Surgical interventions for osteoarthritis of the hip in the young adult: the role of intertrochanteric osteotomies
Haverkamp, D.

Citation for published version (APA):
Chapter 4

Can the long term outcome of a varus intertrochanteric osteotomy be predicted on an Abduction correction view?

D. Haverkamp
P.P. Besselaar
M. Maas
L. Blankevoort
R.K. Marti
In the treatment of young patients with mild osteoarthritic changes of the hip secondary to acetabular dysplasia and coxa valga two main types of surgical interventions exist in the field of joint preserving therapy, being femoral and acetabular osteotomies. If the main deformity is on the acetabular side it seems clear that this side should be corrected, the same applies to the femoral side. However in many hips pathologic changes are present at both sides in which the acetabular dysplasia is only minimal. There is no objective tool to decide which treatment option should be preferred in these hips. The only available tool in deciding whether an intertrochanteric osteotomy could be rewarding is the abduction correction X-ray. This study investigates whether measurements derived from this functional X-ray can predict the long term functional outcome of the osteotomy.

Twenty-one hips in 18 patients who underwent a varus osteotomy were analyzed after 20.2 years (range 16-28). This long term outcome was correlated to objective measurements from the preoperative weightbearing X-ray (CCD, Sharp angle, CE angle, AHI, AIA and FCA) and the objective measurements from the abduction view (CE angle, AHI and FCA, including a newly introduced angle (FCA).

The results indicate that apart from the age of the patient and the severity of osteoarthritis none of the objective measurements from the abduction correction view correlate significantly with the long term outcome of the varus intertrochanteric osteotomy in valgus hips.
Several treatment options exist for relatively young patients with a beginning osteoarthritis (OA) of the hip secondary to acetabular dysplasia and/or coxa valga (antetorta), including total hip arthroplasty (THA). However, in these selected young patients, joint preserving therapy should be preferred.\textsuperscript{2,9,15,17}

Pathological changes are present on both the femoral and acetabular side in most of these hips and therefore both sides can be corrected in an attempt to normalize the hip joint. In those hips where the main problem is a severe coxa valga and where the dysplasia is only mild or absent, an intertrochanteric osteotomy is the most logical surgical intervention. An acetabular realigning osteotomy is the preferred option if the acetabular dysplasia is too severe. To make the decision as to whether to correct the femoral side or the acetabular side is clear in these extreme cases. However in a large group of patients both interventions can be justified, and both show good to excellent results in young patients with an early onset OA.\textsuperscript{2,9,15,17}

Unfortunately, no objective tool exists to judge whether the correction should be performed on the femoral side or acetabular side in these selected patients. The only available tool to help decide whether an intertrochanteric osteotomy is feasible is an abduction correction view on which the effect of the osteotomy was mimicked.\textsuperscript{11} If the containment was judged to be insufficient on this correction X-ray it could be expected that varisation of the femur alone would not be sufficient to treat the hip deformity. In these patients an acetabular realigning osteotomy was more likely to produce better results. This decision whether the abduction view favours an intertrochanteric osteotomy was based on clinical experience and not on objective measurements. No objective tools were identified to support this decision, and even in current practice it is merely based on assumptions made by expert orthopaedic surgeons.

Many authors have described the need for abduction correction X-rays in the pre-operative planning for varus intertrochanteric osteotomies. However, to the best of our knowledge, none of them have ever quantified the minimum amount of containment that is required to expect good to excellent results. Such an objective measurement could be of immense value in current clinical practice. It could assist in differentiating which hips with coxa valga and acetabular dysplasia can be successfully treated by a varus intertrochanteric osteotomy alone, or in which a more demanding acetabular realigning osteotomy should be preferred.

The aim of this study is to investigate whether objective measurements taken from the abduction view can predict the long term outcome of a varus intertrochanteric osteotomy. The approach is to correlate existing measurements and one new measurement derived from the abduction correction X-rays with the long term follow up for these patients.
The abduction correction views of 21 hips in 18 patients for whom an average 20.2 year follow up (range 16-28) was available were reviewed retrospectively to decide whether this long term outcome could have been predicted. To achieve this aim clinical follow up was correlated to objective measurements from the preoperative abduction views.

All patients had a varus (derotation) intertrochanteric osteotomy between 1974 and 1987 performed by the senior author (R.K.M.) for an OA secondary to acetabular dysplasia or acetabular dysplasia and coxa valga (antetorta). Only patients with an OA grade 0-2 (Kellgren and Lawrence) were included in this analysis, all others were excluded. A full clinical follow up was available for all of these patients as they are reviewed in our outpatient clinic on either an annual or biannual basis. The osteotomy was performed at an average age of 46.3 years (range 25-59). Sixteen patients (91%) were female.

The correction view should be made preferably in the calculated amount of abduction reflecting the amount of varisation which will be performed during the osteotomy. While the leg is positioned in abduction the knee should be kept in a neutral position. Special attention should be paid to the rotation of the pelvis as its position should be comparable to that on the weightbearing X-ray. The decision to perform the osteotomy was made on this correction view and was based on the judged improvement of containment. Abduction correction views are difficult to make, and were not always made in the presence of the orthopaedic surgeons. Therefore we examined these X-rays for presence of rotation of the femur and pelvis by measuring: the lesser trochanter/femur ratio, the height differences of the ischial tuberosities and height and width of the obturator foramen.

The preoperative weightbearing pelvic X-ray, the abduction view, the first postoperative weightbearing AP pelvic X-ray and a weightbearing AP pelvic X-ray at maximum follow up were used for radiological measurements. For patients who had a THA, a second osteotomy or additional acetabular realigning osteotomy the X-ray taken shortly before this second operation was used for maximum follow up. In all X-rays the CCD, CE-angle, Sharp angle, Acetabular Index Angle (AIA) and Acetabular Head Index (AHI) were measured. Preoperatively and at maximum follow up the grade of arthritic changes in the hip joint was scored according to Kellgren and Lawrence. Three authors (DH, PPB & RKM) carried out these measurements independently. Interobserver agreements were determined for these measurements.

Survival analysis consisted of the time elapsed before an eventual total hip arthroplasty, a re-osteotomy or an additional acetabular realigning osteotomy. For the surviving hips a Merle d’Aubigné score was obtained at maximum follow up.

In this analysis a new objective measurement is introduced to be used on the abduction view, the Femoral Coverage Angle (FCA). This angle is measured on the preoperative weightbearing pelvic X-ray and the abduction views. Both measurements separately and the difference between both (expected improvement reached by the correction) are added to the analysis. To measure the FCA the
centre of rotation of the femoral head is marked. A line is drawn through the centre of rotation of the femoral head (CR) to the lateral margin of the acetabulum. A second line is drawn from the CR through the centre of the femoral neck. The cranial angle between the two lines is the FCA (Figure I). The rationale behind this new measurement is that it gives an indication for the weightbearing part of the femoral head covered by acetabulum, since it is the only measurement using both femoral and acetabular landmarks. To provide the normal value and range of the FCA, it is measured in weightbearing pelvic X-rays of normal hip joints to establish the normal values of the angle. With an anticipated SD of 5 degrees and acceptable error of 0.5 degrees the estimated sample size is 96. A hip joint was considered to be normal when no signs of OA were present, no leg length discrepancy was present, the CE-angle was more than 25°, the femoral neck-shaft angle between 125° - 135° and the Sharp angle between 30° - 38°. ¹⁶

Figure I
Schematic drawing of the FCA. The centre of rotation of the femoral head is identified using the Moss circle (CR). From here a line is drawn to the lateral margin of the acetabulum. A second line is drawn through the centre of the femoral neck and through the CR. The cranial angle between these lines is the FCA.
Statistical analysis consisted of a Pearson correlation analysis between the long term outcome of the varus intertrochanteric osteotomy and the mentioned objective measurements and preoperative clinical parameters (age, sex, Merle d'Aubigné). Improvement of all measurements on the correction view compared to the preoperative X-rays will also be correlated to the outcome. Success of the osteotomy can be measured in several ways, a second (acetabular or intertrochanteric) osteotomy or THA is a clear endpoint to measure failure of the initial osteotomy. However not all patients without subsequent surgery can be judged as having reached an excellent result, therefore other measurements were used for the outcome of the osteotomy. A clinical score was used to evaluate patients without subsequent surgery at follow up (Merle d'Aubigné score). To be able to correlate the preoperative measurements and the abduction correction radiographs with the long term outcome a score was created to indicate the achieved result of the intertrochanteric varus osteotomy. This score ranges from 1-10, in which 1 is the worst result being a THA (or additional osteotomy) within 2.5 years after the osteotomy and 10 the best result being a excellent Merle d'Aubigné score at maximum follow up. A more detailed explanation of the score is given in Table I. The correlation was interpreted as significant if p<0.05.

**Table I: Outcome of the osteotomy as a numerical score.**

<table>
<thead>
<tr>
<th>Score</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>THA/ re-osteotomy/ pelvic osteotomy within 2.5 years</td>
</tr>
<tr>
<td>2</td>
<td>THA/ re-osteotomy/ pelvic osteotomy after 2.5 - 5 years</td>
</tr>
<tr>
<td>3</td>
<td>THA/ re-osteotomy/ pelvic osteotomy after 5 - 10 years</td>
</tr>
<tr>
<td>4</td>
<td>THA/ re-osteotomy/ pelvic osteotomy after 10 - 15 years</td>
</tr>
<tr>
<td>5</td>
<td>THA/ re-osteotomy/ pelvic osteotomy after 15 - 20 years</td>
</tr>
<tr>
<td>6</td>
<td>THA/ re-osteotomy/ pelvic osteotomy after &gt; 20 years</td>
</tr>
<tr>
<td>7</td>
<td>Merle d'Aubigné score &lt; 12</td>
</tr>
<tr>
<td>8</td>
<td>Merle d'Aubigné score 12 - 14</td>
</tr>
<tr>
<td>9</td>
<td>Merle d'Aubigné score 15 - 17</td>
</tr>
<tr>
<td>10</td>
<td>Merle d'Aubigné score 18</td>
</tr>
</tbody>
</table>
Results

A survival rate of 57% for total hip replacement was reached for the selected patients after an average follow up period of 20.2 years (range 16-28). A total of 9 out of 21 hips were converted to a THA after an average of 8.4 years (range 2-23), one had a re-osteotomy after 7.4 years and one patient had a triple pelvic osteotomy 10.3 years after the intertrochanteric osteotomy.

The newly introduced FCA was measured in 100 healthy hips. The average FCA was 87.4 degrees (range 73-99).

All radiological measurements were obtained independently by three authors. For grading the severity of osteoarthritis the kappa values for the interobserver agreement ranged from 0.3 to 0.6, indicating a fair to moderate agreement. For all radiological measurement the interobserver agreement ranged from 0.3 to 0.9 indicating a fair to excellent agreement (Table II). For the Pearson correlation analysis the averages for each angle was calculated and used.

### Table II: Interobserver variability for the objective measurements

<table>
<thead>
<tr>
<th>measurement</th>
<th>RKM-PPB</th>
<th>PPB-DH</th>
<th>RKM-DH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade OA (K-L)</td>
<td>0.3</td>
<td>0.3</td>
<td>0.55</td>
</tr>
<tr>
<td>CCD</td>
<td>0.87</td>
<td>0.40</td>
<td>0.38</td>
</tr>
<tr>
<td>Weightbearing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharp angle</td>
<td>0.58</td>
<td>0.75</td>
<td>0.53</td>
</tr>
<tr>
<td>X-ray</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE angle</td>
<td>0.84</td>
<td>0.89</td>
<td>0.85</td>
</tr>
<tr>
<td>FCA</td>
<td>0.82</td>
<td>0.66</td>
<td>0.43</td>
</tr>
<tr>
<td>AHI</td>
<td>0.80</td>
<td>0.87</td>
<td>0.66</td>
</tr>
<tr>
<td>Abduction view</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE</td>
<td>0.89</td>
<td>0.79</td>
<td>0.77</td>
</tr>
<tr>
<td>FCA</td>
<td>0.77</td>
<td>0.33</td>
<td>0.33</td>
</tr>
<tr>
<td>AHI</td>
<td>0.69</td>
<td>0.89</td>
<td>0.76</td>
</tr>
</tbody>
</table>

From preoperative data age (r=-0.5) and the grade of OA (r=-0.5) showed to be significantly correlated to the long term outcome. From the preoperative weightbearing X-ray only the Neck Shaft Angle showed to be significantly correlated to the long term outcome (r=0.6). In six hips a CCD of 135° or smaller was present in combination with a mild dysplasia, these hips were all converted to THA after an average of 7.3 years (range 2-13). None of the other objective measurements from the preoperative weightbearing pelvic X-ray were significantly correlated with the long term outcome in this group of patients.
The measurements concerning the quality of the abduction correction X-rays showed that external rotation of the femur was present in 9 of the 21 X-rays, meaning they were not correctly made. Internal rotation of the femur was seen in 4 X-rays of which all had excessive antetorsion and a subsequent varus derotation osteotomy. The pelvic orientation was not horizontal in all the abduction X-rays, an average difference from the weightbearing pelvic X-ray of 1 cm was present (range 0.4 – 3.0 cm). None of the abduction X-rays showed a severe rotation of the pelvis. Four abduction views were judged as being of poor quality, meaning that no reliable measurements could be obtained from them.

None of the objective measurement derived from the abduction views showed a significant correlation with the long term outcome. The amount of improvement between the FCA on the preoperative weight-bearing X-ray and the correction view was the only measurement reaching a significant correlation with the outcome of the osteotomy ($r=0.6$) this significance remains if the abduction views which were judged as poor were excluded. However this correlation disappears if the hips with a normal CCD were excluded from analysis (Figure II).

**Figure II**

Scatterplot showing the improvement of the FCA on the abduction view (ratio) versus the outcome. The scatterplot shows the hips in which the CCD is less than 135 (absence of coxa valga), in the scatterplot all the hips with a coxa valga are shown.
Discussion

The aim of this study was to show whether the long term outcome of an intertrochanteric varus osteotomy could be objectively predicted from abduction correction radiographs. Our study indicates that for young patients with coxa valga and mild dysplasia the long term outcome of a varus osteotomy cannot be predicted from these correction views. Although it seems that the functional X-rays are helpful in the decision making and preoperative planning of these hip disorders none of the objective measurements that can be derived from them "predict" the long term outcome of the osteotomy.

In this analysis only symptomatic hips with a grade 0 to 2 OA (K-L) in relatively young patients were included. In grade 3 or 4 OA (K-L) the severity of the OA can be assumed to be much more predictive for the outcome of the osteotomy than other radiological measurements. Several authors have already showed that the age of the patient and the severity of the preoperative grade of OA are strongly correlated with the outcome of the osteotomy. Even in our selected group of patients with mild OA changes, the preoperative grade of OA is significantly correlated with the long term outcome.

Figure III

A 49 year old female with complaints of the right hip.
The abduction view of the same patient. Some amount of external rotation of the femur is present, and more abduction is given than varisation is performed in the subsequent osteotomy.

Figure III

The first weightbearing X-ray after a 15° varus intertrochanteric osteotomy. The X-ray on the right shows the result after 22 years.
One of the problems of using abduction X-rays is that it is difficult to standardize them. When the leg is put in abduction it tends to externally rotate which has to be actively corrected by the X-ray assistant. In our series 9 of the 21 abduction X-rays showed external rotation, meaning they were not correctly made. Another problem in Pelvic X-rays of a supine patient is the pelvic orientation. In almost all abduction X-rays the pelvis was not horizontal, which could influence the subjective estimation of the containment of the femoral head. The poor quality of some of the abduction X-rays could influence our outcome, however analyzing only the correctly made abduction views still no correlation between objective measurements and outcome was present, while the strong correlation between preoperative grade of OA and age persisted.

The major disadvantage of any plain X-ray technique is that it only provides a 2-dimensional impression of the hip joint. Nowadays Faux profile X-rays are used to measure the anterior coverage of the femoral head. This was not performed for all patients in the past. Femoral antetorsion was measured with a Dunn X-ray if clinical investigation raised the suspicion of excessive antetorsion of the femur \(^4\). A good indication of the amount of dysplasia, the orientation of the acetabulum and the orientation of the femoral neck can be obtained with 3D-CT scanning \(^5\). This could be of great value in identifying the deformities that are present in a dysplastic hip, and could have a role in deciding what type of operation to perform. Murphy et al showed a method to simulate acetabular redirecting osteotomies based on 3D-CT scanning. Haddad et al. showed that the 3D-CT is useful in planning an acetabular redirecting osteotomy \(^6\). The role for 3D-CT scanning in planning femoral osteotomies is not clearly mentioned in the literature. Theoretically it should be possible to perform 3D-CT scan with the leg in abduction (and internal rotation) to measure the result that can be achieved by a varisation (derotation) osteotomy.

Another disadvantage of 2D radiographs is that rotation influences the angles measured. As we know from the research of Dunn, rotation has an influence on the measurement of the CCD on a 2D AP Pelvic view \(^4\). The correction X-ray is made with varying amounts of rotation in hips with a varying amount of (excessive) antetorsion which contributes to the difficulty of obtaining the actual values of several measurements.

Good short term results after intertrochanteric osteotomies are reported by many authors for many ages and indications; however the reported long term results vary widely \(^1\,^9\,^13\,^18\). Several theories are described to explain the good short term results after intertrochanteric osteotomies. An important theory for the patient population in this study is that unloading of the damaged acetabular labrum can decrease pain in the short term. However, since the problem is mainly biomechanical, the long term outcome can only be excellent if the biomechanical situation is restored within a normal range. In all other cases failure of the osteotomy in the long term is inevitable. A valid tool to predict the outcome of the osteotomy should therefore be able to closely reflect these biomechanical forces in a measurable way. The abduction x-ray mimics the effect that can be achieved by the varus osteotomy but fails to
objectively predict whether the situation is normalized after the osteotomy, and therefore seems insufficient to guarantee an excellent long term result based on this X-ray alone.

Several authors described methods to measure the weight bearing surface. However none of them used it in abduction X-rays trying to predict the outcome of the osteotomy. Although the size of the weight bearing surface is of great importance, it is probably not the only factor contributing a successful osteotomy. Persistence of a dislocating force could play an important role, as does the improvement of the offset achieved in the varus correction of pure valgus hips. Body and muscle forces, which probably play an important role in the outcome of the osteotomy, are difficult to predict from X-rays.

For all measurements on X-rays the interobserver agreement is not perfect. The same is true for the measurements used in our study. The analysis was performed using the average of all measurements obtained by the three authors. However, using the values of each observer separately resulted in the same outcome.

The Sharp-angle and the CE-angle do not show a significant correlation with the outcome of the osteotomy. This is probably due to the selected group of patients that was included in our analysis. It could be expected that if patients with a more severe dysplasia were included, the severity of the dysplasia would certainly be related to the outcome, since patients with a more severe dysplasia are known to have a poorer results when treated with an intertrochanteric osteotomy. These measurements do not change on an abduction view (if the head is spherical) and can be obtained from a weight bearing pelvic X-ray.

All subsequent THA were performed at an average age of 63.2 years (range 58-72). In our opinion progression of the OA in women is strongly age-related. In our study all subsequent conversions to THA occurred in the patients who were operated at an age above 44. In all the younger patients no conversion to THA occurred.

Six of our patients who had a varus osteotomy did not have a valgus hip preoperatively; all these osteotomies failed. In these hips a minimal varisation was performed, but with a maximum improvement of the medial offset (20mm). These failures indicate that if no valgus hip is present, a varus osteotomy should not be performed. Overall it seems that the age of the patients and the preoperative grade of osteoarthritis are the strongest predictors for the outcome of the osteotomy.

We conclude that the long term outcome of varus osteotomy in a coxa valga cannot be objectively predicted from abduction correction views. Further research is needed to develop a tool which helps in anticipating the expected long term effect of a varus intertrochanteric osteotomy in valgus hip deformities.
References


