SEVERE KNEE OSTEOARTHRITIS PATIENTS SHOW MORE FEMORAL CORONAL BOWING THAN MODERATE KNEE OSTEOARTHRITIS PATIENTS - A STUDY USING 3DCT

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Disclosure
I have no financial conflicts to disclose.
Introduction

Conventionally, femoral bowing has been evaluated using two dimensional radiography. We have reported a novel method to evaluate accurate 3D femoral bowing using computed tomography (CT) [1]. There is still limited information about 3D femoral bowing of the patients with knee osteoarthritis (OA). Typically, 2D femoral bowing has been evaluated to perform total knee arthroplasty (TKA) for OA knee. However, the 2D images often involves measurement error due to malposition of the legs. Some reports suggested that the femoral bowing affected the likelihood of bone cut error in TKA, so precise measurement of the femoral bowing is required for precise TKA.

The methods of three dimensional precise analysis of the femoral bowing → OARSI 2017
Purpose of this study was to evaluate the difference between the 2D radiographic images and 3D CT in examination of the femoral coronal bowing to indicate superiority of 3D femoral bowing analysis of knee OA patients.
Material and Methods

Femoral CT images and full-leg anterior-posterior radiographic images of 74 patients (15 male, 59 female, mean age 64.4) with knee OA

Kellgren-Lawrence grade
0 : 30   1 : 5   2 : 8   3 : 13   4 : 18

Devide these patients into two groups
K-L 0-2 (n=43) : Moderate OA group
K-L 3-4 (n=31) : Severe OA group
Material and Methods

The xyz-coordinate system was introduced in the 3D femoral bone CAD-model, which was reconstructed based on CT-data with the imaging software (Mimics 14.0, Materialize ®).

The trans epicondyle axis (TEA) based coordinate system was defined with three bony landmarks, the medial/lateral epicondyles and the center of the femoral head. (Fig.1)

Fig.1 The definition of the TEA-based femoral coordinate system is based on three key bony landmarks
Material and Methods

The cross-sectional contours of the femoral canal (cancellous/cortical border) were extracted along the Z axis. The range of the cross-sectional slicing was set between the lesser trochanter and the distal end of the epiphysis. For each extracted cross-sectional contour, a least-square fitted ellipse was calculated. A least-square line was fitted to the centers of the cross-sectional ellipses. The proximal and distal anatomical axes were calculated with the proximal and distal half of the ellipse data, respectively. The angle between these two axes was measured and defined as total bowing of the femur. The directions of lateral/anterior bowing were defined as the plus directions. The proximal and distal axes were made to project to these YZ planes of the coordinate system, and the angles of coronal bowing were examined. Similarly, two axes were made to project to the XZ planes, and the angles of sagittal bowing were examined. (Fig.2B)

Fig.2
Definition of coordinate system and proximal/distal bone axis on the femur (Fig.2A)
Measurement of the coronal and sagittal bowing (Fig.2B)
Material and Methods

The femoral bone on the full-leg radiograph films was divided into two parts by the center line of the femoral canal. The proximal and distal axes were set grossly, and the angle between these axes was measured and the results were compared as coronal bowing and sagittal bowing on reconstructed 3D imaging. (Fig.3)
The average 2D coronal bowing was $0.6 \pm 3.2$ ($-6.6 - 8.1$) degrees, and the absolute value of the difference between the 2D and 3D coronal bowing was shown in Table 1. The averages of 2D coronal, 3D coronal, and 3D sagittal bowing for all patients, moderate OA group, and severe OA group are also shown in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>All patients (Degrees, n=74)</th>
<th>Moderate OA (Degrees, n=43)</th>
<th>Severe OA (Degrees, n=31)</th>
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</thead>
<tbody>
<tr>
<td>2D coronal bowing</td>
<td>$0.6 \pm 3.2$ ($-6.6 - 8.1$)</td>
<td>$-0.6 \pm 2.7$ ($-6.6 - 6.3$)</td>
<td>$2.0 \pm 3.1$ ($-3.5 - 8.1$)</td>
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<tr>
<td>3D coronal bowing</td>
<td>$-0.0 \pm 2.3$ ($-4.2 - 6.8$)</td>
<td>$-0.7 \pm 2.0$ ($-4.2 - 5.6$)</td>
<td>$0.9 \pm 2.2$ ($-2.6 - 6.8$)</td>
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<tr>
<td>3D sagittal bowing</td>
<td>$8.6 \pm 2.0$ ($4.9 - 14.4$)</td>
<td>$8.2 \pm 1.8$ ($4.9 - 12.6$)</td>
<td>$9.1 \pm 2.2$ ($6.1 - 14.4$)</td>
</tr>
<tr>
<td>Difference between 2D and 3D coronal</td>
<td>$0.6 \pm 3.2$ ($0.0 - 6.4$)</td>
<td>$1.4 \pm 1.3$ ($0.0 - 5.2$)</td>
<td>$2.2 \pm 1.7$ ($0.1 - 6.4$)</td>
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Table 1
Comparison of average bowing between moderate OA group and severe OA group
Result

Statistically, the severe OA group showed greater coronal bowing compared to the moderate OA group. The correlation coefficients between 2D coronal bowing and 3D coronal bowing, and between 2D coronal bowing and 3D sagittal bowing, were 0.70 (p<0.01) and 0.36 (p<0.01) in all OA knees, 0.72 (p<0.01) and 0.17 (p=0.28) in moderate OA knees, and 0.57 (p<0.01) and 0.42 (p=0.018) in severe OA knees (Fig.4).

Fig.4 Scatter plot showing 2D vs. 3D coronal bowing (A: moderate OA group; B: severe OA group) and 2D coronal bowing vs. 3D sagittal bowing (C: moderate OA group; D: severe OA group). Differences between 2D and 3D coronal bowing were remarkable in severe knee OA group (B).
Severe OA had greater coronal bowing compared to the moderate OA. The difference in femoral coronal bowing between 2D radiography and 3D CT was average 1.7 degrees, and can be as much as 6.4 degrees in OA knees. (Table.1) And more, in severe OA group, the correlation coefficients between 2D coronal and 3D coronal was low and 2D coronal and 3D sagittal was high compared with moderate OA group. (Fig.4) This phenomenon seemed to be led by the malposition of the legs under radiography, especially in severe OA group. Our data showed that 2D femoral bowing analysis has limited accuracy in severe knee OA and would lead to patient outliers in TKA (Fig.4D). Thus, for precise TKA, we recommend preoperative planning and analysis of femoral bowing using 3D CT.
Conclusion

2D femoral bowing analysis was limited accuracy, especially in severe knee OA.

For precise TKA, we recommend preoperative planning and analysis of femoral bowing using 3D CT.