Objectives

Introduction
- Total Knee Replacements (TKR)
- Perth Protocol
- CATKR Vs JATKR
- Scan Technique

Measurements
- Mechanical Axis
- Femoral & Tibial Varus/Valgus
- Femoral Flexion
- Tibial Slope
- Femoral & Tibial Rotation
- Tubercle Offset

Workup
- Vitrea
A functioning TKR relies on accurate alignment with the mechanical and anatomical axis.

Incorrect alignment can lead to:
- Abnormal wear
- Loosening of components
- Patello-femoral problems

Alignment of TKR are conventionally performed by the use of intramedullary and/or extramedullary jigs.

There was debate over the reliability of the jig system therefore a computer assisted method was developed.
In the planning stages of this study we were faced with the challenge of deciding how to determine the quality of the alignments that resulted. Conventional radiographs, long leg films and CT scanograms were all discarded as inadequate. We therefore developed the ‘Perth CT Protocol’ as described. It provides an objective, sensitive, numerical technique; the results of which can undergo statistical analysis.

The ‘Perth CT Protocol’ provides the best means available so far to assess the adequacy of alignment of the components in knee replacement.
What is Perth Protocol?

- It is a CT scan to assist Orthopaedic Surgeons with the evaluation of certain angles and measurements on patients who have undergone or are soon to be undergoing Total Knee Replacements (TKR).
Total Knee Replacement

https://www.youtube.com/watch?v=Nmb5-e3cwBw
Scan Technique

- AP and Lateral Scanograms
- Keep leg of interest straight in standard position
- Bend other leg up and away from region of interest
- Scan from Acetabular Roof to Talar Dome
- Perform a routine knee scan
- Straighten image up in MPR and reconstruct 2.5mm slices
### Scan Technique

<table>
<thead>
<tr>
<th></th>
<th>Version 6 &amp; Earlier</th>
<th>Version 7</th>
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<tbody>
<tr>
<td><strong>kVp</strong></td>
<td>120 - 135</td>
<td>120 - 135</td>
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<tr>
<td><strong>mAs</strong></td>
<td>Sure Exp</td>
<td>Sure Exp</td>
</tr>
<tr>
<td><strong>Pitch</strong></td>
<td>Detail</td>
<td>Detail</td>
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<tr>
<td><strong>Rot Time</strong></td>
<td>0.5</td>
<td>0.5</td>
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<tr>
<td><strong>Scano Length</strong></td>
<td>999mm (if possible)</td>
<td>Any length below 2000mm</td>
</tr>
<tr>
<td><strong>SEMAR</strong></td>
<td>Off</td>
<td>On</td>
</tr>
<tr>
<td><strong>Slice Thickness</strong></td>
<td>1.0mm @ 0.8mm</td>
<td>1.0mm @ 0.8mm</td>
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<tr>
<td><strong>Recons</strong></td>
<td>2.5mm @ 2.5mm</td>
<td>2.5mm @ 2.5mm</td>
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</table>
What To Do With The Data
Add/Subtract
Add/Subtract
Measurements

- From Scanogram
  - Mechanical Axis (MA)
  - Anatomical Axis (AA)
  - Femoral Varus/Valgus
  - Tibial Varus/Valgus
  - Femoral Flexion (POST OP ONLY)
  - Tibial Slope

- From Axial Imaging
  - Femoral Rotation
  - Tibial Rotation
  - Femorotibital Mismatch (POST OP ONLY)
  - Tubercle Offset
Vertical Axis

- Is a vertical line that extends distally from the center of the pubic.

- This axis is used as a reference axis/line from which the other axes are determined.
Is a straight line passing through the centre of the Femoral Head to the centre of the Talar Dome
Mechanical Axis

- Can be subdivided in two
  - Femoral Mechanical Axis
    - centre of femoral head to centre knee
  - Tibia Mechanical Axis
    - centre plateau to centre of talus / ankle

- The overall alignment of the lower extremity and is usually slightly less than 180° in normal knees
Anatomical Axis

- AA of the femur is a line in the intramedullary canal bisecting the femur in half
- 5°–7° different to that of the MA
- For the Tibia it is a line in the intramedullary canal bisecting the tibia in half
- On AP evaluation, the mechanical and anatomic axes of the tibia commonly correspond exactly with one another.
The lateral angle between the AA of the femur and the tibia is called the femorotibial angle.

The average femorotibial angle is approximately 176° in men, and 174° in women.

The AA can deviate markedly depending on:
- femoral or tibial deformities
- the patient’s hip angle

Factors such as axial limb rotation and flexion deformity can dramatically affect the femorotibial angle.
Varus Vs Valgus

NORMAL

VARUS

KNOCK KNEES (VALGUS)
Femoral Varus/Valgus

- Measurement is made on the AP scanogram.
- The measurement is the angle between the MA and the tangential line running along both femoral condyles.
- Measure the smallest angle:
  - $90° - 83.6°$
  - $= 6.4°$ Femoral Valgus
This time the measurement is made from the angle of the MA and the tangential line running along the tibial plateau.

- Measure the smallest angle:
  - $90^\circ - 84.7^\circ$
  - $5.3^\circ$ Tibial Varus
Measurement is performed only in post op scans. Measured on the lateral Scanogram. Draw a line from the centre of the femoral head to the centre of the Knee. Draw a second line parallel to the posterior coronal cut on the distal femur.

Femoral Flexion

Cobb Angle: 0.6 degs
Tibial Slope

- Measured in the lateral plane
  - Draw a line across the tibial plate
  - Draw a second line down the tibial MA

- A backwards tibial slope is preferred.
Most current systems strive for 3-7 deg of posterior slope.
- bone in the anterior portion of the cut surface is weaker

If proximal tibia is cut perpendicular to long axis of tibia in sagittal plane, subsidence in the tibial component is more likely

Alignment is important as it affects the range of flexion within the knee and the tension in the PCL
Femoral Rotation

- Locate axial image with femoral epicondyles and most posterior condyles

- Draw a tangential line along the most posterior component of the condyles/implant

- Draw a second line between the lateral epicondyle and the notch below the medial epicondyle
Tibial Rotation

- Use the superimposed image of the proximal tibia and an axial image through the distal femur.

- Draw a line along the posterior condyles of the distal femur

- Draw the second line along the posterior margins of the tibia.
Femorotibial Mismatch

- Use the superimposed axial image of posterior femoral condyles and the axial image of the tibial prosthetic stem.
- Draw a tangential line along the posterior components of the femoral prosthesis.
- Draw a second tangential line along the posterior component of the tibial stem.
Tubercle Offset (TT-TG)

- Use the superimposed axial image of trochlear notch and axial image of tibial tubercle.

- Draw a tangential line along the posterior components of the femoral prosthesis.

- Draw a second line through the trochlear notch, at exactly 90.0 deg.

- Measure from the trochlear notch line to the anterior tip of the tibial tubercle.
CATKRs were significantly better aligned than the JATKRs in four of the seven parameters measured:
- femoral rotation,
- femoral flexion,
- tibial slope
- femorotibial matching

No JATKR produced a Tibial slop of 3°

CATKR which produce 3 at 3°
- 2 at 2
- 1 at 4°
To find the centre of the femoral head a FARO-arm which is a measuring robot was used by rigidly fixing 3 balls to the femoral shaft. The femur and attached marker balls where then scanned and digitally mapped.

Results found that there was a 2mm difference in the location of the centre of the femoral head when using the FARO-arm techniques which in turn found no significance difference to the measurement.

Intra-observer error for measurements is calculated to result in errors of <1°
References


Bolognesi M.P. & Clifford R. Wheeless' Textbook of Orthopaedics - *Total Knee Arthroplasty*,


Shannon R. *Total Knee Arthroplasty*,
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