Saturday 30th June 2012

Session 2: Knee Arthroplasty: Surgical techniques
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Should the mechanical axis be zero?

Speaker: Dr Jean-Alain Epinette
Should the mechanical axis be zero?
*What are we talking about?*

*Why a "neutral" mechanical alignment?*

*The future: Mechanical vs. Kinematic?
* What are we talking about?
* Why a "neutral" mechanical alignment?
* The future: mechanical vs. Kinematic?
What are we speaking about?

1- Definition

- **Coronal Alignment in TKRs**
  - Mechanical Axis: **HKA** angle
  - # Anatomical axis **FKA**
  - **FKA = α + β**

- **Does not take into account:**
  - Sagittal alignment
  - Rotational parameters

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What are we speaking about?

1- Definition

- **Linear displacement of the MA**
  - Easy to assess, and define…
  - Focuses on the weight bearing stresses on the knee
  - Does not take into account obliquity of the Joint Line
*Shorten films not convenient*

- Depend on femoral offset
- Variable depending on gender, anatomy, shaft fracture?

= definitely NOT to be used for assessing the mechanical axis of the knee …
What are we speaking about?

2- Means to Assess

* Long-leg standing films are the most convenient
  ▪ Beware of the positioning! (patellae upright, no flexion, ...)
  ▪ Full weight bearing or Unipodal stance?
  ▪ Hip implants/shaft fractures to be taken into account

= to be considered as the routine procedure, commonly performed everywhere.
What are we speaking about?

2- Means to Assess

* Computer tomography scans are the most powerful! ...

* An absolute need for 3D imaging and shape matching procedures

* however:
  - Take time prior to surgery
  - Cost more money to get the procedure performed and analyzed
  - Radiations for the patient? 😞

=not to be considered as a routine procedure
* What are we talking about?
* Why a "neutral" mechanical alignment?
* The future: mechanical vs. Kinematic?
Why a "neutral" mechanical alignment?

1- The History

* John N. Insall, 4 decades ago!... = A sound long-held tenet in TKRs

* MA at 0 degree +/- 3° = weight forces at middle of the Knee
* "Seems" logical upon biomechanical standpoints
* "Supposed" to help long lasting functional results & prevent from wear
Why a "neutral" mechanical alignment?

2- Is it logical???

“The mechanical axis of the limb is not a straight line”

A study based upon 180 "normal" limbs (90 individuals) analyzed on CT scans

- Only 4 limbs (2.2%) were aligned at 0°
- 57% in varus angulation (avg -2.8°) vs. 41% in valgus (avg 2.7°)
- Outliers: 12° varus – 16° valgus
"Is neutral mechanical alignment normal for all patients?"
The concept of constitutional varus.
Johan Bellemans & al.

250 asymptomatic adult volunteers between 20 and 27 years old in a cross-sectional study analyzed on full-leg standing digital radiographs

- 32% of men and 17% of women had constitutional varus knees with a natural mechanical alignment of 3° varus or more.
- Restoration of mechanical alignment to neutral in these cases (i.e. medial release) may not be desirable and would be unnatural for them.
2- Is it logical ???

"Is neutral mechanical alignment normal for all patients? The concept of constitutional varus."
Johan Bellemans & al.

- Average 1.3° varus
- Outliers from 8° varus to 5° valgus

In this "normal" patients Group
"Does a postoperative mechanical axis of $0 \pm 3^\circ$ result in better long-term survival of total knee arthroplasty implants?"

<table>
<thead>
<tr>
<th>Revision rate at 15 yrs</th>
<th>Aligned Group</th>
<th>Outlier Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>N total: 398 primary TKRs</td>
<td>N: 293 knees</td>
<td>N: 106 knees</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reason</th>
<th>Aligned Group</th>
<th>Outlier Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any reason</td>
<td>15.4%</td>
<td>13%</td>
</tr>
<tr>
<td>Aseptic loosening, mechanical failure, wear, or patellar problems</td>
<td>9.2%</td>
<td>7.5%</td>
</tr>
<tr>
<td>Aseptic loosening, mechanical failure or wear</td>
<td>5.8%</td>
<td>3.8%</td>
</tr>
</tbody>
</table>

Obviously NOT !...
Why a "neutral" mechanical alignment?

3- Is it efficient???

"From the United Kingdom and Canada that reviewed more than 10,000 patients at 1 year following mechanically aligned TKA.

- 1-5 patients are not satisfied because of continued pain and poor function in activities of daily living.

- The use of computer assisted surgery has improved the mechanical alignment, but has NOT improved the clinical outcome."

From: *Insall & Scott Surgery of the Knee* - Chapter 121 - *Kinematic Alignment in Total Knee Arthroplasty*
Why a "neutral" mechanical alignment?

3- Is it efficient???

A personal series of 871 primary TKRs

- Do the aligned knees perform better?
- What happens to outliers?
Why a "neutral" mechanical alignment?

- 871 TKRs, Conventional Instruments,
- Non navigated surgery, **NO SYSTEMATIC RELEASE**
- Personal continuous non selective series

Average: 0.34° valgus
(-24° valgus to 8° varus)

92.6 % aligned
7.4% outliers
Why a "neutral" mechanical alignment?

Cross correlation: Mechanical Axis and Knee Score

Degrees of freedom: 386
Student-Fischer test (t): 10.419

p < 0.001 : very highly significant difference (++)
Why a "neutral" mechanical alignment?

**Cross correlation: Mechanical Axis and Function Score**

Degrees of freedom: 386  
Student-Fischer test (t): -0.786

P-value: 0.4323757 (NS)  
p > 0.05 : no significant difference (NS)
Why a "neutral" mechanical alignment?

Cross correlation: HHS Function Score
Aligned vs. Outliers

- **Group 1: Aligned**
  - Mean value: **87.03**
  - Median value: 90
  - (30 -> 100) - SD 14.86

- **Group 2: Outliers**
  - Mean value: **87.69**
  - Median value: 90
  - (50 -> 100) – SD 13.81

Student-Fischer test (t): 0.264
P-value: 0.79192 (NS)

p > 0.05: no significant difference (NS)
Why a "neutral" mechanical alignment?

Cumulative Survival Analysis (retrieval any cause)
Fup @ 15 yrs: Aligned vs. Outliers

- **Group 1: Aligned** N: 604
  - 93.4% (90.6 - 96.2)
- **Group 2: Outliers** N: 267
  - 92.6% (86.7 - 98.8)

Log-rank = 0.14
P-value: 0.708 (NS)
p > 0.05: no significant difference (NS)
For RETRIEVAL ANY CAUSE
Why a "neutral" mechanical alignment?

**Cumulative Survival Analysis (Implant failures)**

Fup @ 15 yrs : Aligned vs. Outliers

- **Group 1**: Aligned N: 604
  - 96.9% (94.9-99)

- **Group 2**: Outliers N: 267
  - 95.1% (89.9-1)

Log-rank = 0.063
P-value: 0.802 (NS)
p > 0.05 : no significant difference (NS)
For IMPLANT FAILURES as endpoint
Should the mechanical axis be zero?

* What are we talking about?
* Why a "neutral" mechanical alignment?
* The future: Mechanical vs. Kinematic?
The future: Mechanical vs. Kinematic?

1- The dilemma

A mechanical axis at zero IS NOT an ultimate goal at surgery

Mechanical Alignment is:

- Not so logical according to the distribution of high rate of outliers in "normal" patients
- Not significantly better than outliers in terms of functional results and survival rates.

SO, the dilemma is a difficult choice between:

- Opt for a Theoretical Mechanical Alignment?
- (Try to) Restaure the initial patient's anatomy?
2- Kinematic Alignment : Principles

History and Definition of Kinematic Alignment

- "Kinematics refers to the relative relationship of the femur, patella, and tibia at any angle of flexion, without force applied to the knee.
- "The joint surface, menisci, and ligament structures determine the normal kinematic relationship among the femur, patella, and tibia.

➤ "The center of the femoral head and center of the ankle, which are used by conventional and computer-assisted instruments to align a TKA mechanically, have no bearing on the kinematics of the knee"
The principle for kinematically is to align the anterior-posterior axis of the tibial component perpendicular to the transverse axis in the femur and femoral component.
2- Kinematic Alignment: Principles

Theoretical concerns of Kinematic Alignment

- **YES!** Respect of the Joint envelope: Studies have shown that release of the collateral ligaments is not needed with Kinematic Alignment, although often necessary in Mechanical Alignment.

- **BUT!** However, during the process of 3D kinematic alignment there are many potential sources of error in the process, (quality of the MRI image, generation of the arthritic and normal knee models, shape fitting of the components, manufacturing the patient-specific cutting guides, and the surgeon using the guides in the operating room).

*Appealing BUT a bit complex?***
The future: Mechanical vs. Kinematic

3- Kinematic Alignment: what's up

Kinematically Versus Mechanically Aligned Total Knee Arthroplasty

H. Gene Dossett, MD, MBA; George J. Swartz, MD; Nicolette A. Estrada, RN, PhD; George W. LeFevre, MD; Bertram G. Kwasman, MD

→ Kinematic alignment on the left vs. Mechanical Alignment on the right hand side...

- The obliquity of the joint line in the kinematically aligned total knee arthroplasty replicates the joint line in the normal limb which was associated with better clinical outcome scores and better flexion than the mechanically aligned total knee arthroplasty.
3- Kinematic Alignment: what's up

Kinematic alignment (patient-specific guides) vs. Mechanical alignment (conventional instruments) in 41 kinematically aligned and 41 mechanically aligned patients.

At 6 months postoperatively, the WOMAC score was 16 points better ($P < .000$), Oxford Score was 7 points better ($P < 0.001$), total Knee Society Score was 25 points better ($P < 0.001$), and flexion was 5.0° greater ($P < 0.043$) in the kinematically aligned group than in the mechanically aligned group.

Thanks to more anatomic alignment of the implant, better flexion and better clinical outcome scores were reported in the kinematically aligned group.
*Take Home Message?

Should the mechanical axis be zero?
A mechanical axis at $0^\circ \pm 3$:  
- Is **NOT** "natural" in 75% of knees 
- Does **NOT** lead to better outcome or survival

Appealing methods based upon Patient's Anatomy?  
- Better respect of the Joint envelope (no release) and Joint Line  
- Complex/expensive procedures, but better functional results???
A personal advice?

- Mechanical Alignment?
  *Important guideline, no more*
- Release of collateral ligaments?
  *Try to respect the Anatomy*
- Kinematic alignment?
  *Just wait and see ...*

Thanks for your kind attention