The whole leg radiograph

Standing versus supine for determining axial alignment

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ABSTRACT The whole leg radiograph (WLR), the standard technique for determining axial alignment, is usually taken in a standing position, although some prefer the supine position. To determine the difference between these two positions, we performed a standing and a supine WLR in 20 patients with a varus alignment. We found an average of 2 degrees more varus deviation in the standing position than in the supine position.

The anteroposterior whole leg radiograph (WLR) is considered the gold standard for determining axial alignment and serves as the basis for planning a knee osteotomy in patients with arthrosis. Correct alignment after high tibial osteotomy (Aglietti et al. 1983, Hernigou et al. 1987, Rudan and Simurda 1990, Coventry 1993), and in total knee arthroplasty (Lotke and Ecker 1977, Dorr et al. 1985) is important. Assessment of the alignment, using the WLR in standing position, has an interobserver variability of 1.3 degrees, which is regarded as sufficient for reliable calculation of the correction (Odenbring et al. 1993).

In many studies, the WLR has been taken in a standing position (Coventry 1985, Hsu et al. 1990, Odenbring et al. 1992), but others have preferred the supine position (Hernigou et al. 1987, Ogata et al. 1991). We assessed the difference between the standing and supine WLR in the same group of patients, and the extent of rotation of the foot in very precise anteroposterior WLR in a standing position.

Patients and methods

Between June and December 2001, we prospectively included 20 consecutive patients (11 women) with clinical and radiographic arthrosis of the medial compartment of the knee. Their mean age was 55 (49–67) years. The exclusion criteria were valgus alignment of the lower extremity on clinical examination, history of a fracture of the lower extremity, and known congenital anomalies. Patients who were unable to stand on one leg were also excluded. 6 patients had had previous surgery (1 high tibial valgus osteotomy, 5 meniscectomy).

We measured the clinical alignment of the lower extremity in a standing position and the range of motion in the supine position with a goniometer. The collateral laxity was graded in a supine position with 30 degrees flexion and in full extension (Insall et al. 1976). The grade of arthrosis was measured on standard short posteroanterior radiographs in a standing position and the knee in full extension (Ahlbäck 1968).

Radiographic technique

First, the WLR in a standing position was taken: the patient stood barefoot on the affected leg with the knee in full extension, while the contralateral flexed knee was supported by a small box. The X-ray beam was centered on the affected knee with the tube at a distance of 1.5 meters. The three-part 136/36 cm cassette with graduated grid was immediately behind the patient. The 100% anteroposterior projection was ensured during lateral fluoroscopic control by superimposing the dorsal

aspect of the femoral condyles. The tube was set perpendicular to this lateral view and was moved from the proximal end to the distal end so that a whole leg radiograph was obtained.

When the standing WLR was taken, the extent of rotation of the foot (standing in a shoe box on a paper) was measured and recorded as the angle between the line of the second toe ray and the AP axis. Then, the WLR in a supine position was taken: the patient had to lie with the same leg on the cassette. The foot was held in the same amount of rotation as with the standing WLR. The tube was again at a distance of 1.5 meters. After the radiographs were developed, they were taped together.

From both radiographs, the Hip-Knee-Ankle (HKA) angles were determined twice by an independent observer who did not know whether the radiographs had been taken in a standing or supine position. Moreover, the HKA was determined by two independent observers. The intra- and interobserver variabilities are expressed as an intraclass correlation coefficient (ICC).

The HKA angle was defined as the lateral angle between two lines: one line from the center of the femur head using Mose circles to the middle of the distance between the tibial spines, and a second line from the center of the ankle to the center of the tibial spines. An angle of more than 180 degrees denoted a varus alignment.

For a 100% anteroposterior WLR, we also determined the difference (mean (SD)) and the mean extent of rotation of the foot.

Differences between the standing and supine positions were analyzed with the paired t-test. Pearson's test was used to analyze the correlation between the grade of arthrosis and the HKA angle, the extent of rotation and the grade of collateral laxity, as well as between the collateral laxity and the HKA angle. A p-value of 0.05 was considered significant.

We also assessed the difference between the two methods for measuring the HKA angle, which had been plotted against the average of these two methods, using the method of Bland and Altman's method (1986).

Results

The lateral collateral laxity was grade 1 (0–5 degrees) in 16 knees and grade 2 (5–15 degrees) in 4 knees. The severity of arthrosis (Ahlbäck 1968) in the medial compartment was grade 1 in 13 knees, grade 2 in 6 and grade 3 in 1.

The mean HKA angle of the standing WLR was 187 (182–196) degrees, but that of the supine WLR was 185 (180–194) degrees (Table). In men the mean HKA angle was 189 degrees standing and 187 degrees supine; in women, it was 185 degrees standing and 182 degrees supine.

In all patients, the mean difference between the HKA angles measured standing and supine was 2 (range 1–3; SD 0.45) degrees (paired t-test; $p < 0.001$), and more varus deviation was measured in the standing position than in the supine. We found no obvious relation between the difference between the methods and the average values. If we adjust for the almost consistent bias of two degrees by subtracting d (mean difference) from the alternative method, the difference will remain less than one degree.

The intraobserver variability and interobserver variability were low: ICC = 0.98; 95% CI = 0.94–0.99 and ICC = 0.97; 95% CI = 0.94–0.99, respectively.

The mean extent of rotation for a 100% anteroposterior WLR in the standing position with lateral fluoroscopic control was 20 degrees external rotation (range 7–34; SD 8.1); the mean extent of rotation in men was 16 degrees compared with 22 degrees in women.

We found a correlation between the grade of arthrosis and the HKA angle both standing (Pearson correlation 0.75; $p < 0.001$) and supine (Pearson correlation 0.75; $p < 0.001$).

The correlation between the grade of arthrosis and extent of rotation (Pearson correlation –0.15; $p = 0.5$) and between the grade of collateral laxity were not significant (Pearson correlation 0.30; $p = 0.2$). There was also no correlation between the grade of collateral ligamentous laxity and the HKA angle standing (Pearson correlation 0.31; $p = 0.2$) or supine (Pearson correlation 0.38; $p = 0.1$).

HKA angle measured on whole leg radiographs, standing versus supine

Case no.	Age (years)	Sex F/M	Ligament laxity	Grade of arthrosis	HKA standing (Ahlbäck)	HKA supine	Difference	External rotation
1	54	F	1	1	186	184	–2	34
2	63	F	1	2	188	186	–2	29
3	51	M	1	2	189	187	–2	19
4	67	M	1	2	187	185	–2	7
5	52	F	1	1	185	184	–1	28
6	50	M	1	1	187	185	–2	10
7	53	F	1	1	182	180	–2	21
8	60	M	2	2	187	186	–1	18
9	49	M	2	3	196	194	–2	16
10	58	M	1	1	188	186	–2	23
11	61	M	1	1	186	184	–2	18
12	53	F	1	1	182	180	–2	25
13	52	F	1	1	186	184	–2	9
14	54	M	1	2	188	186	–2	15
15	56	F	1	1	184	182	–2	10
16	60	M	1	2	196	193	–3	22
17	52	F	1	1	186	184	–2	7
18	51	F	1	1	184	182	–2	29
19	53	F	2	1	186	184	–2	32
20	52	F	2	1	188	187	–1	18

Discussion

We found an average of 2 degrees more varus deviation in the standing than in the supine WLR.

None of the patients had gross abnormal collateral laxity. In patients with an increase in ligamentous laxity, the difference between the standing and supine WLR may be even greater than that found in our patients. Edholm et al. (1976) in an orthoradiographic study with healthy persons, found that knee instability affects the HKA angle.

Sanfridsson et al. (1996) noted less varus alignment in the two-leg stance than in the one-leg stance WLR, because the one-leg stance forces the knee in varus against the lateral stabilizing structures.

A WLR in supine position may be better in patients with abnormal laxity of the lateral collateral ligament, because lateral tibiofemoral separation increases the varus angulation on the WLR in thestanding position, which causes overcorrection in case of a high tibial osteotomy (Hernigou et al. 1987, Dugdale et al. 1992). Ogata et al. (1991) recommended taking WLR in the supine position in all patients in order to evaluate the stretched ligamental structures and the condylar-plateau angle when planning high tibial osteotomy.

In practice, it is not always possible to take a WLR in the standing position because of pain and/or instability of the affected knee (Johnson et al. 1980, Grelsamer 1995). Moreover, the WLR in a standing position with 100% anteroposterior projection is time consuming, more costly, and exposure to radiographic radiation is greater because of the lateral fluoroscopic control. The exposure to radiographic radiation can be reduced by modern techniques (Sanfridsson et al. 1996), but is less accurate if the patient has an extension lag of the knee (Krackow et al. 1990).

The intra- and interobserver variabilities of the measurement of the HKA angle that we found were similar to those of Odenbring et al. (1992) and Sanfridsson et al. (1996).

On the basis of the above-mentioned reports and our findings, we recommend a WLR in the supine position. One should bear in mind that a WLR in the standing position results in two degrees more varus deviation than in the supine position. Secondly, if the anteroposterior WLR is not taken using lateral fluoroscopic control, we recommend that the radiograph should be taken with the affected leg in full extension and at 20 degrees of external rotation.

No competing interests declared.

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