: TRUE Y: TRUE Z: FALSE</i>	IOR_Foot_RSha_Foo_Angle.png{/images/thumb/e/ea/lor_foot_rsha_foo_angle.png/425px-IOR_Foot_RSha_Foo_Angle.png}
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Sha_Cal_Angle

1. Define the RSha_Cal_Angle: - Open the Compute Model Based dialog - Select JOINT_ANGLE from drop down list	Data Name: RSha_Cal_Angle Segment: RCal Reference Segment: Right Shank Cardan Sequence: Z-X-Y	Use Negative: X: TRUE Y: TRUE Z: FALSE	IOR_Foot_RSha_Cal_Angle.png{/images/thumb/e/e9/IOR_Foot_RSha_Cal_Angle.png/425px-IOR_Foot_RSha_Cal_Angle.png}
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Cal_Mid_Angle

1. Define the RCal_Mid_Angle: - Open the Compute Model Based dialog - Select JOINT_ANGLE from drop down list	Data Name: RCal_Mid_Angle Segment: RMid Reference Segment: RCal Cardan Sequence: Z-X-Y	Use Negative: X: TRUE Y: TRUE Z: FALSE	IOR_Foot_RCal_Mid_Angle.png{/images/thumb/c/cf/IOR_Foot_RCal_Mid_Angle.png/425px-IOR_Foot_RCal_Mid_Angle.png}
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Mid_Met_Angle

1. Define the RMid_Met_Angle: - Open the Compute Model Based dialog - Select JOINT_ANGLE from drop down list	Data Name: RMid_Met_Angle Segment: RMet Reference Segment: RMid Cardan Sequence: Z-X-Y	Use Negative: X: TRUE Y: TRUE Z: FALSE	IOR_Foot_RMid_Met_Angle.png{/images/thumb/c/ca/IOR_Foot_RMid_Met_Angle.png/425px-IOR_Foot_RMid_Met_Angle.png}
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Cal_Met_Angle

1. Define the RCal_Met_Angle: - Open the Compute Model Based dialog - Select JOINT_ANGLE from drop down list	Data Name: RCal_Met_Angle Segment: RMet Reference Segment: RCal Cardan Sequence: Z-X-Y	Use Negative: X: TRUE Y: TRUE Z: FALSE	IOR_Foot_RCal_Met_Angle.png{/images/thumb/a/a1/IOR_Foot_RCal_Met_Angle.png/425px-IOR_Foot_RCal_Met_Angle.png}
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References

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[1.00](#) [1.01](#) [1.02](#) [1.03](#) [1.04](#) [1.05](#) [1.06](#) [1.07](#) [1.08](#) [1.09](#) [1.10](#) [1.11](#) [1.12](#) [1.13](#) [1.14](#)

Leardini, A., M.G. Benedetti, L. Berti, D. Bettinelli, R. Nativo, and S. Giannini. "Rear-foot, Mid-foot and Fore-foot Motion during the Stance Phase of Gait." Gait & Posture 25 (2007): 453-55

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[2.00](#) [2.01](#) [2.02](#) [2.03](#) [2.04](#) [2.05](#) [2.06](#) [2.07](#) [2.08](#) [2.09](#) [2.10](#) [2.11](#) [2.12](#)

Serge van Sint Jan "Color Atlas of Skeletal Landmark Definitions: Guidelines for Reproducible Manual and Virtual Palpations" 2007 - Churchill Livingstone

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