Knee kinematics after TKA depends on preoperative kinematics

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Disclosure

Consultant for a company
MicroPort Orthopedics

Medical/Orthopaedic publications editorial/governing board
Sports Health Journal
Journal of Orthopaedic Science

Board member/committee appointments for a society
Asia Pacific Knee Society
Japanese Orthopedic Association
Japanese Society for Replacement Arthroplasty
Japanese Society for Joint Disease
Clinical results of TKA are inferior to THA

- Comparison of total hip and knee arthroplasty cohorts and short-term outcomes from a single-center joint registry.
  
  *Choi JK, J Arthroplasty. 2012*

- Comparing patient outcomes after THA and TKA: is there a difference?
  
  *Bourne RB, Clin Orthop Relat Res. 2010*

- Patient-reported outcomes after total hip and knee arthroplasty: comparison of midterm results
  
  *Wylde V, J Arthroplasty. 2009*
Does TKA restore normal knee function?

Noble et. al. CORR. 2005.
How does the Knee Move?
Normal kinematics

- **Rotation** (-5 to 90° Flexion)
  - Screw home movement
  - Lateral Fem Condyle roll back earlier
  - Medial fem Condyle moves a little during 0-100°

- **Medial Pivot**

- **Translation** 90 to 155° Flexion
  - After 90° of flex: Translation
  - After 120°: Translate much
Normal Knee Kinematics
Knee Kinematics after TKA

Various reports suggest unequable kinematics after TKA

- **No pivot**
  - *Dennis 2003*
  - *Komistek 2001*
  - *Banks 2004*

- **Lateral pivot**
  - *Banks 1997*
  - *Dennis 2004*

- **Medial pivot**
  - *Miyazaki 2011*
  - *Victor 2009*
There were different kinematics among same implant.

Although there were differences among various implants, kinematics after TKA were almost 50% in medial pivot and 50% in non-medial pivot.

Dennis, CORR, 2003
Clinical Results and Kinematics in TKA

- Some patients complain of unsatisfactory function after TKA
- This dissatisfaction may be explained partly by abnormal kinematics following TKA
Clinical Results Correlates with Kinematics

- Kinematic patterns after conventional TKA impact the clinical results. Specifically, normal knee kinematics improved clinical results including knee ROM and patient satisfaction in conventional TKA prosthesis.
Medial pivot reduces PF pressure

- Medial-pivot kinematics reduced PF contact stress
- Restoring normal tibio-femoral kinematics possibly results in a decreased risk of PF problems such as anterior knee pain using conventional TKA prosthesis
Which factors affects kinematics after TKA

Research question

- Preoperative kinematics pattern affects postoperative kinematics?
- Preoperative knee deformity affects postoperative kinematics?
Materials and Methods

- 2010.7-2012.9, primary TKA
- Medial OA (K–L grade 4)
- 39 knees (Male 3 / Female 36)
- Ave. age 72
- Subvastus approach
- Modified gap technique
- Genesis II (Smith & Nephew; Conventional implant)
- Navigation TKA
Kinematics evaluation

Navigation data translated to bone coordinate system

- Transepicondylar axis as flexion axis
- Measure bilateral epicondylar coordinate axis every 10 degrees
- Reflect on bilateral epicondylar coordinate axis at tibial axial face
Divided into two groups

- The node of the epicondylar axis of each 10 deg. measurement was defined as the center of rotation.
- Calculated the average center of rotation between 0 and 90 deg.
- Patients with an average center of rotation between medial were defined as belonging to the medial pivot group
- Other kinematic patterns were defined as belonging to the non-medial pivot group

*Banks, J Arthroplasty, 2004*
Materials and Methods

**Group M (medial pivot)**

- Measured each kinematics pattern twice: just after open the joint *(preoperative knee kinematics)*, and after implantation and capsule closure *(postoperative knee kinematics)*

**Group N (lateral pivot, parallel motion, paradoxical motion)**
Measurements of knee kinematics during TKA surgery using navigation system correlate with postoperative kinematics

Majima T, et. al. JBJS-B, 2012

- Compared the knee kinematics during surgery using navigation system and that 3 months after surgery using 2D/3D Registration Technique
Fluoroscopy
CAD Model-based 2D/3D Registration

Yamazaki T et al., IEEE, 2004
Watanabe T, et al., JOR, 2004

Projected Image + CAD model + Camera Parameter

= 6DOF Pose Estimation
Measurements

- Knee kinematic pattern
- Knee flexion and extension angle before and after surgery
- X-ray evaluation
  - Mechanical axis
  - Mechanical FTA
  - Implant coronal alignment
  - Posterior condylar angle (PCA)
Preoperative knee kinematics significantly correlated with postoperative knee kinematics (P < 0.01).

Results suggest that preoperative knee kinematics robustly impacted upon postoperative knee kinematics in most cases.

<table>
<thead>
<tr>
<th></th>
<th>Group M</th>
<th>Group N</th>
<th>Total</th>
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<tbody>
<tr>
<td><strong>Pre-op</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Group M</td>
<td>16</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>Group N</td>
<td>2</td>
<td>16</td>
<td>18</td>
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<tr>
<td>Total</td>
<td>18</td>
<td>21</td>
<td>39</td>
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</table>

Chi-square test  P<0.01
## Patient demographics and preoperative factor

<table>
<thead>
<tr>
<th></th>
<th>M group</th>
<th>N group</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>age (mean ± SD)</td>
<td>70±8.1</td>
<td>74±6.8</td>
<td>0.28</td>
</tr>
<tr>
<td>side</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>right / left</td>
<td>8/10</td>
<td>12/9</td>
<td>0.65</td>
</tr>
<tr>
<td>sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male / female</td>
<td>2/16</td>
<td>1/20</td>
<td>0.42</td>
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<tr>
<td>BMI</td>
<td>27±4.7</td>
<td>26±4.1</td>
<td>0.60</td>
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<tr>
<td>HKA</td>
<td>-7.9±4.6</td>
<td>-11.7±6.3</td>
<td>0.04</td>
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<tr>
<td>Preoperative mechanical FTA</td>
<td>180.0±3.9</td>
<td>184.7±6.4</td>
<td>0.03</td>
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<tr>
<td>Preoperative knee extension angle</td>
<td>-6.2±6.5</td>
<td>6.4±5.9</td>
<td>0.90</td>
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<tr>
<td>Preoperative knee flexion angle</td>
<td>123.5±13.8</td>
<td>117.2±10.8</td>
<td>0.15</td>
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BMI ; body mass index  
FTA ; Lateral femoro-tibial angle
## Radiological evaluation after TKA

<table>
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<th></th>
<th>M group</th>
<th>N group</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative mechanical axis(%)</td>
<td>50.8 ± 9.8</td>
<td>50.7 ± 11.3</td>
<td>0.99</td>
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<tr>
<td>Postoperative mechanical FTA</td>
<td>180.0 ± 2.4</td>
<td>180.2 ± 2.6</td>
<td>0.79</td>
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<tr>
<td>Femoral coronal alignment</td>
<td>91.1 ± 2.0</td>
<td>90.2 ± 1.9</td>
<td>0.20</td>
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<td>Tibial coronal alignment</td>
<td>88.9 ± 1.7</td>
<td>89.5 ± 0.5</td>
<td>0.22</td>
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<td>PCA</td>
<td>0.3 ± 3.6</td>
<td>2.1 ± 2.9</td>
<td>0.12</td>
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<tr>
<td>Postoperative knee extension angle</td>
<td>8.2 ± 6.4</td>
<td>0.3 ± 1.2</td>
<td>0.63</td>
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<tr>
<td>Postoperative knee flexion angle</td>
<td>121.6 ± 10.5</td>
<td>120.3 ± 9.4</td>
<td>0.70</td>
</tr>
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</table>

PCA; posterior condylar angle
Summery of the research

- We compared the relationship among preoperative knee deformity, knee kinematics and that after fixed bearing TKA
- Preoperative knee kinematics robustly impacted upon postoperative knee kinematics in TKA
- Severe varus knee deformity may be a risk factor for abnormal knee kinematics after fixed bearing TKA
To Improve Performance/Satisfaction

- CAS: Mechanical alignment
  - Component is rectangular to mechanical axis
  - Equalize soft tissue balance
- Kinematic alignment
  - Flex/ext axis is cylindrical axis
  - Pre-OA alignment
- Medial pivot TKA
  - Implant guided normal knee kinematics
Our strategy to achieve normal knee kinematics in TKA

- For the patients with less varus deformity, \(<10\) degrees, conventional prosthesis may be good enough to achieve normal knee motion.

- For the patients with varus knee more than \(10\) degrees, implant which was designed for medial pivot motion may reproduce normal knee kinematics.
Future Study

- We need to clear the issue whether the change of preoperative kinematics (non-medial pivot) to postoperative medial pivot motion affect patient feeling including patient satisfaction and clinical results or not.
Thank you for your attention!!