Clinical application of CT-based navigation system for hip resurfacing arthroplasty

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Introduction:

Hip resurfacing is reevaluated by its resistibility for dislocation and durability for wear. However, malpositioning of the femoral component may result in femoral neck fracture which is one of the typical complications of this procedure. In order to avoid the malpositioning, image-free navigation system was used and reported its good accuracy. But there was few literature about computer tomography (CT)-based navigation for clinical use. We introduce our application of CT-based navigation system of the conventional total hip arthroplasty for hip resurfacing.

Materials and Methods:

Twenty hips (10 females and 10 males) were included in this study (navigation (+)). Average age at operations was 47 years old (range 21 to 59). Average height, weight and body mass index were 164cm (149 to 186), 63kg (44 to 90) and 23kg/m² (18 to 28), respectively. Diagnosis was osteoarthritis in 13 hips and osteonecrosis in 7 hips.

Preoperative planning was performed with our original 3D-templating system. Alignment of the femoral component was planned to be center of the femoral neck but slightly valgus. Fine correction of the alignment was added so as not to make any notch on the femoral neck.

Operation was performed with posterolateral approach. After preparation of the femur, a femoral tracker of the navigation was fixed on the greater trochanter. Thirty registration points were taken on the femur and surface matching was performed. After the accuracy of the surface matching was seemed to be acceptable by touching the femoral neck and bony landmarks with navigated pointer, a guidewire was ready to be inserted. The neck axis of the conventional stem of the computer aided design was utilized as a guide. The entry point and direction of the guidewire were shown on the screen (Fig1). The position of the guidewire was finally checked by the conventional jig which was supplied by the manufacturer so as not to make any notch on the femoral neck.

As a control group (navigation (-)), 5 hip resurfacings (2 females and 3 males) that were adjacentely performed without femoral navigation were used. Their average age at operations was 46years old (range 20 to 55). Average height, weight and body mass index were 162cm (153 to 168), 64kg (61 to 68) and 24kg/m² (22 to 29), respectively. Diagnosis was osteoarthritis in 2 hips and osteonecrosis in 3 hips. In their operations, position of the guidewire was ascertained by fluoroscope and the jig intraoperatively.

As for radiographic evaluation, original neck anteversion (oANT) and neck-shaft angle (oNSA) were measured on preoperative CT. Alignment of femoral implant was measured on CT which was taken two week after surgery. Postoperative anteversion (pANT) and stem-shaft angle (pSSA) of femoral component were compared between plan and postoperative CT in the navigation (+) group. Deviations of them from oANT and oNSA were compared between two groups. Statistically, deviation of pANT from oANT and deviation of pSSA from oNSA were compared between two groups by Student t-test.

Results:

In the navigation(+) group, mean values of oANT, oNSA, planned stem anteversion, planned stem-shaft angle, pANT and pSSA were 25, 139, 25, 146, 26 and 149 degrees, respectively (Table.1). The deviation of postoperative planning from planned one was 1±1 (-17 to 28) degrees in anteversion and 2±4 (-6 to 9) degrees in stem-shaft angle. The deviation of pANT from oANT was 1±1 (-17 to 28) degrees and that of pSSA from oNSA was 9±6 (-1 to 19) degrees.

In the control group, oANT, oNSA, pANT and pSSA were 25, 139, 27 and 151 degrees, respectively (Table.1). The deviation of pANT from oANT was 2±1 (-18 to 13) degrees and that of pSSA from oNSA was 17±4 (12 to 21) degrees.

Between two groups, the deviation of pANT from oANT was not statistically different (F=0.05, p=0.89). On the other hand, the deviation of pSSA from oNSA of the navigation (-) group was significantly larger than the navigation (+) group (F=1.25, p<0.01) (Table.1). It suggested that femoral component tended to be implanted in significantly valgus position without navigation.

Discussion and conclusion:

There were many literatures that reported more accurate implantation with imageless navigation than conventional jigs. [1, 2] However, some researchers mentioned about the limit of them, especially when it was used for hips with abnormal anatomy. [3, 4]

In our study, deformity of the femoral head was found in 40% (osteoarthritis in 2 and osteonecrosis in 6 hips) of the navigation (+) group and in 20% (osteonecrosis in 1 hip) of the navigation (-) group. However, in the navigation (+) group, the deviation of pSSA from oNSA was less than in the navigation (-) group. This result implied that the navigation could prevent from the excessive valgus implantation that might cause a femoral notch.

In conclusion, hip resurfacing with the CT-based navigation was practicable and had the advantage to implant the femoral component without any care for the abnormal anatomy (i.e. secondary osteoarthritis, Perthes’s disease or the collapse of the head in osteonecrosis).

Figure 1: Screen shot of the intraoperative navigation. The neck axis of the conventional stem was utilized as a guide. With the navigated pointer, the operator could find the entry point (red circle) and adjust the direction of the guide according to the lines (green orbit).

Table 1: Radiographic parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>navigation(+)</th>
<th>navigation(-)</th>
<th>p-value</th>
</tr>
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<tbody>
<tr>
<td>original anteversion (oANT)</td>
<td>25±17 (12 to 50)</td>
<td>25±17 (12 to 50)</td>
<td></td>
</tr>
<tr>
<td>planned anteversion (pANT)</td>
<td>26±19 (2 to 74)</td>
<td>27±13 (17 to 49)</td>
<td>0.89</td>
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<td>deviation (pANT-oANT)</td>
<td>1±11 (-17 to 28)</td>
<td>2±12 (-18 to 13)</td>
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<tr>
<td>original neck-shaft angle (oNSA)</td>
<td>139±9 (126 to 161)</td>
<td>134±7 (124 to 145)</td>
<td></td>
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<tr>
<td>planned stem-shaft angle</td>
<td>146±7 (139 to 170)</td>
<td>151±8 (140 to 159)</td>
<td></td>
</tr>
<tr>
<td>deviation (pSSA-oNSA)</td>
<td>9±6 (-1 to 19)</td>
<td>17±4 (12 to 23)</td>
<td>&lt;0.01</td>
</tr>
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All values are in degree. (mean±SD, (range))

References