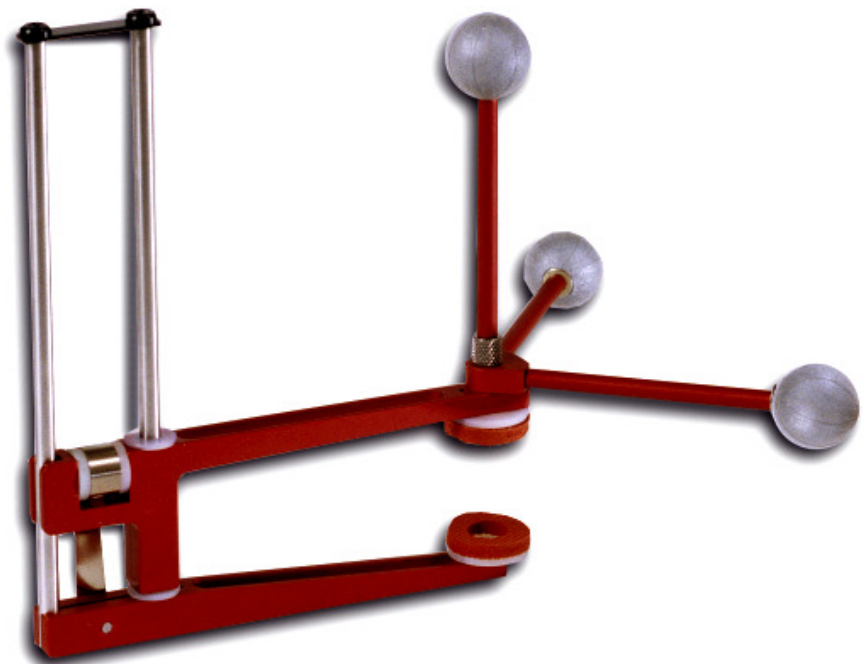


Knee Alignment Device



By Motion Lab Systems, Inc.

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The Motion Lab Systems Knee Alignment Device was developed by Motion Lab Systems, Inc., for use with the Newington Software and the VICON Clinical Manager® program.

VICON Clinical Manager is a product of Oxford Metrics Ltd., who can be contacted at 14 Minns Estate, West Way, Oxford, England, OX2 0JB. Questions regarding the function and operation of the VICON Clinical Manager software should be directed to Oxford Metrics Ltd.

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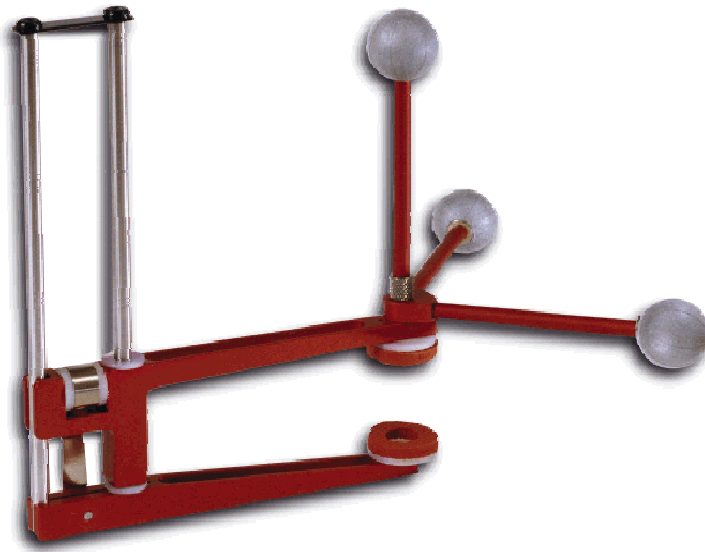
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Introduction

When to use a Knee Alignment Device

The purpose of the Motion Lab Systems Knee Alignment Device (also known as a “KAD”) is to allow the VICON Clinical Manager software application from Oxford Metrics Ltd., (VCM) to automatically establish the knee flexion axis during a static trial. These devices are supplied in sets of two units, each looking like the illustration below. The devices are generally used in pairs, one on each leg.



The Knee Alignment Device is a spring-loaded metal jig that fits gently over the subjects' knee while a static calibration data collection is performed. The design of the Knee Alignment Device is such that the absolute distance between all three of the markers on the device is identical (5.66 inches).

The design of the Motion Lab Systems KAD enables the VICON Clinical Manager software to establish a virtual knee marker at the central joint of the Knee Alignment Device and this, combined with the KAD wand marker, enables the knee flexion axis to be measured.

A C3D (Coordinate 3d Data) file contains the 3D marker locations of the KAD and other subject markers.

When the VICON Clinical Manager software finds marker labels for a Knee Alignment Device defined in the C3D file, it uses the orientation of the three markers on the Knee Alignment Device to establish the knee flexion axis.

After the knee flexion axis has been established, VICON Clinical Manager calculates the relative transverse alignment of this axis, to the transverse plane orientation of the thigh and shank, as calculated using the mid-thigh and mid-shank stick markers. These relative alignments are stored in the subject's Session form as Thigh and Shank Rotations and are applied to all dynamic data within the session. Thus the correct alignment of the thigh and shank wands becomes less critical as any minor alignment errors are measured during the static trial and can be automatically removed during the processing of the dynamic trials. Please refer directly to the Oxford Metrics VCM User Guide or contact the manufacturer for information on the kinematic processing that is performed within the VICON Clinical manager software program.



A Knee Alignment Device should be used **only** during a static trial. The thigh and shank rotation offset values calculated in VICON Clinical Manager are used to align the knee and ankle flexion axes during the dynamic trials.

Please do not attempt to use the Knee Alignment Device during a dynamic or walking trial as it has not been designed to be worn while the subject is walking.

The KAD Environment

When a Knee Alignment Device is used during a static trial, the VICON Clinical Manager software assumes that the knee and ankle flexion axes are parallel. The Knee Alignment Device defined ankle flexion axes will lie parallel to the knee flexion axes and will pass through the lateral malleolus marker.

For some individuals this is incorrect, therefore this built-in assumption may be overwritten, if desired by entering the subject's tibial torsion measurement directly into the VICON Clinical Manager Session Form prior to processing the static trial causing VCM to rotate the ankle flexion axes during its kinematics calculations.



Please note that an external tibial torsion measurement must be entered into the VICON Clinical Manager Session Form as a negative value.

Repair of your KAD

The Motion Lab Systems, Inc., KAD is a precision device that should give you many years of trouble free service. However, it is possible that it may become worn or damaged during use. Please contact Motion Lab Systems for service or exchange of any damaged Knee Alignment Device.

KAD Placement

Defining the Flexion Axis

The placement of the Knee Alignment Device defines the flexion axis of the knee and the ankle for the VICON Clinical Manager software so correct positioning of the device is essential if these two axis are to be measured correctly by the VICON Clinical Manager.

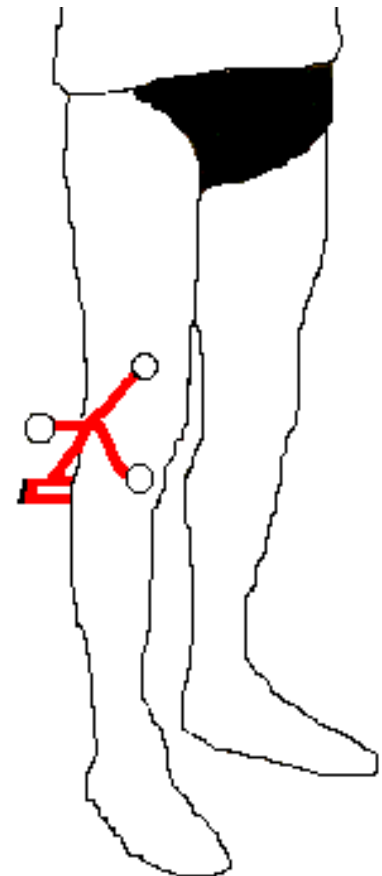
The soft, hollow, outer pad of the Knee Alignment Device jaw is placed directly over the lateral surface intersection of the knee flexion axis and the inner pad is placed on the medial aspect of the knee, close to or over the medial epicondyle.



When the knee is fully extended, particularly in the adult knee, the fibrous and fatty covering of the lateral joint capsule tends to push the lateral pad of the Knee Alignment Device forward, internally rotating the measured knee flexion axis. This must be avoided by adjusting the Knee Alignment Device position to reflect the correct knee axis.



The alignment of the Knee Alignment Device stem with the knee flexion axis must be thoroughly checked. While the medial and lateral epicondyles of the knee provide a good approximation for the correct positions of the Knee Alignment Device pads in normal adult knees, in abnormally shaped knees, these landmarks may not represent the optimal positions for the pads.





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Always check the position of the Knee Alignment Device immediately prior to data collection. The Knee Alignment Device could slip if the subject moves between placing the device on the subjects knee and collecting the data. If the Knee Alignment Device is not in the correct position during a static trial, there is no way to correct the data acceptably.

Editing the Appropriate Files

Configuration Files

In most cases your motion capture system will have been set up with the correct configuration files when it was installed. If this is the case then you can probably skip this chapter. This section is useful for anyone installing a copy of VICON Clinical Manager themselves, anyone who did not purchase the Knee Alignment Device at the same time as VICON Clinical manager, or anyone who is upgrading their data collection system.

Before you can process data collected with the Motion Lab Systems Knee Alignment Device you must first configure your data collection system, as well as your copy of the VICON Clinical Manager software, so that it knows what marker labels you will be using to identify the Knee Alignment Device markers. This information will usually need to be entered in two places. Once in the VICON Clinical Manager configuration file (CFG File) and again in your motion capture systems' Marker Definition file (MRK or DES file).

It is most important that you take care to use identical marker labels and names in both files otherwise the system will not work.

VICON Clinical Manager CFG file

<L/R> means either Left or Right side markers.

In general, the three markers on each Knee Alignment Device are identified internally by VICON Clinical Manager through the Marker group in the CFG file as <L/R>KAX or KNE, <L/R>KD1, and <L/R>KD2. Each Knee Alignment Device marker in the C3D file should have a unique marker label assigned to it. However, as there are no knee markers present during a Knee Alignment Device static trial, the same label can be used for both the knee markers, <L/R>KNE, and the Knee Alignment Device stem markers, <L/R>KAX. Both assignments must be present in the Marker group in the CFG file.

When the VICON Clinical Manager software detects the presence of the Knee Alignment Device markers in a three-dimensional data file, it recognizes the presence of Knee Alignment Device(s). As knee markers cannot be present at the same time as Knee Alignment Device s, the program assigns the shared labels to the Knee Alignment Device stem marker(s).

Clearly, it is important that the labels assigned to the other Knee Alignment Device markers, <L/R>KD1 and <L/R>KD2, are not shared by any other markers.

[Markers]

SACR=sacr	{ Sacral wand }
LASI=lasi	{ Left ASIS marker }
LTHI=lthi	{ Left thigh wand }
LKNE=lkne	{ Left knee marker }
LTIB=ltib	{ Left shank wand }
LANK=lank	{ Left ankle marker }
LTOE=ltoe	{ Left toe marker }
RASI=rasi	{ Right ASIS marker }
RTHI=rthi	{ Right thigh wand }
RKNE=rkne	{ Right knee marker }
RTIB=rtib	{ Right shank wand }
RANK=rank	{ Right ankle marker }
RTOE=rtoe	{ Right toe marker }
LHEE=lhee	{ Left heel marker - static only }
RHEE=rhee	{ Right heel marker - static only }
LKAX=lkne	{ Left knee axis stick - Knee Alignment Device static only }
LKD1=lkd1	{ Left knee wand marker 1 - Knee Alignment Device static only }
LKD2=lkd2	{ Left knee wand marker 2 - Knee Alignment Device static only }
RKAX=rkne	{ Right knee axis stick - Knee Alignment Device static only }
RKD1=rkd1	{ Right knee wand marker 1 - Knee Alignment Device static only }
RKD2=rkd2	{ Right knee wand marker 2 - Knee Alignment Device static only }

Marker Definition (DES or MKR) File

The marker labels used to define the Knee Alignment Device markers must be present in the VICON marker definition files. Depending on the system that you are using these will be either DES files (AMASS and VICON-VX motion capture systems) or MKR files (VICON 370 motion capture systems).

VICON 370 Systems – MKR files

The MKR file used in conjunction with the VICON 370 system is an ASCII file that is usually stored in the 370\MODELS directory for older 370 systems, or in the \VICON\CFG directory in many of the newer 370 systems. Locate and open this file using the NOTEPAD application and check that the correct labels exist. You may need to add the marker label names if they are not present. These labels must match those used in the VICON Clinical Manager CFG file.

There are two slightly different formats for this file – files used with 370 software version 2.01 or lower use the first format (MKR#1 format) while the 2.5 version of the 370 software (current at the time of writing) uses the MKR#2 format. Make sure that you are using the correct format.

The following is a sample MKR file as used by 370 software version 2.01 and lower:

```
!MKR#1
19
SACR  Sacral wand marker
LASI  Left ASIS
LTHI  Left thigh wand marker
```

LKNE Left knee
 LTIB Left tibial wand marker
 LANK Left ankle
 LTOE Left toe
 RASI Right ASIS
 RTHI Right thigh wand marker
 RKNE Right knee
 RTIB Right tibial wand marker
 RANK Right ankle
 RTOE Right toe
 LHEE Left heel
 RHEE Right heel

RKD1 Right top Knee Alignment Device marker
RKD2 Right bottom Knee Alignment Device marker
LKD1 Left top Knee Alignment Device marker
LKD2 Left bottom Knee Alignment Device marker

The KAD specific marker names are shown in **bold** - note that if you add marker names to this format then you must change the marker count at the top of the list. In this example there are 19 marker lines and the count is set to 19.

The following is a sample MKR file as used by 370 software version 2.5:

```

!MKR#2
[Labels List]
SACR Sacral wand marker
LASI Left ASIS
RASI Right ASIS
LTHI Left thigh wand marker
RTHI Right thigh wand marker
LKNE Left knee
RKNE Right knee
LTIB Left tibial wand marker
RTIB Right tibial wand marker
LANK Left ankle
RANK Right ankle
LTOE Left toe
RTOE Right toe
LHEE Left heel
RHEE Right heel
LKAX Left knee axis
LKD1 Left knee device 1
LKD2 Left knee device 2
RKAX Right knee axis
RKD1 Right knee device 1
RKD2 Right knee device 2
PELV dummy pelvis center
  
```

The KAD specific marker names are shown in **bold** - note that this format does not require a marker count at the top of the list.

Please call Oxford Metrics Ltd., technical support if further instructions are required to add KAD labels to your MKR files or if you are in doubt about which file you should edit.

AMASS and VICON-VX Systems – DES files.

Following are the instructions to add marker labels to a DES file as used by AMASS and VICON-VX (AMASS; Adtech, Adelphi, MD). These commands are all issued from the VICON-VX shell. Please call Oxford Metrics Ltd., technical support if further instructions are required.

1. Enter the VICON shell by typing "VIC" at the VAX \$prompt.
2. Enter the Analysis Menu by typing "A" at the VICON Main Menu prompt.
3. Enter the Parameters Menu by typing "P" at the Analysis Menu prompt.
4. Select Update (type "U") at the Parameters Menu prompt.
5. Type "DES" when the system asks for the file to update.
6. Type "L P" for List Point parameters at the file ? prompt.
7. Type "C LA" for Change Labels.
8. Press the Return key until the marker label is not displayed after the prompt. At this point enter RKD1 and press Enter.
9. Enter RKD2 and press Enter
10. Enter LKD1 and press Enter
11. Enter LKD2 and press enter

Joint Axis Determination

Using VICON Clinical Manager

The VICON Clinical Manager software provides a number of alternative methods for determining the axes of the knee and ankle joints.

Basic Rotation Alignments

In the most basic method, the rotations of these axes about the long axes of the femur and tibia are determined by the placement of markers on the "mid"-thigh and "mid"-shank.

As the fixation of any one of these markers is moved anteriorly around the limb, there is an interior rotation of the flexion axis of the joint which lies below it. This rotation always occurs about the marker placed on the lateral side of the joint, so the flexion axis always passes through this joint marker, giving the operator complete control over both the direction of the flexion axis, and the center of the joint.

Note that the height and distance from the limb of these rotation-sensing markers has no effect on the results. Provided their antero-posterior location relative to the distal joint marker is carefully controlled, they can be placed wherever visibility and steady fixation to the limb are optimal, with or without wands.

In this basic method, the "static trial" is used only to establish the position of the forefoot marker relative to the alignment of the foot, by temporarily adding a heel marker. No corrections are made to the flexion axes of the knee and ankle.

Thigh and Tibial Markers

The correct antero-posterior alignment of the thigh and tibial markers is not an easy task.

If the knee and ankle flexion axes are incorrectly determined, a number of highly characteristic errors will result in the kinematic results. After learning to recognize these errors, the operator can make mathematical adjustments which compensate for incorrect thigh and shank marker placement.

Recognizing Errors in Hip Rotation

Hip rotation is measured about the long axis of the femur. Its "neutral" position occurs when the flexion axis is aligned with the lateral axis of the pelvis. If the thigh marker is placed too far forward the flexion axis of the knee is internally rotated and a corresponding internal rotation offset error appears in hip rotation.

It is almost impossible to obtain an independent measure of hip rotation in a standing subject, so a non-zero hip rotation may either be real or due to incorrect thigh marker placement. Clearly, some other corroboration is required.

Exactly the same assumption can be used with the VICON Clinical Manager to check for correct placement of the thigh marker and to correct offsets in hip rotation.

The standard physical examination and test for hip rotation involves lying the subject prone, flexing the knee to close to 90 degrees, and moving the leg medially and laterally. This test relies on the assumption, true for many pathologies, that, as the foot is raised from the table, the knee moves in pure flexion. If the knee has any significant valgus/varus instability, hip rotation from this test will be unreliable.

If, in the report graphs from a walking trial, there is;

- a) hip external rotation offset AND a knee valgus "wave" during swing, the knee flexion axis has been externally rotated, The thigh marker was placed too far posteriorly;
- b) a hip internal rotation offset AND a knee valgus "wave" during swing, the knee flexion axis has been internally rotated. The thigh marker was placed too far anteriorly.

In case (a), the hip external rotation offset and the knee valgus wave are both corrected by entering a small internal (+ ve) Thigh Rotation Offset in the VCM Session form and reprocessing the walking trial.

In case (b), the hip internal rotation offset and the knee varus wave are both corrected by entering a small external (-ve) Thigh Rotation Offset in the VCM Session form and reprocessing the walking trial.

Knee Joint Center Position

Since the thigh rotation offset is applied about the knee joint marker, changes in the placement of the thigh marker and thigh rotation offsets entered into the session form both cause the knee joint center to move. Internal rotations of the knee flexion axis move the joint center posteriorly. External rotations of the knee flexion axis move the joint center anteriorly.

There are three important, related consequences;

- a) If a thigh marker is placed a long way anterior or posterior from its "correct" lateral position, the application of thigh rotation offsets, while still allowing a correct direction for the knee flexion axis, will place the knee joint center too far posterior or anterior.
- b) This antero/posterior mis-location of the knee joint center causes small changes in the flexion/extension axis of the knee.
- c) Knee joint moments, which are calculated about the knee joint center, will also change.

Knee Alignment Device

Because of the difficulties associated with the basic method of establishing correct rotational alignment, far more reliable results can generally be obtained by using the Knee Alignment Device (KAD).

Correct placement of the KAD is essential if hip rotation, knee valgus/varus, and knee joint moments are to be calculated correctly.

This device is placed across the knee during a static "subject calibration" trial. It allows the knee flexion axis to be measured directly, independently of the thigh marker. From this independent measurement, VCM automatically calculated the Thigh Rotation Offset required to correct for any misplacement of the thigh marker, and saves the offset in the Session form.

Over reliance on anatomical landmarks can be misleading. The only safe method is to examine the knee as it is flexed and extended, and to mark the skin at the medial and lateral points which are seen to remain in a constant position relative to both the thigh and shank a task that requires practice. The KAD pads are then placed over these marks.

When the knee is fully extended, particularly in the adult knee, the fibrous and fatty covering of the lateral joint capsule tends to push the lateral pad of the KAD forward, internally rotating the measured knee flexion axis. This must be avoided by adjusting the KAD position.

During a static trial using a KAD, the subject's hip flexion, abduction, and rotation, knee flexion are not important only the correct alignment of the KAD relative to the knee joint axis will ensure that reports from the session's trials are accurate.

Ankle Joint Kinematics

You need to consider what is meant by the common phrase "plantar/dorsiflexion at the ankle"? If the subject stands with the long axis of the foot aligned directly antero/posterior, is the plantar/dorsiflexion axis lateral, through the lateral malleolus, or is it aligned between the medial and lateral malleoli? Or is it somewhere else?

The compound joint between the tibia and hindfoot is only approximated by the relatively simple model in VCM. The model is, however, sufficiently flexible to allow several different methods to be used for calculation the kinematics of the "ankle" joint.

Method A - "Parallel" Knee and Ankle Flexion Axes, with KAD

If a KAD is used to determine the knee flexion axis in a static "subject calibration" trial, VCM will, by default, calculate a second axis, with the same rotation about the long axis of the tibia as the knee flexion axis, and passing through the ankle marker. VCM automatically calculates a Shank Rotation Offset, in exactly the same manner as the Thigh Rotation Offset, and saves it in the Session form.

Plantar/dorsiflexion measured about this axis corresponds most closely to ankle angle which is seen in a sagittal plane projection of the subject. However, it results in an ankle joint center which is directly medial to the lateral marker. If this marker is placed on the lateral malleolus, the joint center ends a long way posterior, resulting in a kinematic dorsiflexion offset and an increase in plantarflexion moment.

One remedy to this problem is to place the ankle marker anterior to the lateral malleolus, remembering to measure the ankle width correctly at this narrower point.

Method B - Tibial Torsion between Knee and Ankle Flexion Axes, with KAD

If a KAD is used for the static "subject calibration" trial, a value of Tibial Torsion can be used to alter the direction of the plantar/dorsiflexion axis of the ankle, and the location of the ankle joint center. This value of Tibial torsion must be entered into the Session form before the static trial is processed.

If a negative value of Tibial Torsion is used, then ankle plantar/dorsiflexion axis is externally rotated (as is normally required) with respect to the knee flexion axis, and the ankle joint center is moved anteriorly.

If a positive value of Tibial Torsion is used, the ankle plantar/dorsiflexion axis is internally rotated with respect to the knee flexion axis, and the ankle joint center is moved posteriorly.

If this method is used to establish an inter-malleolar direction for the axis, the ankle width should be measured obliquely between the malleoli. On average, using this method with 15 - 20 degrees of Tibial Torsion, the ankle joint is 3 - 5 degrees plantarflexed by comparison with the "parallel" axes method.

Method C - Alignment of the Shank (wand) with the Ankle Flexion Axis with or without KAD

Whether or not the KAD is used to determine the knee flexion axis, it is always possible to set up the rotational alignment of the ankle plantar/dorsiflexion axis by the placement of the shank marker. This may be useful as a direct means of incorporating the Tibial Torsion of a standing subject.

Especially when using a shank marker wand aligned directly above the inter-malleolar axis of a standing subject, this method may provide a more accurate way of setting true tibial torsion into the alignment of the plantar/dorsiflexion axis.

Leaving Tibial Torsion to zero, process a static trial with the KAD in the normal way. After the program has saved the rotation offsets in the Session form, reset the Shank Rotation Offset to zero before processing any walking trials.

As with the previous method, if the axis is set up with an inter-malleolar alignment, the ankle width should be measured obliquely between the malleoli. On average, using this method introduces the equivalent of more than 20 degrees of Tibial Torsion, and the ankle joint is 5 - 7 degrees plantarflexed by comparison with the "parallel" axes method.

If Knee Rotation is required as a VCM report graph, it may include an offset due to the non-alignment of knee and ankle axes. This offset can be reduced by entering a value of Tibial Torsion into the Session form after processing of the static trial. No variable other than Knee Rotation is affected.

Method D - Foot-Aligned Ankle Flexion Axis, with or without KAD

The last model/method is radically different from the three previous.

The Grood and Suntay convention for joint articulation fixes the flexion axis in the segment proximal to a joint. However, once the location of the ankle joint center has been established, using any of the above methods, it is possible for VCM to establish a plane, which lies through the knee and ankle joint centers, and the forefoot marker. The axis for plantar/dorsiflexion can then be set perpendicular to this plane, passing through the ankle joint center.

This redefined flexion axis is, of course, not fixed relative to the rotation of the tibia, so tibial torsion has no effect. However extreme the internal or external rotation of the foot, downward movements of the toe are always treated as plantarflexion and upward movements as dorsiflexion.

This measure of ankle plantar/dorsiflexion can be calculated in addition to normal ankle flexion by calling up an extra GCD variable, FootBasedDorsiPlanFlex (see documentation supplied with the VICON Clinical Manager software for details).

Processing Data in VCM

"I Used a KAD, Now What"

The Session Form

Once a static trial is collected it must be processed by the VICON Clinical Manager software so that the information about the relative positions of the markers can be determined. A Knee Alignment Device static trial is processed in the same manner as a static trial that does not contain KAD information. There are only the following two differences between the methods:

1. A tibial torsion measurement may be included in the Session Form prior to processing a static trial that contains Knee Alignment Device information.
2. When the static trial is processed, Thigh and Shank Rotations values other than 0.0 are stored in the Session database and displayed in the Session form.

The thigh rotation offset value is the angular difference between the transverse alignments of the knee flexion axis defined by the Knee Alignment Device versus the transverse plane of the thigh as defined using the thigh wand.

The screenshot shows the 'Session [3 Trials]' form. It contains fields for Patient No (82739), Last name, first name(s) (Gilmore, Chad), Session no (3), Session date (1/16/94), Age (16/10), Height (64.6 in), and Weight (112.2 lb). Below these are fields for Inter ASIS distance (cm), Marker dia mm (25.0), Frame Rate (60), Config file (grf), Videotape Reference, and Date Report required. A 'Report distn' section has checkboxes for Patient, Parent, Physician, and 2nd Physician... To the right is a table of measurements for Left and Right sides.

	Left	Right
ASIS-to-troc dist		
Leg length (cm)	85.1	84.2
Knee width (cm)	9.2	9.4
Ankle width (cm)	6.4	6.5
Tibial torsion		
Thigh rotation	-22.2	-11.7
Shank rotation	17.2	15.6
Static plantar flex	5.9	3.4
Static foot rotation	0.8	-0.7

Figure 1 - A Session Form after a static trial was processed with KAD information.

The shank rotation offset value is the angular difference between the transverse alignments of the knee flexion axis defined by the Knee Alignment Device versus the transverse plane of the shank as defined using the shank wand. If tibial torsion measurements are entered into the Session Form prior to processing a trial, the shank rotation offset value is calculated taking the values into account.

Session [3 Trials]									
Patient No		Last name, first name(s)							
82739		Gilmore, Chad							
Session no	Session date	Age	Height	Weight					
4	1/16/94	16/10	64.6 in	112.2 lb					
Inter ASIS distance (cm)		ASIS-to-troc dist		Left		Right			
Marker dia mm	Frame Rate	Log length (cm)		85.1		84.2			
25.0	60	Knee width (cm)		9.2		9.4			
Config file		Ankle width (cm)		6.4		6.5			
grf		Tibial torsion		-30.0		-34.0			
Videotape Reference		Thigh rotation		-22.2		-11.7			
Date Report required		Shank rotation		-1.4		-5.1			
Report distn	☐ Patient	Static plantar flex		8.3		7.1			
	☐ Parent	Static foot rotation		8.8		7.5			
	☐ Physician								
	☐ 2nd Physician...								

Figure 2 - A Session Form after a static trial was processed with KAD information. Tibial torsion measurements were entered prior to processing the static trial.

The Cycles Window

When the Stick figure displayed in the Cycles Window for the static trial collected with Knee Alignment Devices is displayed in the Cycles window, the Knee Alignment Device markers are not shown. Instead the 'virtual knee marker' is plotted to allow its position to be checked. Stick figures in Knee Alignment Device trials should therefore look exactly the same as in non-Knee Alignment Device trials.

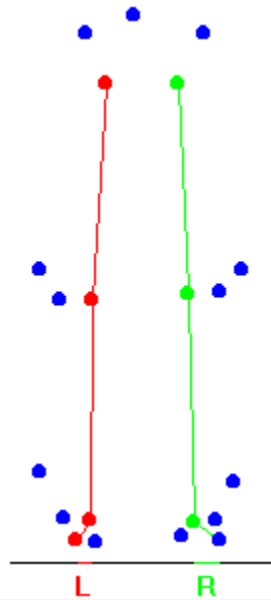


Figure 3 – A typical view in the VCM Cycles Window when a KAD is used.

Please refer to Checking for Errors in KAD Use on page 17 for more information about a trial with Knee Alignment Device information displayed in the Cycles Window.

Checking for Errors in KAD Use

The Static Trial

Stick figures displayed in the Cycles Window for static trial data containing Knee Alignment Device information should look exactly the same as in non-Knee Alignment Device trials, because rather than the Knee Alignment Device markers, only the 'virtual' knee marker is displayed. If the stick figure looks “bowlegged” and/or displays the knee joint center lateral to the knee marker, either the markers were labeled incorrectly or the markers are defined incorrectly in the VICON Clinical Manager CFG file. If this information is correct, please contact Oxford Metrics technical support for assistance with VICON Clinical Manager.

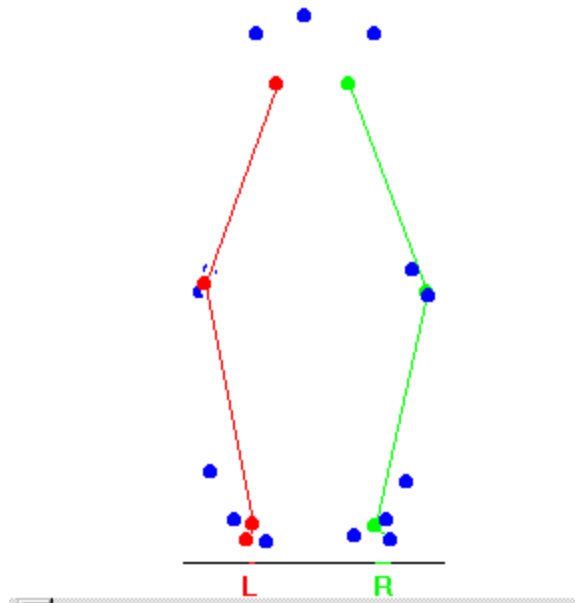


Figure 4 - When the KAD markers are labeled incorrectly, the VICON Clinical Manager Cycles Window displays the joint centers lateral to their true position.

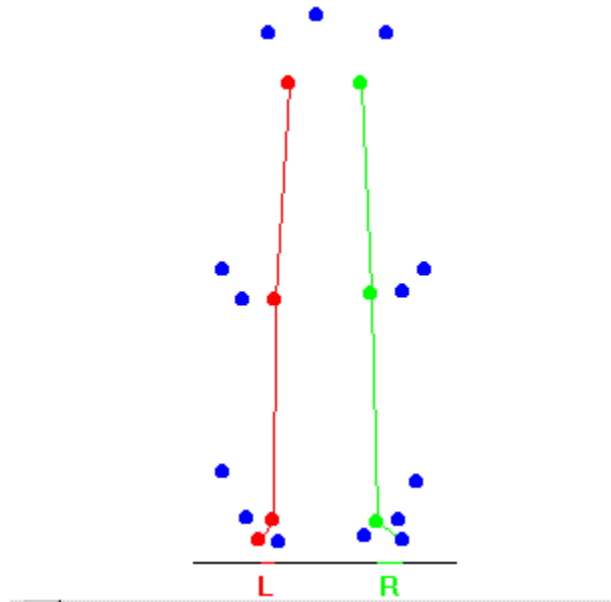


Figure 5 - Only the knee marker of a KAD is displayed in the VICON Clinical Manager Cycles Window when a KAD is used.

If care was taken to place the thigh wand in the plane defined by the knee flexion axis and the hip joint center, then the calculated thigh rotation offset value can also be used to indicate misplacement of the Knee Alignment Device. If care was taken during the thigh wand marker placement, then the thigh rotation offset value should be minimal. A value greater than 10 may signify misplacement of the Knee Alignment Device. If this is true, please continue to the Dynamic Trial section.

The Dynamic (walking) Trial

It is possible to place the Knee Alignment Device incorrectly or for it to slip prior to data collection. In either case, the knee flexion axis defined by the Knee Alignment Device will be incorrect. Correct alignment of the knee flexion axis can be estimated in two manners.

First, as mentioned above, if care was taken to place the thigh wand in the plane defined by the knee flexion axis and the hip joint center, then the calculated thigh rotation offset value should be minimal. A value greater than 10 may signify misplacement of the Knee Alignment Device.

Secondly, the knee varus/valgus and hip rotation graphs from a dynamic trial can be used to determine Knee Alignment Device misplacement. If, in the report graphs from a walking trial, there is:

- Hip external rotation offset AND a knee valgus "wave" during swing, the knee flexion axis has been externally rotated. The thigh marker was placed too far posteriorly.
- A hip internal rotation offset AND a knee varus "wave" during swing, the knee flexion axis has been internally rotated. The thigh marker was placed too far anteriorly.

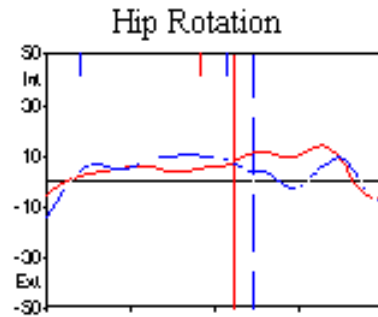


Figure 6 These hip rotation values appear normal, but the red line is suspect because of the knee varus graph.

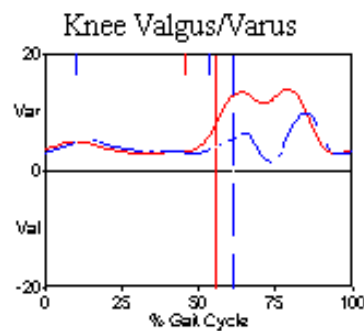


Figure 7 The red line in this graph displays the knee varus "wave" during swing.

In the first case, the hip external rotation offset and the knee valgus wave can both be corrected by entering a small internal (positive) Thigh Rotation Offset in the VICON Clinical Manager Session form and reprocessing the walking trial.

In the second case, the hip internal rotation offset and the knee varus wave can both be corrected by entering a small external (negative) Thigh Rotation Offset in the VICON Clinical Manager Session form and reprocessing the trial.

Whenever the KAD is placed incorrectly you will see significant valgus/varus values, which on close examination tend to follow the knee flexion extension trace. For normal gait the knee varus/valgus graph should be relatively flat – any deviation from this should alert you to the probability of errors in the alignments of KAD or the thigh marker wands.

Using Vicon-Nexus

KAD usage with Vicon software

The KAD axis is calculated by the Vicon Plug-in-Gait module using exactly the same code in both Vicon-Workstation and Vicon-Nexus.

In both Vicon-Workstation and Vicon-Nexus the KAD processing defines the knee coronal plane of the femur and relieves the user of the need to accurately place the Thigh Marker (THI) in the coronal plane of the femur. An offset angle is calculated which, from the intermediate coordinate system defined by HJC-THI-KNE is able to re-create the anatomical coordinate system for the femur in the dynamic trials.

Tibial Torsion

The original implementation of the KAD in Vicon Clinical Manager (VCM) assumed that the transmalleolar axis was parallel to the knee flexion/extension axis. Any discrepancy between the two axes was corrected in the VCM model by entering in a measured value for tibial torsion – usually obtained by direct manual measurement of the subject. Tibial torsion could also be directly calculated by collecting a static trial with medial markers and using the Vicon BodyBuilder software to calculate the tibial torsion

Marker Size

The Vicon-Workstation and Vicon-Nexus software uses the KAD to define a virtual knee (VKNE) marker at the position where the plane containing the VKNE and the KD1+KD2 markers is also perpendicular to the line from the VKNE to the KAX marker. This calculation has two mathematical solutions; Plug-in-Gait assumes that KD1 is above KD2 to figure out the correct solution and orientation of the KAD in 3D space. Using the VKNE, Plug-in-Gait calculates the offset angle between the technical coordinate system defined by HJC-THI-VKNE and the anatomical coordinate system defined by HJC, KJC and KAX. The offset angle depends on the correct marker diameter, not of markers on the KAD, but of the marker that will be used on the knee (and everywhere else) in the dynamic.

The marker diameter to be used in the static processing is not the one used for the KAD markers, but the one used for the ordinary marker set – thus the KAD markers are not required to be the same size as the standard subject marker set as the VKNE marker size is defined by the fixed KAD dimensions and NOT by the subject marker dimensions.