Arch Orthop Trauma Surg (2011) 131:1383–1388
DOI 10.1007/s00402-011-1326-1



# Does medial rotational deformity of the whole pelvis universally exist in unilateral DDH?

**JingYu Jia · LiJun Zhang · Qun Zhao · LianYong Li · XiJuan Liu**

Received: 21 February 2011 / Published online: 27 May 2011


**Abstract**
*Introduction* There are no reports on the morphologic features of the entire pelvis in the subgroup of dislocation of hips according to the classification system of Tönnis. In addition, the correlation of excessive medial rotation of the lower pelvis with the increased acetabular anteversion was uncertain in the children with unilateral developmental dysplasia of the hip (DDH).
*Patients and methods* In the study, 74 patients with unilateral DDH and 31 subjects of normal control were involved, and the images of three-dimensional computed tomography (3D-CT) were retrospectively reconstructed to compare the acetabular anteversion angle (AA), the rotational angle of the upper pelvis (URA), and the rotational angle of the lower pelvis (LRA). The correlation of the AA with LRA was analyzed.
*Results* In the group of grade II and IV, though the LRA was increased on the dislocated side as compared with the unaffected side ($P < 0.05$), the URA did not differ between the two sides ($P > 0.05$). There was positive correlation between AA and LRA on the dislocated side in the group of grade II, III, and IV.
*Conclusion* The excessive medial rotation of whole pelvis on the dislocated side was not universally presented in unilateral DDH. The excessive medial rotational deformity of the lower pelvis could induce increased acetabular anteversion. An individualized treatment plan based on the accurate assessment of morphologic features of the whole pelvis and the exact understanding for underlying causes of acetabular anteversion through 3D-CT should be considered to avoid complications during surgery.

**Keywords** DDH · 3D-CT · Whole pelvis · Deformity

J. Jia · L. Zhang · Q. Zhao (✉) · L. Li · X. Liu
Department of Paediatric Orthopaedics,
Shengjing Hospital of China Medical University,
Shenyang 110004, Liaoning, China
e-mail: zhaoqunxz@163.com

## Introduction

Developmental dysplasia of the hip (DDH) is one of the most complex deformities studied under 3D-CT. For surgeons, the choice of a surgical procedure for DDH depends on the understanding of the morphologic insufficiencies of the acetabulum, femur, and the entire pelvis. Computed axial tomography (CT) and magnetic resonance imaging (MRI) have led to the rapid discovery of numerous morphologic abnormalities of DDH, including excessive femoral and acetabular anteversion, insufficient acetabular coverage of the femoral head, shallow acetabular concavity, coxa valga, and shortened femoral neck [1–6]. However, as of now, the study of morphologic features of the entire pelvis in DDH is insufficient [7–9]. Suzuki [8] observed the morphologic features of whole pelvis through MRI in eight infants (two boys and six girls) with unilateral DDH and found that the most fundamental deformity was a medial twist of the pelvis in the side of affected hips in the transverse plane. Fujii et al. [7] examined the morphologic features of the whole pelvis using 2D-CT for 50 patients with DDH (age range, 17–60 years). They also observed greater internal rotation of the innominate bone in patients with DDH than in the control subjects and found that internal rotation of the innominate bone was associated with increased acetabular anteversion angle and acetabular inclination angle. They thought that the morphologic acetabular abnormalities were not caused solely by local dysplasia around the hip, but were influenced by the morphologic features of the entire pelvis.

Although 2D-CT scanning and roentgenography are accurate methods for quantitative assessment of the morphologic abnormalities in DDH, the reliability and accuracy are limited by anatomical and positional variables. For example, any rotation of the pelvis about the longitudinal axis or any inclination about the transverse axis can lead to inaccuracies [10–12]. In such situations, three-dimensional computed tomography (3D-CT) is usually recommended, because the physician can inspect and measure the anatomy from any desired angle [13]. At present, the research of larger sample size with respect to the morphologic features of the entire pelvis in children with unilateral DDH using 3D-CT is not reported. The morphologic features of the entire pelvis in the subgroup of dislocation of hips according to classification system of Tönnis [14] are not analysed. In addition, the correlation of excessive medial rotation of the lower pelvis with the increased acetabular anteversion was uncertain in the children with unilateral DDH. An exact understanding the morphologic features of the entire pelvis is fairly crucial to avoid the complications during surgery.

The objectives of our study were to observe whether the excessive medial rotational deformity of the pelvis on the dislocated side was universally presented in children with unilateral DDH using 3D-CT and whether excessive medial rotation of the pelvis was correlated with the increased acetabular anteversion.

**Table 1** The 74 patients of unilateral dislocation of hip are divided into three subgroups (grade II, III, and IV) according to classification system of Tönnis

| Classification system of Tönnis | |
|---|---|
| Grade I ($N = 0$) | The femoral head's ossification centre is medial to Perkin's line |
| Grade II ($N = 17$) | The femoral head's ossification centre is lateral to Perkin's line and below the transverse line passing from the superolateral rim of the acetabulum |
| Grade III ($N = 42$) | The femoral head's ossification centre is at the level of the transverse line passing from the superolateral rim of the acetabulum |
| Grade IV ($N = 15$) | The femoral head's ossification centre is above the level of the transverse line passing from the superolateral rim of the acetabulum |

## Patients and methods

This is a retrospective review of the medical records, plain anteroposterior pelvic radiographs, and CT images of 485 patients with a primary diagnosis of unilateral DDH treated at our institution between 2005 and 2010. Since non-operative or operative treatment can alter the acetabular anatomy, patients with a history of prior treatment were excluded. The present research did not involve dysplastic hips and subluxated hips. Thus, 74 patients with unilateral dislocation of hips were studied. They comprised 64 females and 10 males, mean age 19 months (range 6–60 months) and provided 148 hips for study. The left hip was involved in 42 cases, the right hip in 32 cases. Of the 74 affected hips, 17 hips were classified as grade II, 42 hips as grade III, and 15 hips as grade IV (Table 1) according to the classification system of Tönnis [14]. In the normal control group, the subjects with known congenital, developmental, or metabolic abnormalities influencing the musculoskeletal system were excluded. In this study, 31 subjects underwent a CT scan with reconstruction of the 3D-CT images of the urinary system following excretory urography, including 20 cases of hydronephrosis, 9 cases of megaloureter, and 2 cases of tumor. They comprised 14 females and 17 males of mean age 21 months (range 7–48 months) and provided 62 hips for study. The Medical Ethics Committee, Shengjing Hospital, China Medical University, had approved this research. A Philips Brilliance 64 scanner (Marconi Medical Systems, The Netherlands) was used to take the 3D-CT scans. The scanning technique used was 120 kV, 70–120 mA (depending on the patient's size), with a 0.5-s rotation time. Contiguous slices (1.5 mm) were obtained from the anterior superior iliac spine to the level of the lesser trochanter in DDH and from 11 thoracic vertebrae to the inferior margin of pubic symphysis in the normal control group, with the patients placed in a supine position with hips extended and thighs horizontal and parallel. The images were retrospectively reconstructed on a CT workstation (Extended Brilliance™ Workspace V3.5.0.2250) to produce the 3D images. Once the data were acquired, the images could be observed and measured from any angle. After the 3D image of the pelvis was acquired though 3D-CT reconstruction, we selected to measure the acetabular anteversion angle (AA), the rotational angle of upper pelvis (URA), and the rotational angle of lower pelvis (LRA) from the inferior view of pelvis. The AA was the angle formed by a line connecting the anterior and posterior margins of the acetabulum (yellow line) and the sagittal line (yellow line, Fig. 1). The pelvis was divided into two parts using the triradiate cartilage as the boundary. The upper pelvis consisted of the ilium and the lower pelvis consisted of the pubis and the ischium. A line connecting the midpoint of the anterior superior iliac spine with the midpoint of posterior superior iliac spine (green line) and the horizontal line (green line, Figs. 1, 2) formed the URA. The angle represented the medial rotational extent of the upper

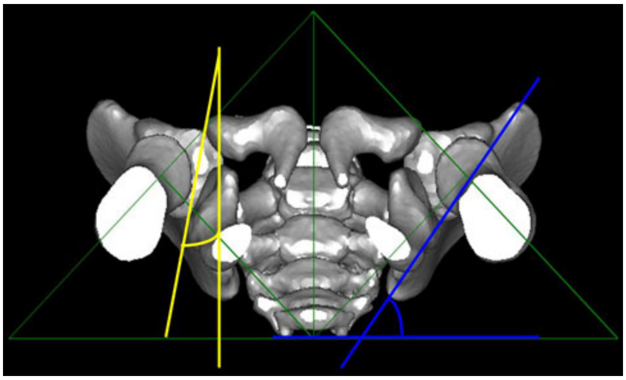

**Fig. 1** The AA was the angle formed by a line connecting the anterior and posterior margins of the acetabulum (*yellow line*) and the sagittal line (*yellow line*) from the inferior view of the pelvis. The URA is formed by a line connecting the midpoint of anterior superior iliac spine with the midpoint of posterior superior iliac spine (*green line*) and the horizontal line. The *image* is from children of normal control group

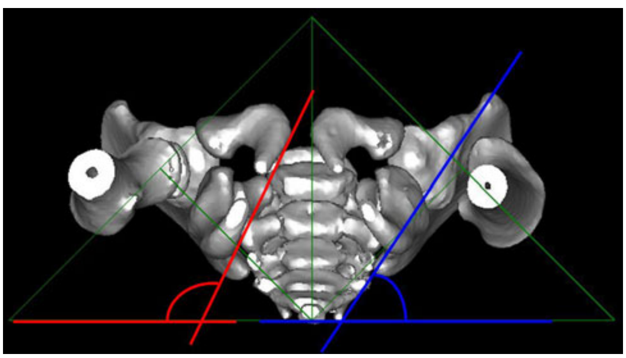

**Fig. 2** The LRA is determined by a *red line* connecting the *A* point with *B* point and the *red horizontal line*. The most internal point of pubis was the *A* point and the most internal point of ischium is the *B* point from the inferior view of pelvis. The *image* is from children with dislocation of left hip

pelvis. The LRA was determined by a line connecting the A point with B point and the horizontal line (Fig. 2). The angle represented the medial rotational extent of the lower pelvis. The most internal point of pubis was the A point and the most internal point of ischium is the B point from the inferior view of pelvis (Fig. 2). The triangle ruler was regarded as the marker to correct the pelvic obliquity induced by abnormal posture (Figs. 1, 2). For example, when the midline of the triangle ruler equally divides the sacrum (with the right sacral cornu and the left sacral cornu at the same level), the assumption is that the position of the pelvis is unaffected by the posture of the patients.

To determine intra-observer variation, the measurement was repeated 2 weeks later by one of the paediatric orthopaedic surgeons (observer A). For evaluation of inter-observer variation, we randomly selected 40 patients with 80 hips and the measurements were taken by three experts, including two paediatric orthopaedic surgeons (observers A and B) and one radiologist (observer C).

**Table 2** Comparison of intra-observer and inter-observer agreement in the measurement of three-dimensional the angle of acetabular anteversion (AA), medial rotation angle of upper pelvis (URA) and medial rotation angle of lower pelvis (LRA) as calculated by the intra-class correlation coefficient (ICC)

| Observer | AA | | URA | | LRA | |
|---|---|---|---|---|---|---|
| | ICC | *P* value | ICC | *P* value | ICC | *P* value |
| A-A | 0.933 | 0.000 | 0.894 | 0.000 | 0.950 | 0.000 |
| A-B | 0.877 | 0.000 | 0.778 | 0.000 | 0.848 | 0.000 |
| A-C | 0.817 | 0.000 | 0.782 | 0.000 | 0.864 | 0.000 |
| B–C | 0.896 | 0.000 | 0.701 | 0.000 | 0.779 | 0.000 |

Statistical analysis was performed using SPSS® version 11.5 (SPSS Inc., Chicago, IL, USA) for Windows®. Intra-observer agreements between the two sets of measurements of observer A and inter-observer agreements between the three sets of measurements of observers A, B and C were analysed using Pearson correlation coefficient and the intra-class correlation coefficient (ICC). An ICC $>$ 0.75 was regarded as excellent, ICC 0.40–0.75 was fair to good, and ICC $<$ 0.40 was poor.

The paired sample *t* test was used to assess the difference in the URA, LRA, and AA between the right side and the left side in normal control group, and between the dislocated side and the unaffected side in unilateral DDH. Because the differences of body height and weight between individuals likely affect the URA, LRA, and AA, we did not directly compare these angles between the DDH group and the normal control group. We hypothesized these angles between the right side and left side are symmetric in the normal children. Thus, if these angles show significant difference between the dislocated side and the unaffected side in unilateral DDH, this means the hip bone existed the rotational deformity. The correlation of AA with LRA on the dislocated side was analysed using Pearson correlation analysis.

## Results

The 3D-CT-based measurement of URA, LRA and AA revealed excellent intra-observer agreement and inter-observer agreement across the three observers (Table 2).

The URA, LRA, and AA between left side and right side in the normal control group is shown in Table 3, and meanwhile significant difference was not found between the two sides ($P > 0.05$). This means these angles are symmetric between the right hip bone and the left hip bone in the nor-

**Table 3** The URA, LRA, and AA between left side and right side are compared in the normal control group

| | Left side ($n = 31$) | Right side ($n = 31$) | $P$ value |
|---|---|---|---|
| URA | 57.41 ± 3.69 | 57.06 ± 3.67 | 0.109 |
| LRA | 118.65 ± 3.27 | 118.84 ± 2.98 | 0.115 |
| AA | 10.97 ± 3.24 | 10.54 ± 2.98 | 0.337 |

**Table 4** The URA, LRA, and AA between the dislocated side and the unaffected side are compared in unilateral DDH

| | Dislocated side ($n = 74$) | Unaffected side ($n = 74$) | $P$ value |
|---|---|---|---|
| URA | 56.57 ± 3.78 | 55.37 ± 3.55 | 0.000 |
| LRA | 125.33 ± 4.37 | 120.15 ± 4.05 | 0.000 |
| AA | 17.38 ± 3.34 | 12.18 ± 2.97 | 0.000 |

**Table 5** The URA, LRA, and AA between the dislocated side and the unaffected side are compared in the grade II group

| | Dislocated side ($n = 17$) | Unaffected side ($n = 17$) | $P$ value |
|---|---|---|---|
| URA | 55.07 ± 2.50 | 53.81 ± 3.03 | 0.107 |
| LRA | 123.96 ± 2.90 | 119.27 ± 3.80 | 0.000 |
| AA | 15.89 ± 2.78 | 11.68 ± 2.77 | 0.000 |

mal children. The URA, LRA, and AA were larger on the dislocated side than the unaffected side in unilateral DDH ($P < 0.05$, Table 4). However, after the 74 patients of unilateral dislocation of hip were divided into three subgroups according to classification system of Tönnis based on the level of dislocation of femoral head, the result indicated the excessive medial rotation of the hip bone on the dislocated side was not universally presented in children with unilateral DDH. In the group of grade II and grade IV, though the LRA was increased on the dislocated side compared with the unaffected side ($P < 0.05$), the URA did not differ between the two sides ($P > 0.05$, Tables 5, 7). In the group of grade III, the URA and LRA on the dislocated side were more than the unaffected side ($P < 0.05$, Table 6). The AA was larger on the dislocated side than the unaffected side in the group of grade II, grade III and grade IV ($P < 0.05$, Tables 5, 6, 7). The positive correlation AA with LRA on the dislocated side was presented in the group of grade II, III and IV ($r = 0.594$ $P = 0.012$, $r = 0.618$ $P = 0.000$, $r = 0.729$ $P = 0.002$, respectively).

## Discussion

Until recently, surgical planning was largely based upon two-dimensional imaging modalities such as plain films and computed tomography. Although it is widely considered that 2D-CT scanning and roentgenography are accurate methods for quantitative assessment of the morphologic abnormalities in DDH, its reliability and accuracy are sometimes uncertain. This is mainly due to pelvic tilt or loss of landmarks for measurement in severely deformed hip joints. Previously, we have reported that the 3D-CT showed better intra- and inter-observer agreement than 2D-CT for assessing acetabular anteversion [3]. Therefore, in the present study, we employed 3D-CT analyzing the morphologic features of entire pelvis.

**Table 6** The URA, LRA, and AA between the dislocated side and the unaffected side are compared in the grade III group

| | Dislocated side ($n = 42$) | Unaffected side ($n = 42$) | $P$ value |
|---|---|---|---|
| URA | 56.84 ± 4.14 | 55.66 ± 4.02 | 0.004 |
| LRA | 125.42 ± 4.71 | 120.78 ± 4.24 | 0.000 |
| AA | 17.84 ± 3.21 | 12.41 ± 3.42 | 0.000 |

**Table 7** The URA, LRA, and AA between the dislocated side and the unaffected side are compared in the grade IV group

| | Dislocated side ($n = 15$) | Unaffected side ($n = 15$) | $P$ value |
|---|---|---|---|
| URA | 57.54 ± 3.61 | 56.34 ± 1.93 | 0.165 |
| LRA | 126.65 ± 4.56 | 119.37 ± 3.71 | 0.000 |
| AA | 17.76 ± 3.96 | 12.11 ± 1.60 | 0.000 |

Suzuki [8] observed the morphologic features of pelvis through MRI in eight infants and found that the opening angle of the upper pelvis was less on the affected side than on the normal side, and the closed angle of the lower pelvis was greater on the affected side than on the normal. It indicated that the whole pelvis of affected side rotated medially more than the normal side. In our study, the URA and LRA in the 74 children with unilateral DDH were larger on the dislocated side than the unaffected side. It indicated that the entire hip bone of dislocated side seem to also be more excessive medial rotation than the normal side. However, after the 74 patients of unilateral dislocation of hip were divided into three subgroups according to classification system of Tönnis based on the level of dislocation of femoral head, the result indicated the increased medial rotation of entire pelvis on the dislocated hips was not universally presented in children with unilateral DDH, which is currently not reported in the literatures published. Although the LRA was larger on the dislocated side than the unaffected side in the group of grade II, III and IV, the URA was increased on the dislocated side compared with on the unaffected side only in the group of grade III because the URA between the dislocated side and the unaffected side did not differ in the group of grade II and IV. This means that the medial rotation of upper pelvis and lower pelvis on the dislocated side did not completely act as a whole in the group of grade II and grade IV when the triradiate cartilage did not close. It is not impossible that there are different biomechanics in the medial rotation of upper and lower pelvis. In the group of grade III, the femoral head directly pressed the superolateral margin of acetabulum, which should make the femoral head produce more pressure against pelvis than the group of grade II and IV. Thus, the URA was larger on the dislocated side than the unaffected side only in the group of grade III. The existence of contiguous relationship between the acetabulum and femoral head may be responsible for the excessive medial rotation of the upper pelvis on the dislocated side. Growth in depth and the construction of the final acetabular shape heavily depends on the interaction with a spherical femoral head. The acetabulum requires the spherical femoral head as a template to further expand these three bones in the peripheral direction and enlarge the cavity. Thus, we speculated the lower pelvis presented larger medial rotation on dislocated side than the unaffected side likely due to the absence of the growth-stimulating of centralized pressure from femoral head to result in abnormal rotational alignment of the ischium and the pubis in the axial plane after the femoral head dislocated.

Increased acetabular anteversion is related to hip instability [15] and acetabular retroversion can cause hip pain and osteoarthrosis of the hip [16–18]. Consequently, it is important to accurately assess anteversion of the acetabulum and exactly understand underlying cause of excessive acetabular anteversion for reasonable surgical planning and to avoid complications in the treatment of DDH. The reliability of 3D-CT with respect to assessing acetabular anteversion had been confirmed by previous study. However, to date, the underlying cause of excessive acetabular anteversion in DDH is uncertain. In addition to the fact that the defect in the anterior acetabulum wall was correlation with excessive acetabular anteversion, the result of our study indicated the excessive medial rotation of lower pelvis (the ischium and the pubis) on dislocated side was also positive correlation with excessive acetabular anteversion. Moreover, we speculated the increased medial rotation of upper pelvis on the dislocated side could also induce excessive acetabular anteversion through the triradiate cartilage acting as a hinge in the group of grade III, because the medial rotation of upper pelvis was larger on the dislocated side than on the unaffected side only in the group of grade III.

The author suggests that the causes inducing excessive acetabular anteversion ought to be considered before choosing the type of surgical procedure. For example, if increased angle of acetabular anteversion is mainly caused by the excessive medial rotation of the lower pelvis without serious underdevelopment of anterior acetabulum wall, it could be corrected through lateral rotation of the distal fragment of osteotomy of the innominate of bone to the normal range. If increased angle of acetabular anteversion is induced by the excessive medial rotation of the lower pelvis and serious underdevelopment of anterior acetabulum wall, the retroversion of acetabulum should likely occur in adults through lateral rotating the distal fragment of osteotomy of the innominate bone to the normal range in childhood. The anterior and posterior walls of the acetabulum determine the angle of acetabular anteversion in the transverse plane. Because anterior acetabulum wall exist serious underdevelopment, the lateral rotation of entire acetabulum may be larger on the dislocated side than on the normal side when the angle of acetabular anteversion on the dislocated side was recovered to normal range through lateral rotating the distal fragment of osteotomy of the innominate of bone. This means that the angle of acetabular anteversion cannot sometimes accurately represent the extent of acetabular medial rotation. It is notable that if the increased angle of acetabular anteversion was corrected to normal range through lateral rotating the distal fragment of osteotomy of the innominate of bone, it should be more risk in the patient of grade III than the patient of grade II and IV to present the retroversion of acetabulum. Because the excessive medial rotation of upper pelvis on the dislocated side exist only in the group of grade III, it is not impossible that the excessive medial rotational upper pelvis of dislocated side could spontaneously recover to the normal angle in future after the femoral head of dislocation is reduced. Therefore, though the increased angle of acetabular anteversion was corrected to normal range through osteotomy of the innominate of bone in childhood, spontaneous reduction of the upper pelvis should lead to further lateral rotation of the acetabulum and likely show retroversion of acetabulum in adults. Claudio et al. [19] reported the retroversion of acetabulum was presented in 27% and averaged −15° in DDH after osteotomy of the innominate bone. The average follow-up at the time of the last anteroposterior radiograph was 11.5 years. They thought that anterior over-coverage of the femoral head resulted from ignorance of where coverage needs to be improved in an individual hip. For example, if acetabular insufficiency is mainly located superolaterally, Salter's reorientation of the acetabulum will exaggerate anterior coverage. We agree with their opinion, but we think exact understanding of the reason of acetabular anteversion also is fairly important to avoid complications, especially retroversion of acetabulum, in the treatment of DDH. Of course, this ought to be further confirmed in future research.

In our research, the result indicated that the excessive medial rotational deformity of whole pelvis on the dislocated hips was not universally presented in children with unilateral DDH. The excessive medial rotational deformity of the entire pelvis on the dislocated hips was found only in the grade III group. Although the grade II and IV groups revealed excessive medial rotational deformity of the lower pelvis on the dislocated hips, there was no excessive medial rotational deformity of the upper pelvis. The excessive medial rotational deformity of the lower pelvis correlated positively with increased acetabular anteversion. An individualized treatment plan based on the accurate assessment for morphologic features of the whole pelvis and the exact understanding for underlying causes of acetabular anteversion through 3D-CT should be considered to avoid complications in the treatment of DDH.

**Acknowledgments** We thank Dr. QiWei Li and Dr. EnBo Wang for helpful advice during this study.

**Conflict of interest** None of the authors received financial support for this study. The authors declare no conflict of interest.

## References

1. Sankar WN, Neubuerger CO, Moseley CF (2009) Femoral anteversion in developmental dysplasia of the hip. J Pediatr Orthop 29:885–888
2. Sarbana S, Ozturkb A, Tabura H, Lsikan UE (2005) Anteversion of the acetabulum and femoral neck in early walking age patients with developmental dysplasia of the hip. J Pediatr Orthop B 14:410–414
3. Li LY, Zhang LJ, Zhao Q, Wang EB (2009) Measurement of acetabular anteversion in developmental dysplasia of the hip in children by two- and three-dimensional computed tomography. J Int Med Res 37:567–575
4. Jacobsen S, Rømer L, Søballe K (2006) The other hip in unilateral hip dysplasia. Clin Orthop Relat Res 446:239–246
5. Clohisy JC, Nunley RM, Carlisle JC, Schoenecker PL (2009) Incidence and characteristics of femoral deformities in the dysplastic hip. Clin Orthop Relat Res 467:128–134
6. Mootha AK, Saini R, Dhillon M, Aggarwal S, Wardak E, Kumar V (2010) Do we need femoral derotation osteotomy in DDH of early walking age group? A clinico-radiological correlation study. Arch Orthop Trauma Surg 130:853–858
7. Fujii M, Nakashima Y, Sato T, Akiyama M, Iwayoto Y (2011) Pelvic deformity influences acetabular version and coverage in hip dysplasia. Clin Orthop Relat Res [Epub ahead of print]
8. Suzuki S (1995) Deformity of the pelvis in developmental dysplasia of the hip: three-dimensional evaluation by means of magnetic resonance image. J Pediatr Orthop 15:821–826
9. Albinana J, Morcuende JA, Delgado E, Weinstein SL (1995) Radiologic pelvic asymmetry in unilateral late-diagnosed developmental dysplasia of the hip. J Pediatr Orthop 15:753–762
10. Zilber S, Lazennec JY, Gorin M, Saillant G (2004) Variations of caudal, central, and cranial acetabular anteversion according to the tilt of the pelvis. Surg Radiol Anat 26:462–465
11. Van Bosse HJ, Lee D, Henderson ER, Sala DA, Feldman DS (2011) Pelvic positioning creates error in CT acetabular measurements. Clin Orthop Relat Res [Epub ahead of print]
12. Van der Bom MJ, Groote ME, Vincken KL, Beek FJ, Bartels LW (2011) Pelvic rotation and tilt can cause misinterpretation of the acetabular index measured on radiographs. Clin Orthop Relat Res
13. Gose S, Sakai T, Shibata T, Murase T, Yoshikawa H, Sugamoto K (2009) Morphometric analysis of acetabular dysplasia in cerebral palsy: three-dimensional CT study. J Pediatr Orthop 29:896–902
14. Tönnis D (1984) Nomenklatur der angeborenen Hüftluxation. In: Die angeborene Hüftdysplasie und Hüftluxation im Kindes-und Erwachsenenalter. Springer, Berlin, p 86 (in German)
15. Buckley SL, Sponseller PD, Magid D (1991) The acetabulum in congenital and neuromuscular hip instability. J Pediatr Orthop 11:498–501
16. Kim WY, Hutchinson CE, Andrew JG, Allen PD (2006) The relationship between acetabular retroversion and osteoarthritis of the hip. J Bone Joint Surg Br 88:727–729
17. Giori NJ, Trousdale RT (2003) Acetabular retroversion is associated with osteoarthritis of the hip. Clin Orthop Relat Res 417:263–269
18. Fujii M, Nakashima Y, Yamamoto T, Mawatari T, Motomura G, Matsushita A, Matsuda S, Jingushi S, Iwamoto Y (2010) Acetabular retroversion in developmental dysplasia of the hip. J Bone Joint Surg Am 92:895–903
19. Dora C, Mascard E, Mladenov K, Seringe R (2002) Retroversion of the acetabular dome after salter and triple pelvic osteotomy for congenital dislocation of the hip. J Pediatr Orthop B 11:34–40