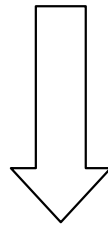


Plug In Gait and the Knee Alignment Device

Gabriele Paolini
Support Engineer

INTRODUCTION

The purpose of the Knee Alignment Device (KAD) is to allow Plug In Gait to automatically define the direction of the knee flexion axis during a static trial



- The anterior-posterior position of the *THI* marker less critical
- Consistency improved
- Inter and Intra operator repeatability improved

INTRODUCTION

What is a KAD?

A KAD is a spring-loaded metal Jig that fits over the subject's knee



NOTE: the distance between the three KAD markers is identical (143.76 mm)



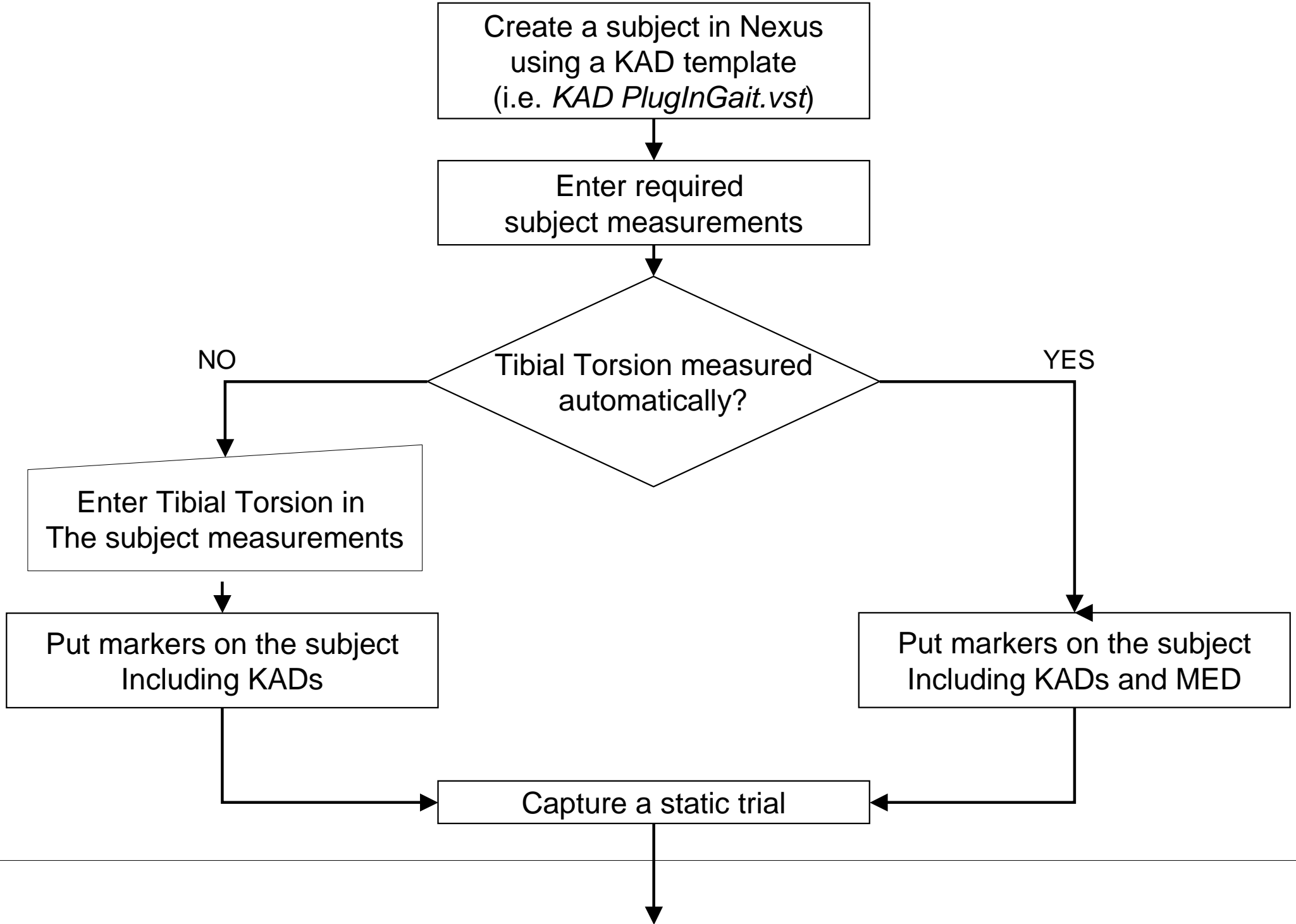
INTRODUCTION

How does PiG establish the direction of the Knee flexion axis?

1. Creation of a virtual knee marker equidistant from the KAD markers
2. The direction of the line connecting the virtual knee marker and the KAD wand marker is the direction of the knee flexion axis



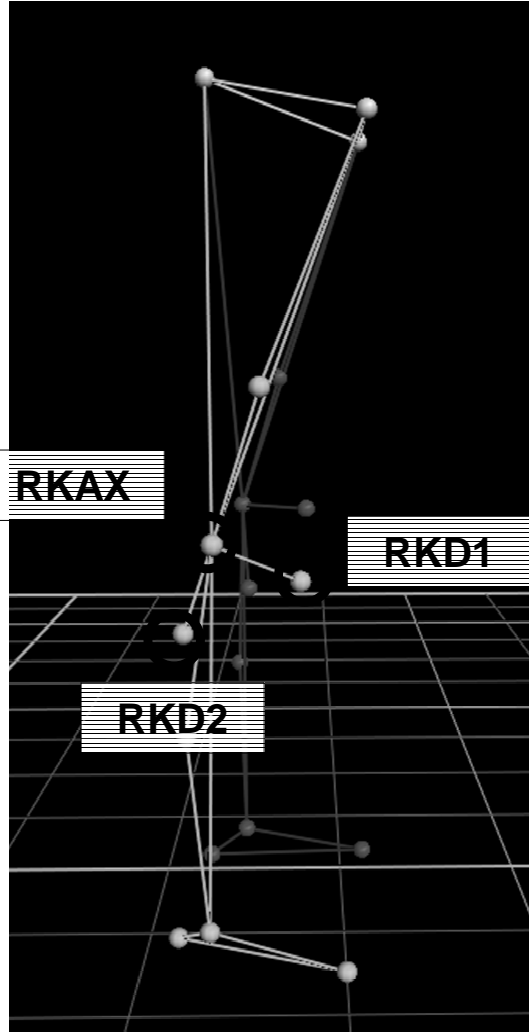
PLUG IN GAIT WORKFLOW USING NEXUS AND KADs



PLUG IN GAIT WORKFLOW USING NEXUS AND KADs

Reconstruct and manually
Label the markers

KAX, KD1, KD2
Right side: clockwise
Left side: anti-clockwise



PLUG IN GAIT WORKFLOW USING NEXUS AND KADs

Run static PiG

Remove KADs (and MED) and
Place KNE marker
where the KAD pad was

Attach the corresponding
Non-KAD template to the
Subject
(i.e. PlugInGait.vst)

Run static subject calibration

Capture and process dynamic
Trials as usual

Thigh and Shank offsets
Saved in the parameter file.
If MED were used, Tibial Torsion
Saved to mp file too

KAD PLACEMENT

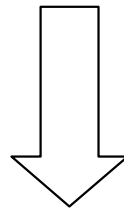
The KAD must be placed in such a way that the KAD wand marker is parallel to the knee flexion axis.

Although putting the KAD on the femoral condyles is a good starting point, over relying on anatomical points for KAD placement will lead to errors in determining the knee flexion axis, causing the observation of some cross-over in the joint kinematics

KAD PLACEMENT

KAD placement suggestions from the KAD user manual:

- When the knee is fully extended, the fibrous covering the lateral joint capsule tends to push the lateral pad of the KAD forward, thus internally rotating the measured knee flexion axis. This must be avoided by adjusting the KAD position to reflect the correct knee axis
- The alignment of the KAD stem with the knee flexion axis must be thoroughly checked. While the medial and lateral epicondyles of the femur provide a good approximation for normal adult knees, in pathological knees, these may not represent the optimal landmarks for the KAD placement.



The placement of the KAD must be carried out taking into consideration the fact that the knee flexion axis is a functional axis and its orientation does not necessarily depend on anatomical points

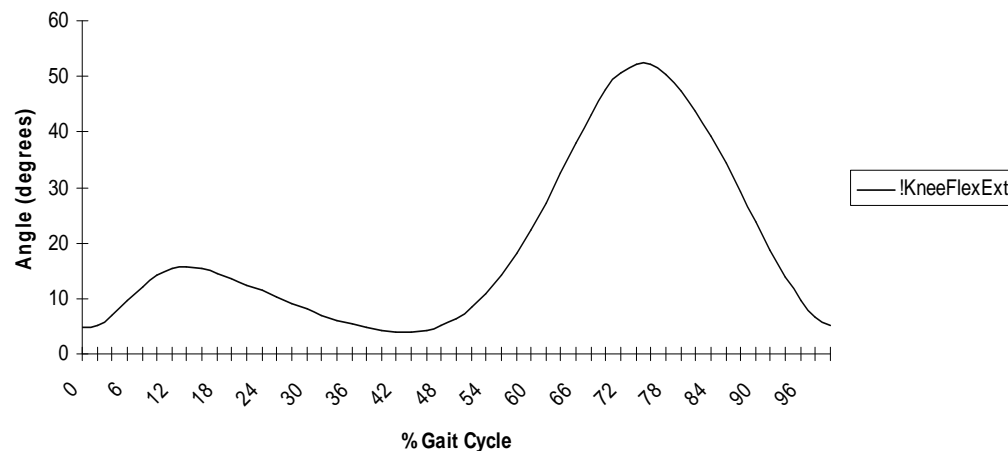
EFFECTS OF KAD MISPLACEMENT

One of the most common effects of KAD misplacement is the observation of **significant knee varus-valgus during swing**.

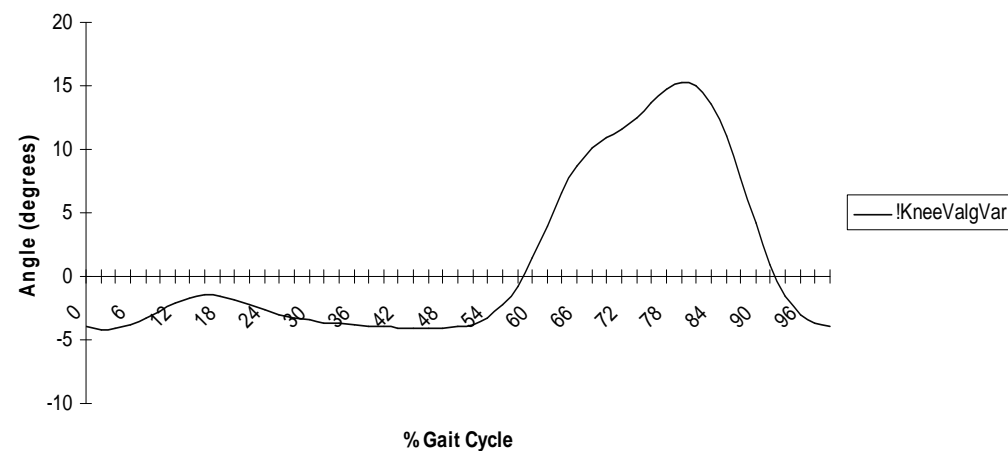
Furthermore this knee varus-valgus seems to be correlated with the knee flexion-extension curve (see figures below).

The knee varus-valgus curve should be almost flat during walking; if this does not happen there might have been a KAD misplacement that reflects in what is called '**cross-talk**': the motion on one anatomical plane (sagittal) is seen happening on another plane (frontal)

Knee Flex. / Ext.



Knee Valg. / Var.



PEOPLE'S EXPERIENCE AT OUR SERVICE

- i. The KADs were attached to both knees with the subject sitting on a plinth high enough from the floor to allow the legs to swing freely
- ii. The horizontal wands of the KADs were aligned parallel to the floor;
- iii. The subject was then asked to actively flex and extend each knee in turn, whilst an observer watched the wand indicating the flexion/extension axis of the KAD
- iv. The location of the KAD was adjusted until the point was found at which the wand showed minimum movement during knee flexion/extension

<http://www.univie.ac.at/cga/faq/reliability/>

THE ANKLE PLANTAR-FLEXION AXIS

When using KADs, Plug In Gait assumes that the **ankle plantar-flexion axis is parallel to the knee flexion axis if the Tibial Torsion measurement is set to 0.**

This may lead to a misplacement of the ankle joint center, that will be calculated to be directly medial to the ANK marker. If the ANK marker is placed on the lateral malleolus, the AJC position will be much posterior to the real AJC position.

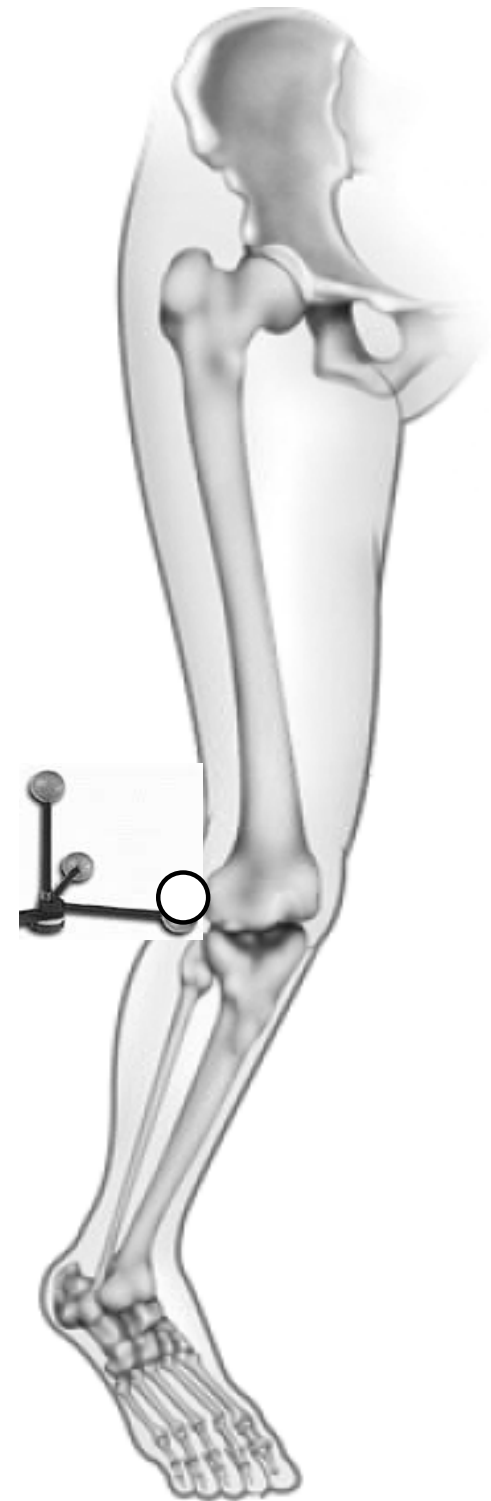
It is then very important to either enter the Tibial Torsion measurement manually or to have it calculated by PiG using the medial malleoli markers (MED).

KAD PROCESSING STEPS

STATIC PiG

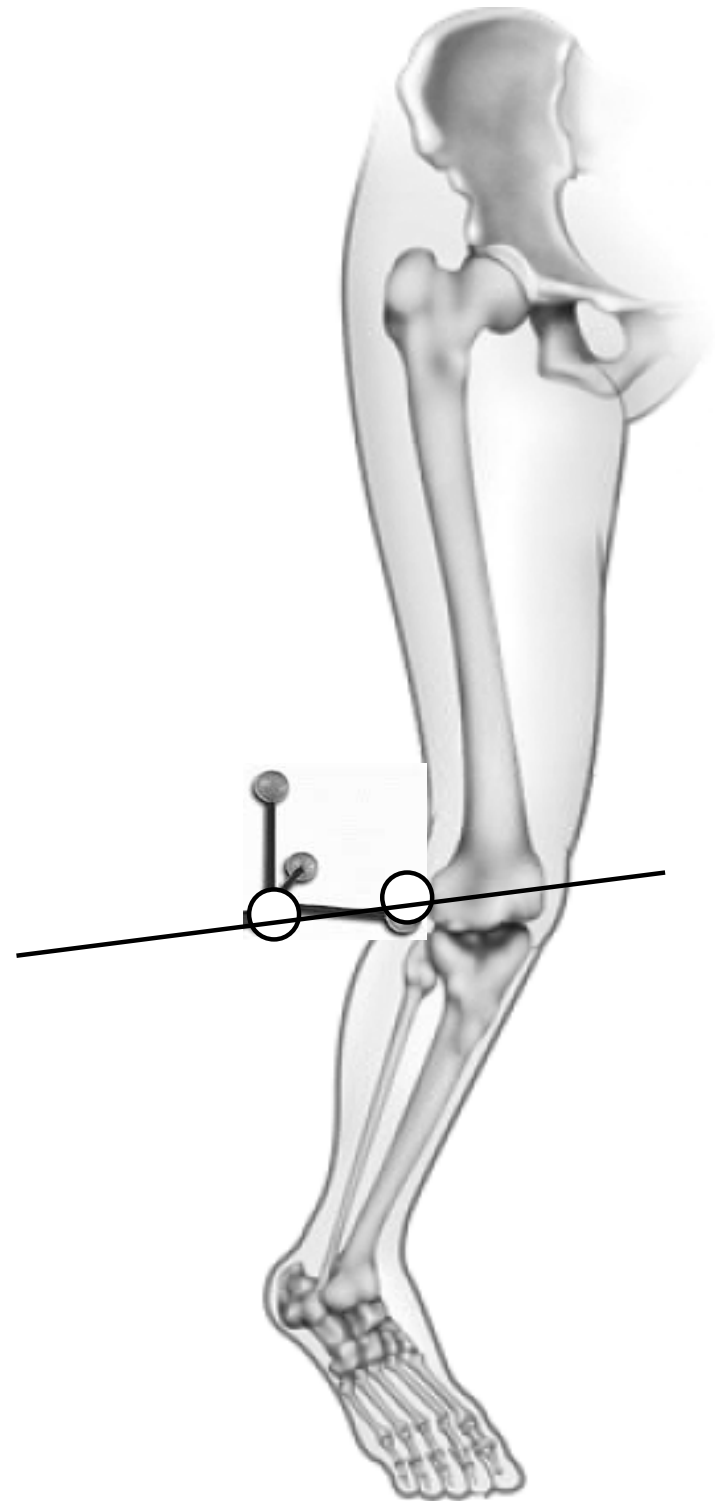
KAD PROCESSING STEPS

1. Virtual KNE marker creation



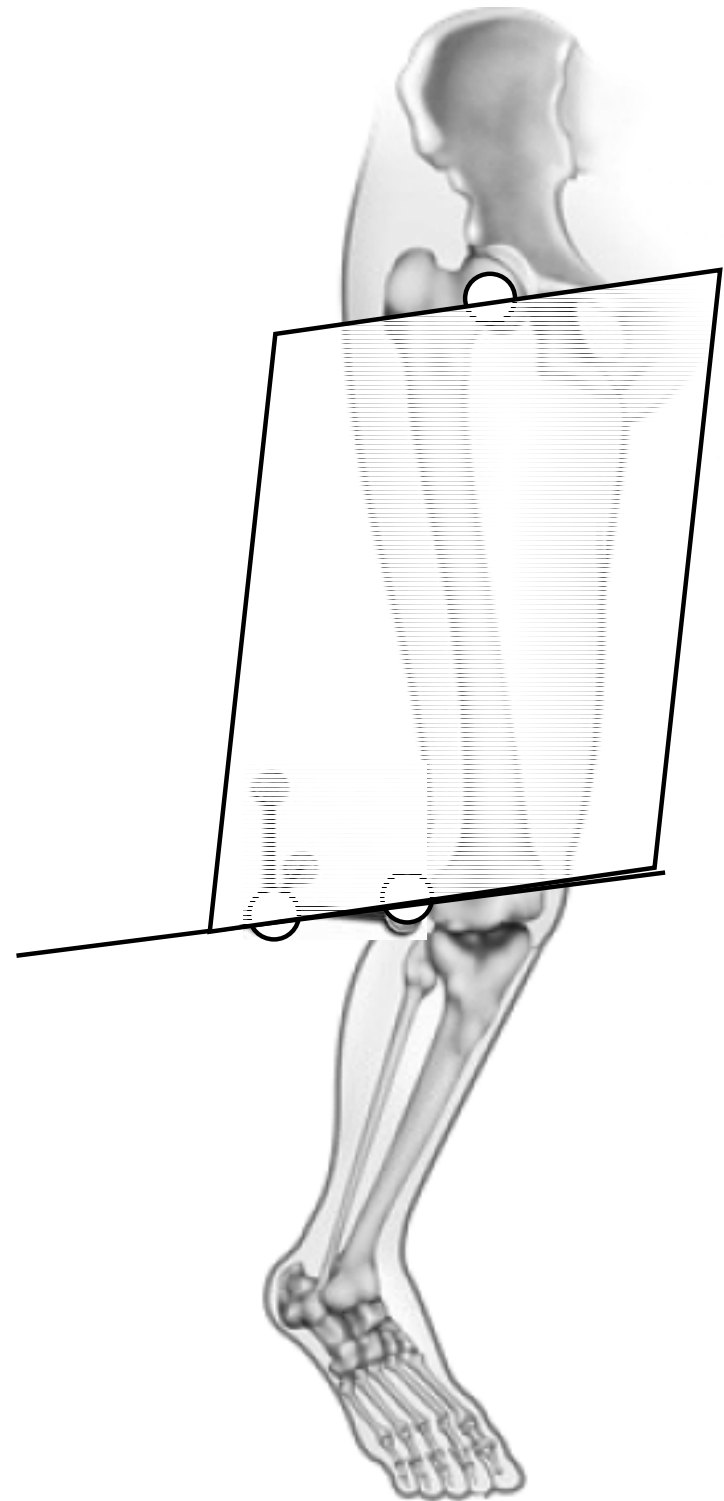
KAD PROCESSING STEPS

1. Virtual KNE marker creation
2. Knee flexion axis direction from KNE to KAX markers



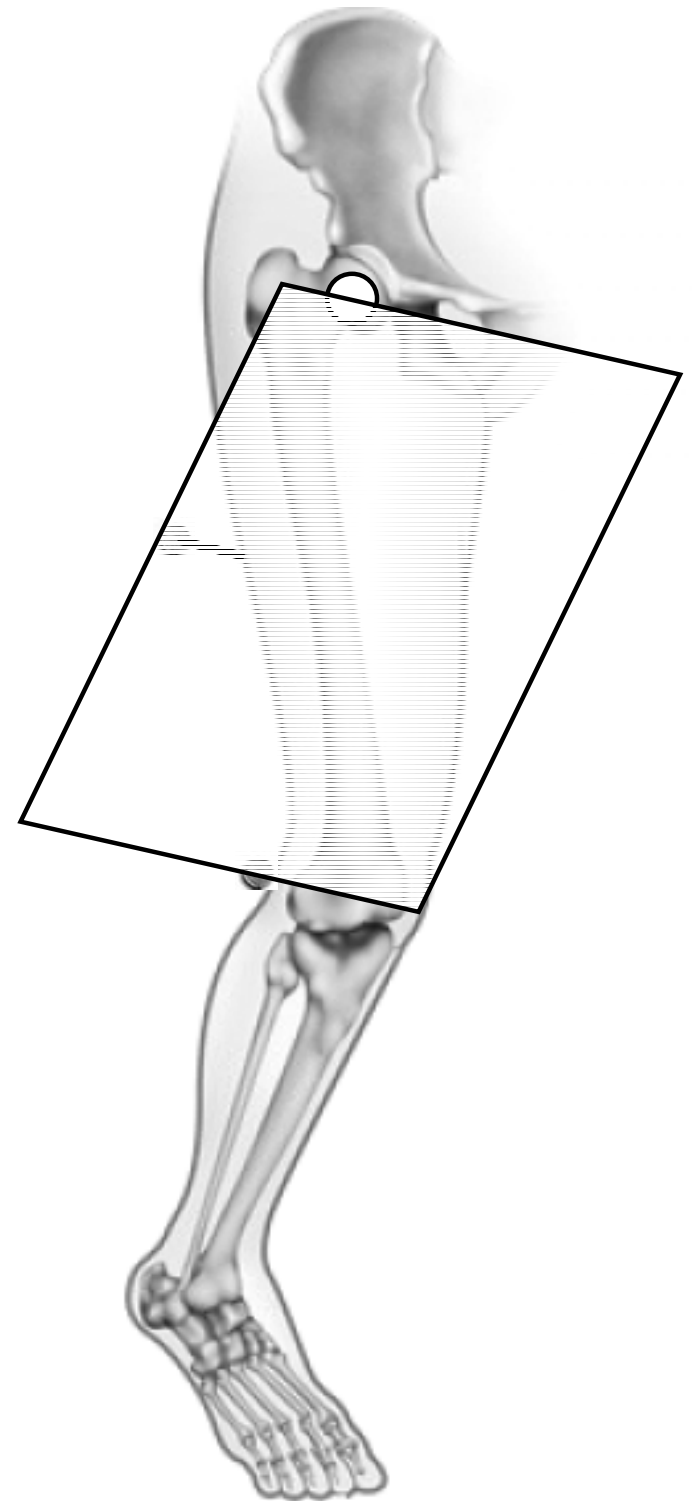
KAD PROCESSING STEPS

1. Virtual KNE marker creation
2. Knee flexion axis direction from KNE to KAX markers
3. Reference frontal plane defined using the knee flexion axis and the HJC



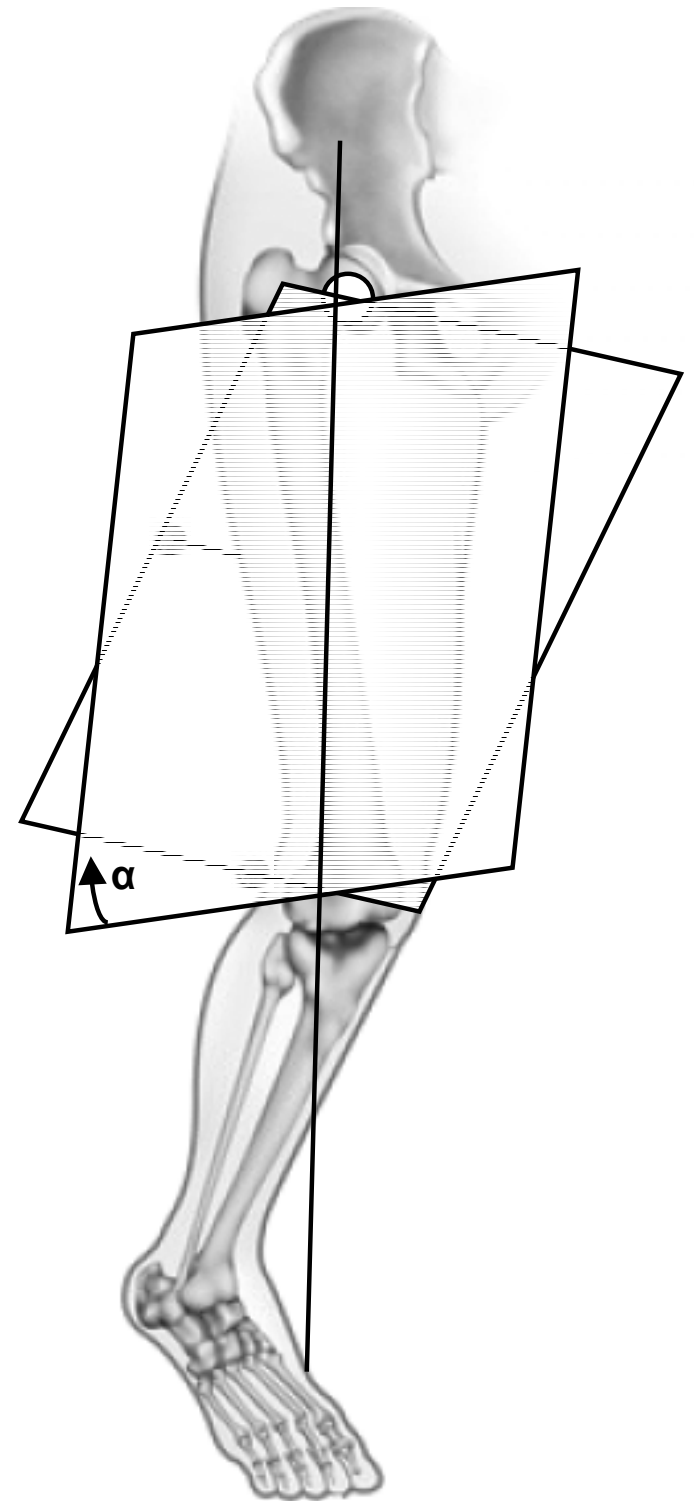
KAD PROCESSING STEPS

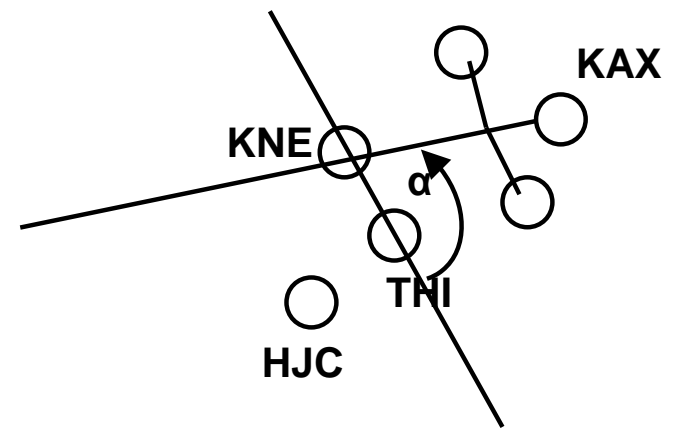
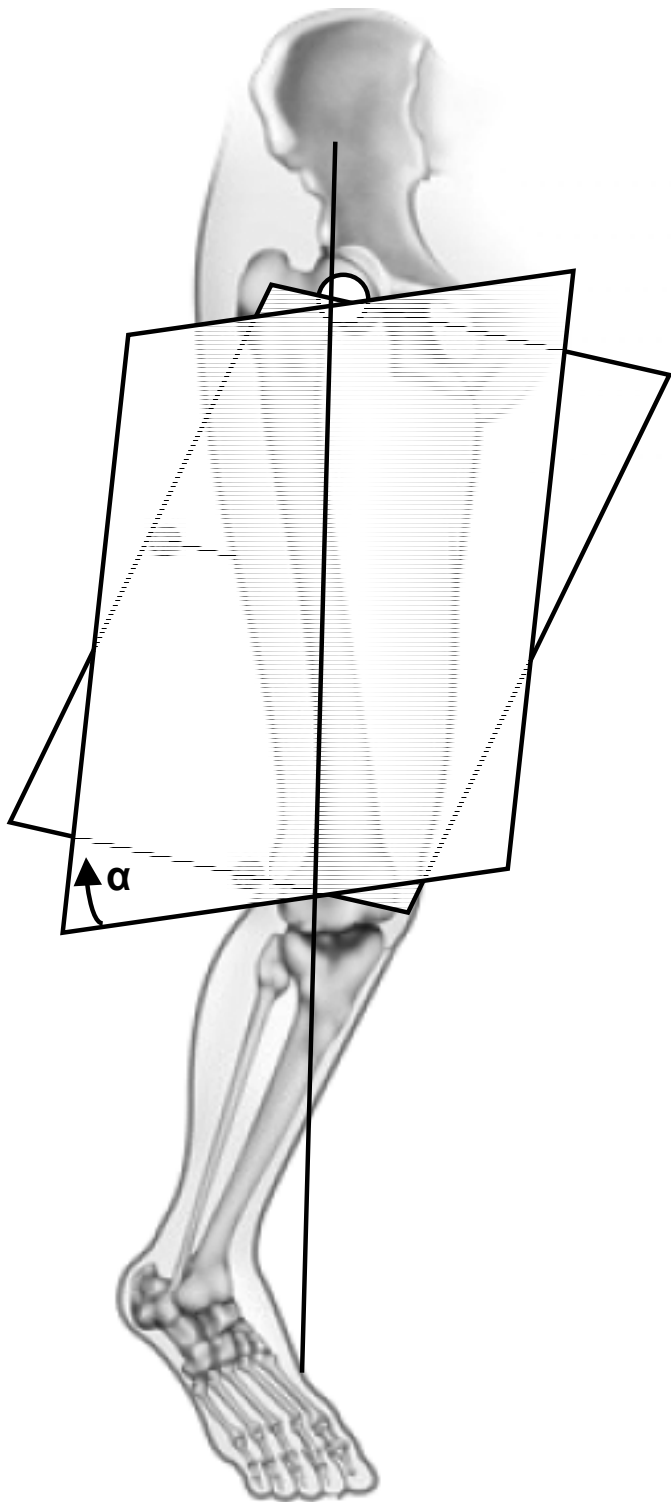
1. Virtual KNE marker creation
2. Knee flexion axis direction from KNE to KAX markers
3. Reference frontal plane defined using the knee flexion axis and the HJC
4. THI-based frontal plane defined



KAD PROCESSING STEPS

1. Virtual KNE marker creation
2. Knee flexion axis direction from KNE to KAX markers
3. Reference frontal plane defined using the knee flexion axis and the HJC
4. THI-based frontal plane defined
5. Thigh rotation offset calculation





α : Thigh Rotation Offset

ANKLE PLANTAR-FLEXION AXIS

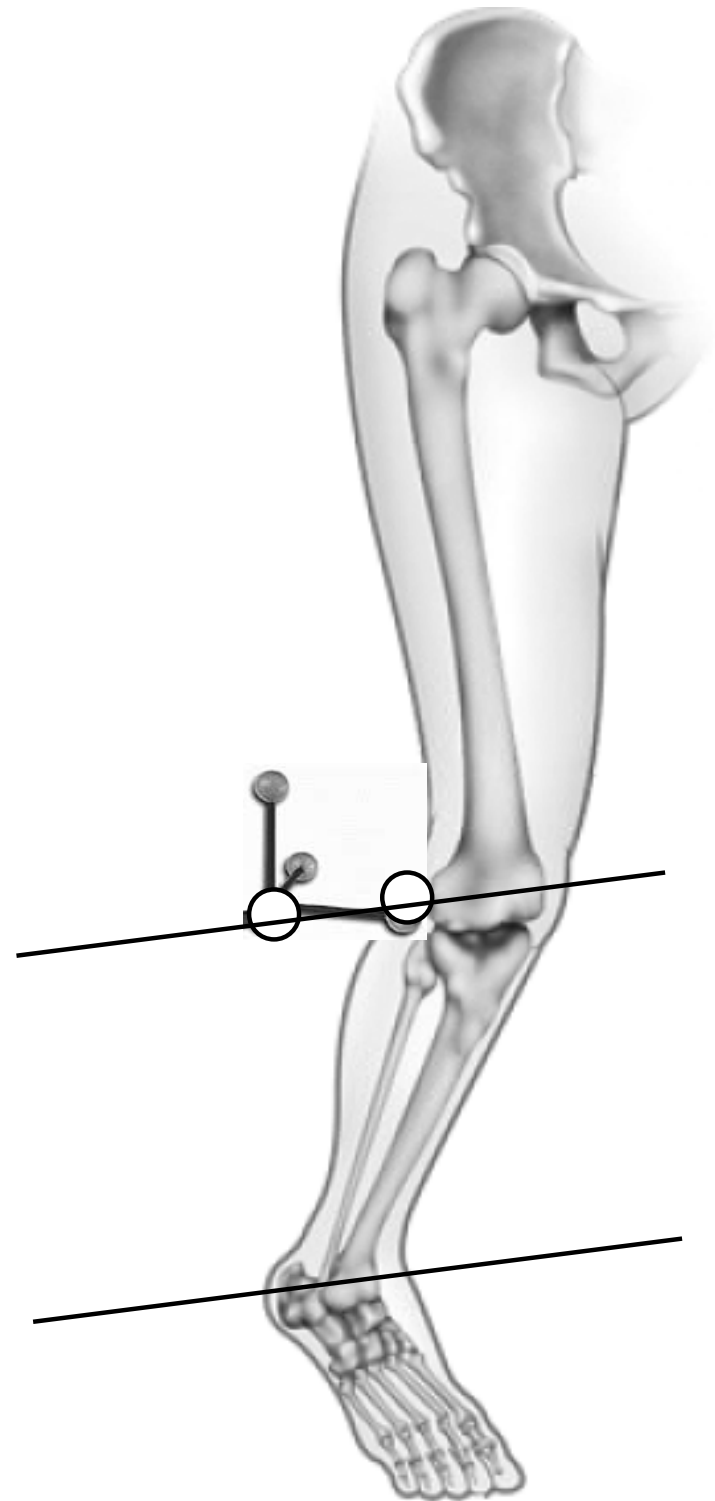
- When KADs are used, the Shank rotation offset gets calculated too, based on the orientation of the ankle plantar-flexion axis.
- The Shank rotation offset is the angle between the reference ankle plantar/flexion axis (based on the KAD, knee flexion axis and the Tibial Torsion measurement) and the plantar-flexion axis as defined using the TIB marker

ANKLE PLANTAR-FLEX AXIS

CASE #1

Tibial Torsion = 0

The Shank rotation offset is calculated based on the orientation of the ankle plantar-flexion axis being parallel to knee flex axis



ANKLE PLANTAR-FLEX AXIS

CASE #2

Tibial Torsion = α

The Shank rotation offset is calculated based on the orientation of the ankle plant-flex axis being rotated with respect to knee flex axis by Tibial Torsion degrees

