Three Dimensional Comparison of Tibial Torsion Changes Following Lateral Closed Wedge- or Medial Open Wedge High Tibial Osteotomy

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We have no potential conflicts of interest to declare.
Introduction

- Lateral closed wedge high tibial osteotomy (CWHTO) and medial open wedge high tibial osteotomy (OWHTO) are established surgical treatments for the medial compartment in osteoarthritis (OA) cases.

- A previous meta-analysis also reported no significant difference between the clinical outcomes of these two procedures over a short term follow-up. (Smith T et al. Knee 2011)

- Recently, several studies have also suggested that unexpected axial tibial rotation occurs after OWHTO.

- Few studies to date have reported on changes in rotation after CWHTO.

- A rotation change resulting from a HTO procedure may affect the patello-femoral joint. (Gaasbeek R et al. KSSTA 2007)
The purpose of our current study was to evaluate whether rotational changes occur in the tibia after CWHTO and OWHTO using 3D measurements.

We also assessed the effects of both procedures on the patello-femoral joint.
Thirty knees of 25 patients who underwent HTO were enrolled.

Fifteen knees of 14 patients that underwent CWHTO and 15 knees of 11 patients that received OWHTO were match-paired.

Computed tomography (CT) scans were taken before and at three weeks after surgery.

Torsional changes in the tibia were assessed by measuring the tibial torsion angle (TTA) with three dimensional measurement.
Materials and Methods

- Hybrid CWHTO (Takeuchi R, Arthro Tech, 2014) was performed on all knees in the CWHTO cohort with fixation of Lateral HTO plate (Olympus Terumo Biomaterials, Tokyo, Japan).

- In the OWHTO cohort, all knees underwent biplane medial OWHTO (Takeuchi R, Arthroscopy, 2009). Osferion 60 (Olympus Terumo Biomaterials, Tokyo, Japan) was inserted into the osteotomy site, and TomoFix (Synthes, Bettlach, Switzerland) was used.

<table>
<thead>
<tr>
<th></th>
<th>Hybrid CWHTO</th>
<th>OWHTO</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of knee</td>
<td>15</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Preoperative age (years)</td>
<td>64.9 ± 6.6</td>
<td>65.5 ± 8.2</td>
<td>0.826</td>
</tr>
<tr>
<td>Gender (male / female)</td>
<td>5 / 10</td>
<td>3 / 12</td>
<td>0.407</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>25.6 ± 3.6</td>
<td>24.3 ± 3.0</td>
<td>0.312</td>
</tr>
<tr>
<td>Preoperative FTA (°)</td>
<td>-5.6 ± 3.5</td>
<td>-4.8 ± 2.9</td>
<td>0.554</td>
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</tbody>
</table>
CT scans were taken at the level of each hip joint, knee joint and ankle joint at 2-mm intervals both preoperatively and postoperatively. A 3D image of the lower extremity was reconstructed using the 3D template program (Kyocera Medical, Osaka, Japan).

The Z-axis of the tibia (proximal-distal) was defined as the tibial mechanical axis that connected the knee and ankle centers. The ankle center was defined as the geometric center of the talar dome (center of the trochlea of the talus). The plane normal to the Z-axis at the center of the knee was defined as the XY plane. The X-axis (anterior-posterior) was defined as the perpendicular bisector of the medial and lateral condylar centers projected onto the XY plane.
Materials and Methods

- The TTA was defined as the angle between the proximal posterior tibial axis (PTA) and the transmalleolar axis (TMA).
- To evaluate the effects of tibial rotation on the patello-femoral joint, the tibial tuberosity-trochlear groove distance (TT-TG) was also measured.
- Paired t tests were performed to compare pre- and postoperative variables of TTA and TT-TG in each surgical group. A student t test was used to compare the rotational change at the tibia (ΔTTA) and the extent of the changes to the TT-TG (ΔTT-TG) between the CWHTO and OWHTO patients.
Results

- There was significant internal rotation of the distal fragment of the tibia after Hybrid CWHTO (p < 0.001).
- No significant change of rotation was observed in the OWHTO group (p > 0.05).
- The ΔTTA between the two procedures was significant (p < 0.001).

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<tbody>
<tr>
<td>Pre TTA</td>
<td>18.5 ± 4.6°</td>
<td>20.2 ± 4.1°</td>
<td></td>
</tr>
<tr>
<td>Post TTA</td>
<td>14.9 ± 4.4°</td>
<td>19.7 ± 4.3°</td>
<td></td>
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<tr>
<td>ΔTTA</td>
<td>-3.6 ± 2.6° (-8.9 to -0.2)</td>
<td>-0.5 ± 2.5° (-5.2 to 3.9)</td>
<td>0.002</td>
</tr>
<tr>
<td>P value</td>
<td>&lt; 0.001</td>
<td>&gt; 0.05</td>
<td></td>
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</table>
Results

- The mean value for the TT-TG decreased significantly after CWHTO ($p < 0.001$) and OWHTO ($p = 0.005$).
- There were significant differences between the two procedures in terms of the ΔTT-TG ($p < 0.001$).

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<th>OWHTO</th>
<th>$P$ value</th>
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<tbody>
<tr>
<td><strong>Pre TTA</strong></td>
<td>16.5 ± 2.9 mm</td>
<td>12.4 ± 2.3 mm</td>
<td></td>
</tr>
<tr>
<td><strong>Post TTA</strong></td>
<td>9.2 ± 3.4 mm</td>
<td>10.1 ± 4.7 mm</td>
<td></td>
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<tr>
<td><strong>ΔTTA</strong></td>
<td>-7.3 ± 3.0 mm (-12.8 to -1.0)</td>
<td>-2.3 ± 2.7 mm (-6.5 to 1.6)</td>
<td>$0.001$</td>
</tr>
<tr>
<td><strong>$P$ value</strong></td>
<td>&lt; 0.001</td>
<td>0.005</td>
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Several previous studies have reported a rotational change at the tibia after OWHTO.

These previous studies did not find any significant postoperative changes and reported a wide range of rotational variance from external rotation to internal rotation.

Our current study is the first to evaluate the rotational change at the tibia following CWHTO using 3D measurements and to compare the effects of Hybrid CWHTO and OWHTO on the patello-femoral alignment.

(Jacobi et al. KSSTA 2015)
(Jang KM et al. J Arthropasty 2016)
(Lee BH et al. Knee 2017)
In our study, the distal fragment of the tibia rotated internally and the TT-TG decreased significantly in Hybrid CWHTO patients.

Gaasbeek et al. reported previously that HTO led to significant changes in patellar tracking, and that these effects were more profound after OWHTO than after CWHTO. Furthermore, these authors found that CWHTO caused elevation and proximalisation of the tibial tuberosity.

The distal fragment is advanced proximally and anteriorly by the thickness of the flange (thickness of the tibial tuberosity) in Hybrid CWHTO.

As a result of internal rotation found in this study and proximal elevation of the tibial tuberosity, a hybrid CWHTO may provide greater benefit to the patello-femoral joint. Further studies will be needed to evaluate the arthroscopic and clinical outcomes of hybrid CWHTO on the patello-femoral joint, in direct comparison with the OWHTO.
Conclusion

- The distal fragment of the tibia rotates internally to a significantly different extent after Hybrid CWHTO than after OWHTO.

- Hybrid CWHTO may have larger effects to the patello-femoral joint than OWHTO.