EXTENDED REPORT

# The normal hip joint space: variations in width, shape, and architecture on 223 pelvic radiographs

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**Objectives:** To determine the range of normal radiographic joint space width (JSW) values and the shape of the normal hip, and the influence of age, sex, dysplasia, coxa profunda, and acetabular roof curve abnormalities on these values.

**Methods:** On routine conventional pelvic radiographs taken in the supine position in patients with no history of hip or lumbar pain, JSW was measured at three points (superolateral, apical, superomedial), together with the VCE, HTE, and neck shaft angles; acetabular depth; and femoral head diameter.

**Results:** 223 radiographs (446 hips) from 127 women and 96 men (mean age 51.3 years) were examined. Interindividual variations in JSW were large (apical site: 4.19 (0.92) mm; range 2–7). Mean JSW values were higher at the superolateral site than at the apical and superomedial sites in nearly 80% of cases. Women had lower JSW values than men. JSW values did not fall with age. Marked right/left JSW asymmetry was seen in 13/221 (5.9%) subjects. Eight cases of acetabular dysplasia (7 unilateral) and 16 cases of coxa profunda were found, but no cases of acetabular protrusion. The JSW was thicker in dysplastic hips, and thinner in hips with coxa profunda. A roof curve abnormality was found in 96/446 (21.5%) hips.

**Conclusions:** Normal JSW values vary widely; the JSW is commonly narrower at the superomedial site than at the apical site, and is sometimes asymmetric. The roof curve is dysmorphic in about 20% of patients. These findings may have important implications for epidemiological studies and early diagnosis of osteoarthritis of the hip.

More information is needed on the radiographic joint space (JS) of the normal hip, including its shape, its width at precise locations, and the influence of age, sex, and congenital morphology. These normal values are needed to set the limits of significant early radiographic alterations in patients with osteoarthritis (OA). The American College of Rheumatology classifies as "OA" only painful hips meeting at least two of the following three criteria: sedimentation rate ⩽20 mm/1st h, osteophyte, and joint space narrowing (JSN).[1] As epidemiological studies include many painless OA hips, they often include JSN as the most robust and useful radiographic feature.[2 3] However, in studies of occupational risk, for example, the threshold JS value defining OA of the hip varies among authors from <4 to <1.5 mm,[4–7] and measurements are generally made only at the apical site. Moreover, owing to a lack of accepted normal values, the JSW of interest is usually compared with the contralateral JSW, which may itself be abnormal.[8]

We found five main published studies offering sufficient methodological details and dealing with the JSW of normal hips. Two comprised 533 *x* ray studies[9] and 118 *x* ray studies[10] on plain urographic and abdominal films, respectively. These radiographic incidences do not encompass exactly the same JS segment as routine radiographs of the pelvis, which are centred at a lower point. The other three studies used pelvic *x* ray findings and involved 120,[11] 240,[12] and 171[8] subjects. All these studies sought differences in JSW according to age and sex. In contrast, we found no studies considering the relationship between JSW and dysplasia, acetabular protrusion, or coxa profunda, or the distortion of the JS shape by possible acetabular roof dysmorphia.

Our study was sponsored by GETROA, a French research group comprising radiologists, rheumatologists, and orthopaedic surgeons, and involved 10 centres in France and one in Belgium (see Acknowledgements). The aims were not only to measure the JSW of normal hips at the three principal sites (fig 1), and to determine the influence of age and sex, but also to check the possible relationship between JSW and primary architectural deformities (dysplasia, acetabular protrusion, and coxa profunda). Furthermore, we examined the shape of the acetabular roof according to the three types noted by one of us over many years (see definitions below).

## METHODS

### Definitions of the parameters used

For the purposes of this study, the parameters used are defined as follows:

- JSW of the hip on the coronal radiograph refers to the interbone area between the acetabular roof and the part of the femoral head facing it. The roof limits are the lateral extremity of the condensed subchondral bone and, medially, the junction roof-acetabular fossa line (fig 1). The acetabular fossa is devoid of cartilage.
- The VCE angle (Wiberg's angle) is the angle formed by the vertical line drawn through C (centre of the femoral head) and the line CE, E being the acetabular roof lateral brim (fig 2A). It measures the lateral covering of the femoral head by the acetabular roof; it is considered insufficient (congenital dysplasia) when ⩽20°[13 14] and excessive (coxa profunda) when ⩾40°.[15]
- Clear acetabular protrusion is diagnosed when the acetabular projects medially to the ilio-ischial line by 3 mm or more in men and by 5 mm or more in women.[13]
- The HTE angle is the angle formed by the horizontal line drawn through point T (medial extremity of the acetabular

**Abbreviations:** JS, joint space; JSW, joint space width; OA, osteoarthritis

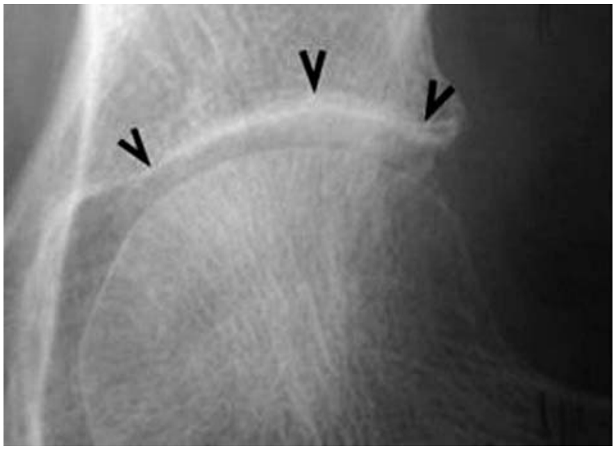

**Figure 1** Normal hip joint space. Location of the three sites of JSW measurement. From right to left: the superolateral, the apical, and the superomedial sites (point of arrow).

roof) and the line TE (E: see above) (fig 2A). It measures acetabular roof acclivity and is considered too oblique (dysplastic) when ⩾12°.[14 15]

- The NSA (neck shaft angle) is formed by the line N (neck axis) and the line S (axis of the femoral diaphysis) (indicated as $CC^1D$ in fig 2A). It reveals coxa valga when ⩾140°.[14 15]
- Acetabular depth is defined in fig 2B; this is a criterion of dysplasia (acetabular insufficiency) when ⩽9 mm.[16]
- Acetabular dysmorphias, noted by one of us (ML) over many years, and not hitherto described, were categorised as indicated in fig 3 and were systematically recorded.

## Patients

Patients of both sexes aged from 18 to 89 years were eligible for this study if they were free of hip and lumbar pain and required plain radiographs of the pelvis for diagnosis or monitoring of metastasis, bone marrow disease, renal failure, long term steroid treatment, or trauma.

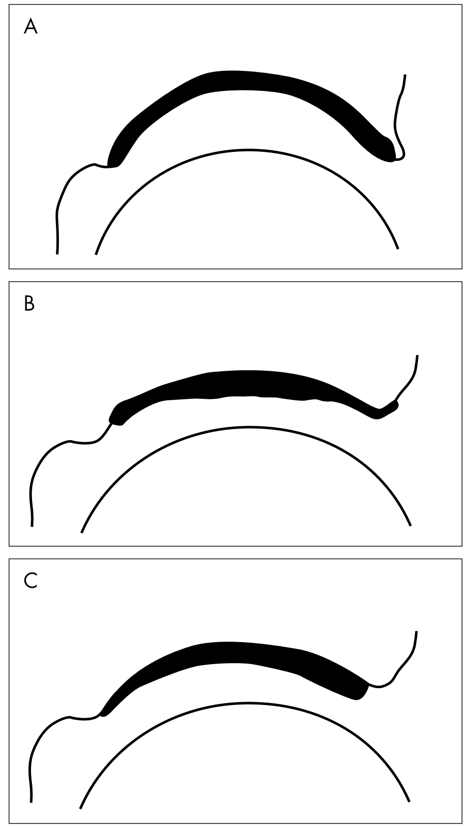


**Figure 3** Sketch of the three main types of acetabular roof dysmorphia: (A) excessively arched roof; (B) excessively flat roof; (C) roof with a prominent segment (angular roof).

## Radiographs

Conventional full size radiographs were taken in the supine position, with the legs in medial rotation of 15°. The focal length was from 1.00 to 1.15 m, according to usual practice in each centre. Only one centre, which provided 14 radiographs, used the 1.15 m focal length. The other centres used the

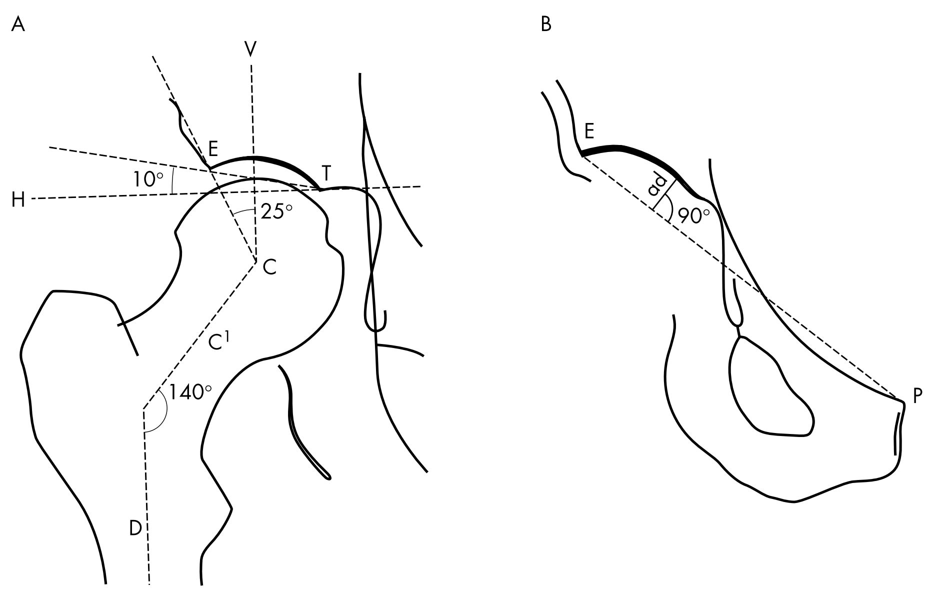


**Figure 2** (A) The VCE, HTE, and NSA (indicated as $CC^1D$, 140°) angles; (B) acetabular depth: segment ''ad'' stretches from the deepest point of the acetabulum and the line EP, drawn from the lateral extremity of the acetabular roof to the superior pubic angle.

**Table 1** Intraobserver reproducibility of measurement of the main variables

| | Standard error of measurement (95% CI) | | Intraclass correlation coefficient (95% CI) | | Limits of agreement | |
|---|---|---|---|---|---|---|
| | 1st Observer | 2nd Observer | 1st Observer | 2nd Observer | 1st Observer | 2nd Observer |
| JSW (mm) | 0.26 (0.20 to 0.38) | 0.33 (0.25 to 0.48) | 0.90 (0.77 to 0.96) | 0.77 (0.50 to 0.90) | −0.90 to 0.55 | −1.09 to 0.74 |
| VCE angle | 1°04 (0°79 to 1°52) | 1°81 (1°38 to 2°65) | 0.98 (0.94 to 0.99) | 0.93 (0.82 to 0.97) | −3°38 to 2°38 | −4°42; 5°62 |
| HTE angle | 0°87 (0°66 to 1°21) | 1°68 (1°28 to 2°45) | 0.97 (0.94 to 0.99) | 0.90 (0.77 to 0.96) | −1°93 to 2°88 | −3°85 to 5°45 |
| NSA angle | 1°35 (1°02 to 1°97) | 2°07 (1°57 to 3°02) | 0.94 (0.84 to 0.97) | 0.82 (0.59 to 0.93) | −4°18 to 3°28 | −6°08 to 5°38 |
| Acetabular depth (mm) | 0.35 (0.27 to 0.52) | 0.84 (0.64 to 1.22) | 0.99 (0.97 to 1.00) | 0.93 (0.83 to 0.97) | −1.20 to 0.75 | −1.97 to 2.67 |

1.00 m focal length. We checked that the images of a 4 mm space between two metallic wires, *x* rayed at focal lengths of 1.00 m and 1.15 m, were impossible to distinguish one from the other. The *x* ray beam was centred 6 cm above the pubic symphysis.

### Exclusion criteria

Patients with known hip disease or pain located in the hip region, including ambiguous pain probably of lumbar origin but irradiating to the region of the greater trochanter, groin, or thigh, were excluded from the study. We also excluded patients with bone disorders such as Paget's disease, femoral head disease, acquired deformities, unequivocal OA of the hip, and evident osteophytes or cysts adjacent to the hip joint cavity. Films with incorrect patient positioning (misalignment of the sacrum-pubic symphysis vertical axis ⩾1.5 cm) were also excluded.

### Measurements

All measurements were made using a new Plexiglass instrument, the ''arthrometer'', designed by one of us. It comprises a ruler for JSW measurement and protractors appropriate for measuring hip architectural angles.[15]

JSW was measured at the superolateral, apical, and superomedial sites (fig 1). The following variables were also measured: VCE angle, HTE angle, neck shaft angle (NSA), and acetabular depth (fig 2); and femoral head diameter. The various types of acetabular roof dysmorphias (fig 3) were recorded.

### Reproducibility

Before measuring the entire series of radiographs, the intraobserver and interobserver reproducibility of two readers was assessed on 30 randomly selected radiographs (60 hips). The two observers ''blindly'' measured JSW and all the above-mentioned angles and segments twice, 1 month apart, on the same series of 30 *x* ray pictures. The reader with the best intraobserver reproducibility made all subsequent measurements.

### Statistical analysis

Reproducibility was expressed as the standard measurement[17] error, intraclass correlation coefficient, and limits of agreement.[18] The Shapiro-Wilk test was used to determine the normal or non-parametric distribution of variables. The variables, all of which were quantitative, were analysed by analysis of variance bilateral Student test; the Wilcoxon rank test was used for non-parametric variables; p values of $\leqslant 0.05$ were considered significant. The significance of correlations between parametric variables was expressed by Pearson's correlation coefficient. Spearman's correlation coefficient was used for non-parametric variables. All analyses were performed using SAS software version 6.12.

**Table 2** Joint space width (JSW) in three locations in 446 normal hips. Mean (SD) [range], in mm

| | Superolateral | Apical | Superomedial |
|---|---|---|---|
| Women (n = 127) | 4.69 (0.95) [3–8] | 4.01 (0.82) [2–6] | 3.45 (0.89) [2–6] |
| Men (n = 96) | 5 (1.15) [3–8] | 4.42 (1.00) [2–7] | 3.81 (0.89) [2–6] |
| Both sexes (n = 223) | 4.82 (1.05) [3–8] | 4.19 (0.92) [2–7] | 3.61 (0.90) [2–6] |

**Table 3** JSW according to age (before/after 50 years)

| | 16–50 years (n = 220) | 51–88 years (n = 226) | 25–50 years (n = 184) |
|---|---|---|---|
| Superolateral | 4.77 (1.02) | 4.89 (1.06) | 4.80 (1.22) |
| Apical | 4.09 (0.92) | 4.28 (0.92) | 4.12 (0.96) |
| Superomedial | 3.60 (0.93) | 3.60 (0.91) | 3.59 (0.93) |

## RESULTS

### Population

A total of 265 patients were eligible for the study. Thirty seven pelvic radiographs were excluded because of positioning or centring errors. Among the remaining 228 films (456 hips), we eliminated 10 hips (3 bilateral and 4 unilateral) with an unequivocal aspect of OA, osteophytes, and/or cyst(s). The remaining 446 assessable hips belonged to 127 women and 96 men with a mean age of 51.3 years (SD 16.0; range 16–88). The reasons for pelvic radiography were metastasis screening in 44 cases; bone marrow disease in 12; renal failure in 64; long term steroid treatment in 36; trauma in 38; and miscellaneous in 31. Two patients had two reasons for pelvic radiography.

### Reproducibility

Table 1 shows the intraobserver reproducibility of the two readers. Interobserver reproducibility, expressed as the intraclass correlation coefficient with regard to JSW (apex), VCE, HTE, NSA angles, and acetabular depth, was 0.78, 0.90, 0.90, 0.89, and 0.95, respectively. Femoral head diameter measurement was very reproducible, with a coefficient of variation of 1.6% and an intraclass correlation coefficient of 0.99.

### JSW values and correlations

The mean JSW at the apical site was 4.19 mm (SD 0.92, range 2–7).

Mean JSW values were higher at the superolateral site (4.82 mm) than at the apical site (4.19 mm), and higher at the apical site than at the superomedial site (3.61 mm). The differences were significant ($p = 0.02$ to 0.0001 according to the location) in both men and women. Women had a significantly smaller JSW than men ($p = 0.02$ to $<0.0001$ according to the location) (table 2).

In 378 hips, mean JSW was higher at the superolateral site than at the apical site and higher at the apical site than at the

**Table 4** Values of the VCE, HTE, NSA angles, and of the acetabular depth

| | Mean | SD | 95% IC | Extremes |
|---|---|---|---|---|
| VCE | 32° 28 | 6°54 | 19° 47–45° 11 | 3°; 50° |
| HTE | 3° 63 | 4° 52 | −5° 23–12° 49 | −7°; 22° |
| NSA | 132°83 | 4°37 | 124° 3–141° 4 | 120°; 144° |
| Acetatabular depth (mm) | 11.64 | 2.46 | 6.82–16.46 | 4; 24 |

superomedial site. Among the remaining 68 hips (15.2%), mean JSW was identical at the three sites in 40 cases (9%), while 28 hips (6.3%) showed lower JSW values at the superolateral site than at the apical site (18 hips), the superomedial site (9 hips), or both latter sites (1 hip).

JSW asymmetry exceeding 1.45 mm—that is, the limits of agreement—at one or more of the three sites was found in 13/221 (5.9%) patients; side to side comparison was not possible in two cases. The number of cases of asymmetric JSW at the superolateral site only, the superomedial only, both the superolateral and apical sites, and on the whole JS were 5, 3, 3, and 2, respectively.

Interestingly, JSW did not diminish with age: on the contrary, it was higher after 50 years than before 50 years. However, the difference was not significant when only subjects aged 25–50 years were compared with those aged 50–88 years (table 3).

Table 4 shows values of VCE, HTE, NSA angles, and acetabular depth. Acetabular dysplasia, considered as a VCE angle <20°, was found in nine subjects and was unilateral in all nine cases (4%). Acetabular dysplasia, defined as a VCE angle ⩽20° with acetabular depth <9 mm, was found in eight subjects (3.6%) and was unilateral in seven cases. These two groups of dysplasia, which have only slightly different definitions, almost entirely overlap with each other.

The VCE angle was inversely proportional to JSW at the apical and superomedial sites (Pearson's p = −0.27 and −0.35, respectively), whereas the HTE angle was proportional to JSW at the same sites (Pearson's p = 0.32 and 0.37, respectively) (table 5). Likewise, when we compared apical and superomedial JSW values between patients representing the 10th and 90th centiles of VCE values, the largest JSW values were associated with the smallest VCE angles, and the lowest JSW values were associated with the largest VCE angles. Similar results were obtained when the smallest and largest VCE angles were considered (⩾45° and ⩽20°) (table 6). Unlike the other angles, NSA correlated weakly, or not at all, with JSW values at the three sites (data not shown).

JSW values correlated weakly with acetabular depth ($r_s = 0.26$, 0.125, and 0.198 at the superolateral, apical, and superomedial sites, respectively). JSW values correlated moderately with femoral head diameter ($r_s = 0.28$, 0.33, and 0.27, respectively; p = 0.002).

Non-concentric acetabular roof-femoral head curves (figs 2 and 5) were found in 96 (21.5%), hips, with no significant difference between men and women. Twenty two hips (4.9%) belonged to type A (excessively arched roof), of which three were unilateral; 44 (9.9%) hips belonged to type B (excessively flat roof), of which two were unilateral; and 29 (6.5%) hips belonged to type C (angular or irregular roof with a prominent segment), of which three were unilateral.

**Table 5** Pearson coefficient of correlation (p) of JSW with the VCE and HTE angles

| | VCE | HTE |
|---|---|---|
| Superolateral JSW | −0.11 (0.02) | 0.35 (<0.009) |
| Apical JSW | −0.27 (<0.001) | 0.32 (<0.001) |
| Superomedial JSW | −0.35 (<0.001) | 0.37 (<0.001) |

**Table 6** JSW values in patients with the smallest and largest VCE angles

| | JSW differences (mm)* in VCE 10th centile (n = 29) v VCE 10th decile (n = 69) | JSW differences (mm)* in VCE = 20° (n = 14) v VCE = 45° (n = 16) |
|---|---|---|
| Superolateral JSW | 0.08 (p = 0.74) | 0.25 (p = 0.41) |
| Apical JSW | 0.89 (p<0.001) | 0.97 (p = 0.007) |
| Superomedial JS | 0.98 (p<0.001) | 1.18 (p<0.001) |

*Mean JSW differences in the three locations measured in relation to the acetabular architecture.

## DISCUSSION

The normal hip joint space width shows large interindividual variability: the SD is close to 1 mm, for a mean value close to 4 mm, depending on the site of measurement; extreme values in our series were 3–8 mm (superolateral JSW), 2–7 mm (apical JSW), and 2–6 mm (superomedial JSW) (table 2). These values are not far from other published results. In the principal studies, mean (range) JSW values at the apical site (often the only site measured) were 4 (2–7) mm,[14] 3.83 to 3.98 (2.2–6.3) mm,[12] and 4.33 (2.2–7.5) mm.[8] The last of these studies was probably the most reliable, as it used a magnifying glass with 0.01 mm graduations, rather than a simple ruler. A study of 118 normal hips of Turkish subjects, using a dial caliper with 0.02 mm graduations, gave mean values of 3.62 (0.59) mm.[10] However, the site of measurement was the JSW "narrowest point", and supine abdominal radiographs rather than pelvic radiographs were used.

In that study, as in most others, men had a larger JSW than women (3.78 (0.67) mm *v* 3.43 (0.4) mm—that is, a mean difference of 0.35 mm). Using the JSW narrowest point on intravenous urography films, a recent English study showed a similar JSW difference between men (n = 257) and women (n = 276): 0.34 mm (95% CI 0.24 to 0.44).[9] We confirm that the JSW is larger in men than in women.

The JSW does not become narrower with age,[10–12] except, according to Lanyon *et al*, in women.[9] In our series, values tended to be lower at the superolateral site in young adults (16–50 years) than in the 51–88 year age group (4.77 (1.02) mm *v* 4.89 (1.06) mm) (table 3). However, this difference was attenuated when 16–24 year olds were excluded from the "young adult" group (table 3, last column). It is noteworthy that an anatomical study of femoral head cartilage thickness showed that hyaline cartilage does not reach its maximal thickness before age 25 years.[19]

The minimal normal hip JSW value is important for epidemiological studies of OA, where a diagnostic cut off point of 2.5 mm is generally used [20]; this seems appropriate when the JSW is measured at the superolateral site, but the

**Table 7** JSW in three sites in 171 normal subjects (342 hips) mean (SD) [range]. Reproduced from Reis *et al*,[8] with permission

| | No | Superolateral | Apical | Superomedial |
|---|---|---|---|---|
| Women | 98 | 4.57 (0.69) [2.6–6.5] | 4.21 (0.68) [3.0–7.5] | 3.8 (0.67) [2.3–6.3] |
| Men | 73 | 4.96 (0.81) [2.8–7] | 4.49 (0.83) [2.2–7.4] | 3.99 (0.81) [2.4–6.8] |
| Total | 171 | 4.74 (0.81) [2.6–7] | 4.33 (0.76) [2.2–7.5] | 3.88 (0.75) [2.3–6.8] |

site of measurement is not always mentioned. In our series, the minimal JSW values were 3 mm, 2 mm, and 2 mm at the superolateral, apical, and superomedial sites, respectively (table 2). In our study, all hips with JSW <2 mm were associated with osteophytes and/or cysts, and were therefore excluded from the analysis of normal values. To define a threshold beneath which the JSW may be considered pathological, one can either choose the minimal value at the appropriate site or adopt the lower normal values, defined as mean – 2SD, that is 2.72, 2.35, and 1.81 mm, respectively, at the three sites. These values were close to the generally used cut off point, except for JSW at the superomedial site, which is rarely considered by itself for setting a limit between normal and pathological JSW. Few data have been published on this point, and our results showing a relatively thin superomedial JSW in normal hips are therefore difficult to compare with previous studies. It seems reasonable to use minimal JSW values of 3 mm, 2 mm, and 2 mm for the three sites considered (table 2).

A JSW gradient, with a decline from the superolateral site to the superomedial site (fig 1), was found in about 80% of hips in our series. To our knowledge, this JSW gradient has only been mentioned in two previous reports. Reis *et al* measured the JSW at all three sites on pelvic radiographs of 171 healthy subjects, using a magnifying glass with 0.1 mm graduations, and found higher values at the superolateral site than at the apical (''superointermediate'') site, and higher values at the apical site than at the superomedial site (table 7),[8] with a distribution similar to that found here (table 2). In another study of supine pelvic radiographs of 25 healthy men aged 45–65 years, a significant difference was also found between the mean JSW at the superolateral and superomedial sites (4.9 (1) and 4.3 (0.6) mm, respectively).[21] In most cases, it is possible to appraise the JSW gradient ''at a glance'': theoretically, JS narrowing is absent if the feature is roughly symmetric and osteophytosis is absent. If in a given patient the JSW gradient is doubtful, is it useful to measure the JSW at the three sites? We think not, as the differences in JSW according to the site of measurement are mean values that may not be applicable to all individual subjects.

Interestingly, we found identical JSW values at the three sites in 15.2% of our patients, and lower values at the superolateral site than at the apical or superomedial site in 6.2% of patients. This implies that a lower JSW value in the target hip than on the contralateral side is not sufficient to establish a diagnosis of OA when the measurement is only made at the superolateral site.

The diagnosis of early or mild OA is usually based, in part, on a comparison of the index hip and the contralateral hip. Asymmetry in normal subjects is relatively rare: taking into account only right/left differences above the limit of agreement (that is, 1.45 mm), we found 13 subjects with clear asymmetry of 1.5–2 mm. Likewise, Reis *et al*, in a ruler based study, found asymmetry of 0.6 mm or more in only 5% of cases. As in our series, Reis *et al* found that JSW asymmetry was most common at the superolateral site.[8]

The prevalence of acetabular dysplasia is interesting to consider. However, it may have been underestimated in our population (mean age 51.3 years), as OA—which was excluded from our study by definition—is often present before age 50 years in cases of dysplasia. In the present study, acetabular dysplasia was present in eight or nine subjects, depending on the definition, and it was bilateral in only one subject (see ''Results''). In contrast, coxa valga, that is an NSA angle ⩾140°, was bilateral in most of the subjects. Its borderline value (140°) was reached in five instances (bilaterally in two) and was between 141° and 144° in eight subjects (bilaterally in seven). We found no cases of acetabular protrusion as defined by Armbuster *et al*.[13] Coxa profunda, defined as an excess of covering (VCE = 45°), was found in 16 subjects (table 6).

We found no studies examining the relationship between JSW values and the congenital acetabular architecture. This architecture is characterised by the VCE or Wiberg angle and

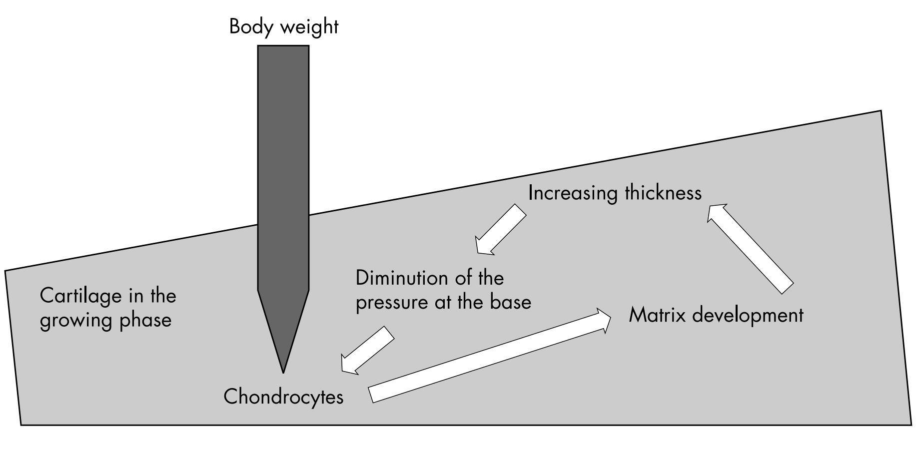


**Figure 4** Cybernetics of the growing cartilage regulating (negative) feedback. The system input is the pressure (in the standing position) exerted on cellular receptors (chondrocytes of the deep layer). These cells build the matrix, which is the outcome. The thicker the matrix (acting as a ''cushion''), the lower the pressure exerted on deep chondrocytes. At a certain point, matrix secretion stops through a lack of stimulation. Thus, the higher the pressure (/$cm^2$ in hip dysplasia), the thicker the matrix.

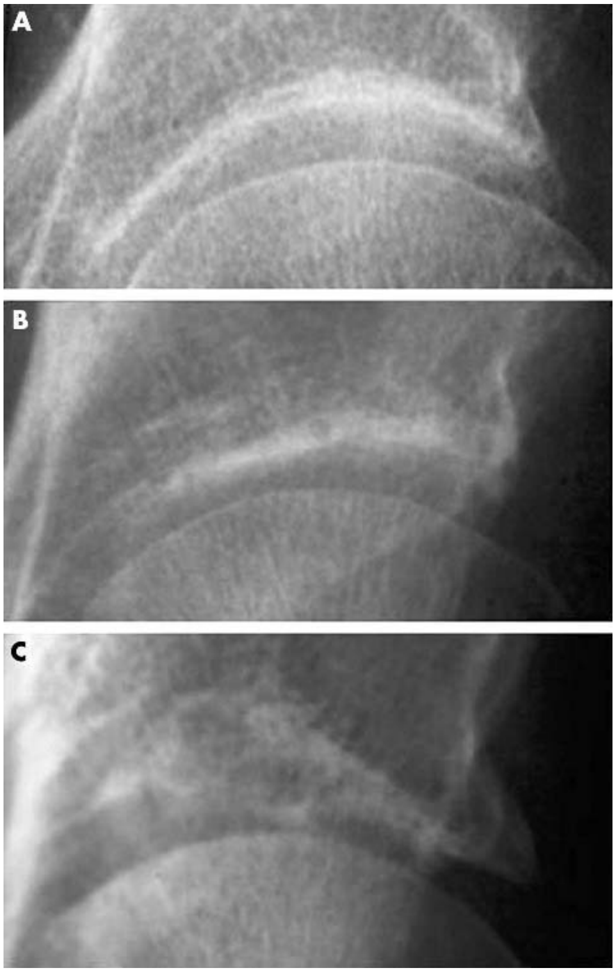


**Figure 5** Acetabular roof dysmorphias. The three main types: (A) excessively arched roof: the radius of the curve is smaller than that of the femoral head; (B) excessively flat roof: the radius of the curve is larger than that of the femoral head; (C) angular roof; note the prominent segment in the superolateral part.

by the HTE angle (roof obliquity vis a vis the horizontal axis)[14 15] (fig 2). We found a moderate but significant relationship between JSW and the VCE angle (negative correlation), and between JSW and the HTE angle (positive correlation) (table 5). In contrast, we found no relationship between JSW and either acetabular depth or the NSA angle. Mean JSW was significantly larger in hips with acetabular insufficiency and smaller in hips with coxa profunda (tables 5 and 6). We have previously postulated that these features may be explained by a self regulated increase in articular cartilage thickness during growth (fig 4)[22]; pressure on the hip cartilage would be higher in acetabular insufficiency, leading to thicker growth, while the contrary would apply in coxa profunda. Consequently, in patients with unilateral dysplasia, the hip with a normal acetabular roof would have a thinner JSW than the dysplastic hip, and this would not necessarily imply a joint space narrowing reflecting OA. Conversely, in a hip with unilateral acetabular insufficiency, OA should be considered if the JSW is the same on both sides: the possibility that the dysplastic hip might have lost a certain proportion of its normal excessive JSW should be considered. In doubtful cases, the false profile of the hip may help to diagnose early OA.[23]

A similar relationship between mechanical solicitations (dynamic and static forces) and a given anatomical configuration during development and the thickness of a cartilage or a disc is found in another study. The height of the lumbosacral disc is dependent on the configuration of the L5-S1 junction: the less mobile the L5 vertebral body (deeply situated between, and closely attached to, the medial iliac walls), the thinner the L5-S1 disc: $r = 0.618$ ($p<0.0001$).[24] A cybernetic hypothesis may be applied to this disc location, likewise: the authors suggest that the L5-S1 disc height can be evaluated and interpreted in connection with this anatomical variable—that is, the situation (level) of the L5 vertebral body, as we indicated above for the acetabular anatomy.

Various types of acetabular roof curve abnormalities (roof dysmorphias) (fig 5) were found in 21.5% of hips in our series, with no correlation with sex, the affected side, or dysplasia. These roof dysmorphias obviously alter the shape of the joint space. This finding does not imply OA in the absence of other criteria such as osteophytes or cysts. We found no published studies of such roof shape abnormalities, and no information about whether or not they represent a risk factor for OA of the hip.

This study has several limitations. The relationship of JSW with height and weight has been established in previous studies. We did not re-examine this point, as weight and even height were altered in a considerable proportion of our patients, as a result of the disease for which radiological studies were indicated. We did not record past sporting activity, the dominant side, or possible occupational overwork during adolescence, which are possible causes of JSW augmentation. The correlation of the JSW between the right and left hip was not considered; however, clear asymmetry was recorded (5.9%) and was similar to that found in another study.[8] The statistical method we chose considered all individual hips as independent, which is debatable. This choice was made prospectively, in order to avoid missing certain rare but important unilateral abnormalities. Indeed, we observed seven unilateral dysplastic hips (3.1% in our series). If only one hip for each pelvis *x* ray examination had been randomly selected, the prevalence would have fallen to 1.5%, and the risk of missing such an event in a series of 223 subjects would have been 10–15%.

In conclusion, JSW values of 446 normal hips varied widely, from 3 to 8 mm and from 2 to 6 mm at the superolateral and superomedial sites, respectively. In general, JSW decreases from the superolateral site to the superomedial site. However, no such JSW gradient is found in 21% of hips, implying that this feature alone is unreliable for the diagnosis of OA. In the same way, a small proportion of healthy subjects (5.9% in this series) show clear right/left JSW asymmetry.

Finally, the JSW should be assessed according to the acetabular configuration, being larger in dysplasia and smaller in coxa profunda, independently of OA. Likewise, roof curve abnormalities (excessive or inadequate curvature, or angularity) may create pseudo-JS narrowing, for obvious geometrical reasons.

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## REFERENCES

1 **Altman R**, Alarcon G, Appelrouth D, Bloch D, Borenstein D, Brandt K, *et al.* The American College of Rheumatology criteria for the classification and reporting osteoarthritis of the hip. *Arthritis Rheum* 1991;**34**:504–14.
2 **Croft P**, Cooper C, Wickham C, Coggon D. Defining osteoarthritis of the hip for epidemiologic studies. *Am J Epidemiol* 1990;**132**:514–22.
3 **Spector T**. Radiographic criteria for epidemiologic studies of osteoarthritis. *J Rheumatol* 1995;**22**(suppl 43):46–7.
4 **Lindberg H**, Danielsson L. The relation between labour and coxarthrosis. *Clin Orthop* 1984;**191**:159–61.
5 **Thelin A**, Jansson B, Jacobsson B, Ström H. Coxarthrosis and farm work; a case-referent study. *Am J Ind Med* 1997;**32**:497–501.
6 **Craft P**, Coggon D, Crudas M, Cooper C. Osteoarthritis of the hip: an occupational disease in farmers *BMJ* 1992;**304**:1269–72.
7 **Roach KE**, Persky V, Miles T, Budiman-Mak E. Biomechanical aspects of occupation and osteoarthritis of the hip: a case-control study. *J Rheumatol* 1994;**21**:2334–40.
8 **Reis P**, Nahal Said R, Ravaud P, Dougados M, Amor B. Are radiological joint space widths of normal hip asymmetrical? *Ann Rheum Dis* 1999;**58**:246–9.
9 **Lanyon P**, Muir K, Doherty S, Doherty M. Age and sex differences in hip joint space among asymptomatic subjects without structural change : implications for epidemiologic studies. *Arthritis Rheum* 2003;**48**:1041–6.
10 **Goker B**, Sancak A, Arac M, Shott S, Block JA. The radiographic joint space width in clinically normal hips: effects of age, gender and physical parameters. *Osteoarthritis Cartilage* 2003;**11**:328–34.
11 **Fredensborg N**, Nilsson B. The joint space in normal hip radiograms. *Radiology* 1978;**126**:325–6.
12 **Pogrund H**, Bloch R, Mogle P. The normal width of the adult hip joint. The relationship to age, sex and obesity. *Skeletal Radiol* 1983;**10**:10–12.
13 **Armbuster TG**, Guerra J Jr, Resnick D, Georgen TG, Feingold M, Niwayama G, *et al.* The adult hip: an anatomical study. Part 1: the bony landmarks. *Radiology* 1978;**128**:1–10.
14 **Delaunay S**, Dussault RG, Kaplan PA, Alford BA. Radiographic measurements of dysplastic adult hips. *Skeletal Radiol* 1997;**26**:75–81.
15 **Lequesne M**, Morvan G. Description of the potential of an arthrometer for standard and reduced radiographs suitable to measurement of angles and segments of hip, knee, foot and joint space widths. *Joint Bone Spine* 2002;**69**:282–92.
16 **Murray RO**. The aetiology of primary osteoarthritis of the hip. *BMJ* 1965;**38**:810–24.
17 **Bland JM**, Altman DG. Measurement error. *BMJ* 1996;**313**:744–8.
18 **Bland JM**, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986;**i**:307–10.
19 **Armstrong CG**, Gardner DL. Thickness and distribution of human femoral head articular cartilage. Change with age. *Ann Rheum Dis* 1977;**36**:407–12.
20 **Maetzel A**, Makela M, Hawker G, Bombardier C. Osteoarthritis of the hip and knee and mechanical occupational exposure. A systematic overview of the evidence. *J Rheumatol* 1997;**24**:1599–607.
21 **Arokoski JPA**, Arokoski MH, Voivalin T, Niemitukia L. Comparison of hip joint space width in radiographs taken in supine and standing positions in healthy men and men with hip osteoarthritis [abstract]. *Osteoarthritis Cartilage* 2000;**8**(suppl B):S64.
22 **Lequesne M**. La cybernétique des êtres vivants. *Economie Med Animale* 1972;**13**:197–211.
23 **Lequesne M**, Laredo J-D. The faux profil (oblique view) of the hip in standing position. Contribution to the evaluation of osteoarthritis of the adult hip. *Ann Rheum Dis* 1998;**57**:676–81.
24 **Inoue H**, Ormori K, Miyasaka K, Hosoe H. Radiographic evaluation of the lumbosacral disc height. *Skeletal Radiol* 1999;**28**:638–43.