A comparison of kinematic and mechanical alignment with regards to bony resection, soft tissue release, and deformity correction in total knee replacement

Presented By
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Declaration of Interest

I declare that in the past three years, one or more authors:

- held shares in: 360 Knee Systems, Trium, Optimised Ortho
- received royalties from: Nil
- done consulting work for: Arthrex, Optimised Ortho, 360 Knee Systems, Global Orthopaedics, Omni
- given paid presentations for: Arthrex, Global Orthopaedics, MatOrtho
- received institutional support from: Smith & Nephew, Surgical Specialties, Global Orthopaedics, Zimmer, Arthrex, Friends of the Mater (equipment purchase)

Signed: Brett Fritsch
Goal of TKR

A TKR which is well balanced in the coronal and sagittal plane, and achieves full extension

Alignment philosophies

Mechanical alignment

- Coronal resections of femur and tibia are made perpendicular to the mechanical axis
- Rotation set against anatomical landmarks
  - TEA/PCA/WL
- Balance is achieved through soft tissue releases where needed
- Alignment drives resection depth
- Goal is a “dead straight knee”

Kinematic alignment

- Resections are made equal to the thickness of the implant accounting for any cartilage or bone loss
  - Distal (coronal) and posterior (rotation)
- Resection depth drives alignment
- Balance is achieved with bony cuts rather than soft tissue release
- Goal is an individualised component position to reproduce the pre-diseased joint line and soft tissue envelope
Study Details

Aim
To compare the efficacy and efficiency of MA and KA philosophies in TKA on achieving full extension and well balanced knee

Methods
Retrospective review of prospectively collected data
• 210 consecutive TKA’s
• Single surgeon
• Single implant (Apex CR; Global)
• Computer navigated (OmniNav)
• Robotic assisted femoral cuts (OmniBot)

Data collected

Patient Characteristics
• Age
• Gender
• Side of surgery

Intra-operative data
• Component positioning
  • Alignment – coronal and sagittal
  • Resection depths
  • Need for any recuts
• Soft-tissue release
• Compartmental change
• Components used

Post-operative alignment
• Coronal alignment
• Sagittal alignment
• Laxity curves
## Patient Characteristics

<table>
<thead>
<tr>
<th></th>
<th>MA</th>
<th>KA</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>120</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>67.9 (10.7)</td>
<td>67.0 (12.9)</td>
<td>0.58</td>
</tr>
<tr>
<td>Male</td>
<td>37.5%</td>
<td>38.9%</td>
<td>0.67</td>
</tr>
<tr>
<td>Left side</td>
<td>52.5%</td>
<td>62.2%</td>
<td>0.16</td>
</tr>
</tbody>
</table>

No Difference

## Pre-operative Alignment Data

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>120</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Pre Op Alignment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronal Deformity (Absolute)</td>
<td>5.3 (3.3)</td>
<td>5.2 (3.2)</td>
<td>0.82</td>
</tr>
<tr>
<td>Coronal (Varus +ve, Valgus -ve)</td>
<td>4.3 (-4 to 20)</td>
<td>4.8 (-7 to 20)</td>
<td>0.77</td>
</tr>
<tr>
<td>Pre-Op Within 3 Degrees</td>
<td>30.8%</td>
<td>31.1%</td>
<td>0.97</td>
</tr>
<tr>
<td>Max Extension</td>
<td>7.3 (1 – 25)</td>
<td>8.1 (1 – 21)</td>
<td>0.1</td>
</tr>
<tr>
<td>Pre-Op More than 15 degrees of FFD</td>
<td>5.8%</td>
<td>8.9%</td>
<td>0.41</td>
</tr>
</tbody>
</table>

No Difference
## Post-operative Component Resection and Alignment

**Femoral Cuts**

<table>
<thead>
<tr>
<th></th>
<th>MA</th>
<th>KA</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distal Resection (mm)*</td>
<td>9.95 (7-19)</td>
<td>8.6 (6.5-13.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Varus/Valgus (angle)*</td>
<td>-0.03 (-2.5 - 1)</td>
<td>-2.5 (-6 - 1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Flexion</td>
<td>1.6 (-1 - 5)</td>
<td>1.2 (-1.5 - 4)</td>
<td>0.052</td>
</tr>
<tr>
<td>Distal Femoral Recut</td>
<td>1.7% (n=2)</td>
<td>0%</td>
<td>0.51</td>
</tr>
</tbody>
</table>

**Tibial Cuts**

<table>
<thead>
<tr>
<th></th>
<th>MA</th>
<th>KA</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Resection (mm)*</td>
<td>9.1 (4 – 11.5)</td>
<td>8.1 (4.5 - 13)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Varus/Valgus (angle)*</td>
<td>0.3 (-1 – 3.5)</td>
<td>2.3 (-1.5 - 6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Posterior Slope*</td>
<td>3.3 (-6 - 3)</td>
<td>2.8 (-6 – 7))</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**Statistically significant difference**

KA – More valgus femoral alignment, less distal femoral resection

KA – More varus tibial alignment, less tibial resection, less slope

- **Sum of max Tibial + max Distal Femoral Resection**
  - MA: 18.9 (2.7)
  - KA: 16.7 (2.1)
  - p-value: <0.0001

2.2mm (12%) less resection in KA
Post-op HKA

<table>
<thead>
<tr>
<th>Post Op Alignment</th>
<th>MA</th>
<th>KA</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronal Deformity (Absolute)</td>
<td>0.8 (0.9)</td>
<td>1.5 (1.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Coronal</td>
<td>0.4 (-3 to 5)</td>
<td>1.1 (-3 to 5)</td>
<td>0.0007</td>
</tr>
<tr>
<td>Post-Op Within 3 Degrees</td>
<td>99.2%</td>
<td>95.6%</td>
<td>0.16</td>
</tr>
</tbody>
</table>

KA knees:
- Overall greater varus alignment
- NO difference in percentage within 3 degrees of neutral
# Correction of Fixed Flexion Deformity

<table>
<thead>
<tr>
<th></th>
<th>MA</th>
<th>KA</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-op Max Extension (FFD)</td>
<td>7.3° (1-25°)</td>
<td>8.1° (1-21°)</td>
<td>0.1</td>
</tr>
<tr>
<td>Postoperative Max Extension</td>
<td>-0.1° (-4 to 4°)</td>
<td>-0.1° (-5 to 3°)</td>
<td>0.99</td>
</tr>
</tbody>
</table>

No difference in correction of FFD

# Soft Tissue Releases

<table>
<thead>
<tr>
<th></th>
<th>MA</th>
<th>KA</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Release</td>
<td>72.5%</td>
<td>3.3%</td>
<td>&lt;0.000 1</td>
</tr>
<tr>
<td>Medial Release*</td>
<td>35.8%</td>
<td>3.3%</td>
<td>&lt;0.000 1</td>
</tr>
<tr>
<td>Posterior Release*</td>
<td>18.3%</td>
<td>3.3%</td>
<td>0.002</td>
</tr>
<tr>
<td>Lateral Release*</td>
<td>5.8%</td>
<td>0.0%</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Significant difference in rate of soft tissue release
### Changes in Laxity

<table>
<thead>
<tr>
<th></th>
<th>Pre-operative Laxity (Degrees, SD in brackets)</th>
<th>Post-operative Laxity (Degrees, SD in brackets)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alignment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 degrees*</td>
<td>2.8 (2.3)</td>
<td>1.8 (1.6)</td>
<td>0.01</td>
</tr>
<tr>
<td>30 degrees*</td>
<td>7.4 (2.6)</td>
<td>4.6 (2.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>90 degrees*</td>
<td>4.5 (2.7)</td>
<td>2.7 (1.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Kinematic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alignment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 degrees</td>
<td>3.0 (1.6)</td>
<td>2.3 (2.0)</td>
<td>0.06</td>
</tr>
<tr>
<td>30 degrees*</td>
<td>7.9 (2.2)</td>
<td>5.3 (2.4)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>90 degrees</td>
<td>4.98 (2.3)</td>
<td>4.7 (3.2)</td>
<td>0.49</td>
</tr>
</tbody>
</table>

There is a significant change in the pre-op to post-op laxity curves in MA knees at all measured flexion angles, and less so in KA knees.
Discussion

Kinematic alignment will achieve the goal of a balanced knee with full extension with:

- Less disturbance to native tissues
  - Less Bony resection
    - Avg 2.2mm (12%) less
  - Less Soft tissue release
    - 3.3% Vs 72.5%
  - Less change in ligament laxity
- Different alignment characteristics
  - Femur in valgus
    - 2.5° valgus
  - Tibia in Varus
    - 2.3° varus
  - Overall alignment in slight varus
    - 1.1° varus
- No difference in proportion of patients within 3° of neutral mechanical alignment
Potential Benefits and Problems of KA philosophy

Potential Benefits

• Minimising soft tissue releases:
  o Less soft tissue trauma
    o Pain ? Swelling ? ROM ?
  o Less disruption of proprioceptors
    o Kinematics ? Function ? PROM ?
  o More objective, reproducible procedure
    o Soft tissue releases are hard to quantify
    o Teaching
• Less bone resection
  o Bone stock preservation
  o Excessive bony resection → joint line shift → postop pain and increased component wear (Fornalski et. al, 2012)
• More natural knee kinematics
  o Improved Knee function

Potential Problems

• Longevity
  o Less data on long term outcomes for non-mechanical alignment

• Outliers
  o At what point does “natural” alignment become “pathological” alignment?

• Greater potential for “way off” cuts
  o Delivery tool dependent?
Limitations

• Methodology – Retrospective

• Difficulty standardising soft tissue laxity testing using varus/valgus stress
  • Minimised by using a single surgeon with the same aim of final “feel” of balance in all cases, but difficult to quantify

• Soft tissue releases not quantified

• Data not correlated to PROMs
Conclusion

KA allows for the same correction of coronal and sagittal deformity as MA with:

- less bone resection
- less soft tissue release
- less change in laxity profile

References: