Technical Note

Fluoroscopically Assisted Stress Radiography for Varus-Valgus Stability Assessment in Flexion After Total Knee Arthroplasty

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Abstract: A radiographic technique to quantify varus and valgus joint laxity in flexion after total knee arthroplasty (TKA) was evaluated by means of inter-rater assessment in 12 patients. The test was shown to have good reliability. The simple method helps to detect instability in knee flexion that might be overlooked in a conventional clinical examination. **Key words:** knee, arthroplasty, stability, laxity, stress, flexion, varus, valgus.

In total knee arthroplasty (TKA), over-resection of the posterior femoral condyle may lead to varus or valgus instability in knee flexion without affecting stability in extension. It has therefore been proposed that varus-valgus stability should not only be assessed in extension, but rather over the entire range of motion [1]. However, clinical assessment of varus and valgus stability in knee flexion is not always precise, because as the flexed knee is stressed into the varus or valgus direction, tibiofemoral varus-valgus tilt can barely be distinguished from simultaneous hip rotation. Furthermore, as the knee is stressed, the amount of medial or lateral joint opening is difficult to palpate, especially in obese patients. Because there appears to be no better method than the clinical examination for assessing knee joint opening in flexion, the goal of this study was to evaluate a radiographic measurement technique.

The radiographic examination was performed with the patient lying on a radiolucent board consisting of 3 parts connected by hinges with the hip and knee joints flexed to 80° (Fig. 1). The hinge at the hip level allowed the thigh to be guided in adduction or abduction. The hinge at the knee level allowed the knee flexion angle to be varied. The board below the thigh was adjustable to individual thigh length to stabilize the thigh distally in a holster. The thigh was free to rotate within the holster. The buttocks touched the board below the thigh. With a spring scale a force of 50 N applied 0.3 m (12 inches) distal to the tibiofemoral joint perpendicular to the lower leg. The board below the thigh was rotated to adduct or abduct the thigh so that a sagittal radiograph of the femoral component could be taken (Fig. 2). The knee flexion angle was altered to produce the narrowest projection of the plateau of the tibial component. The diode was

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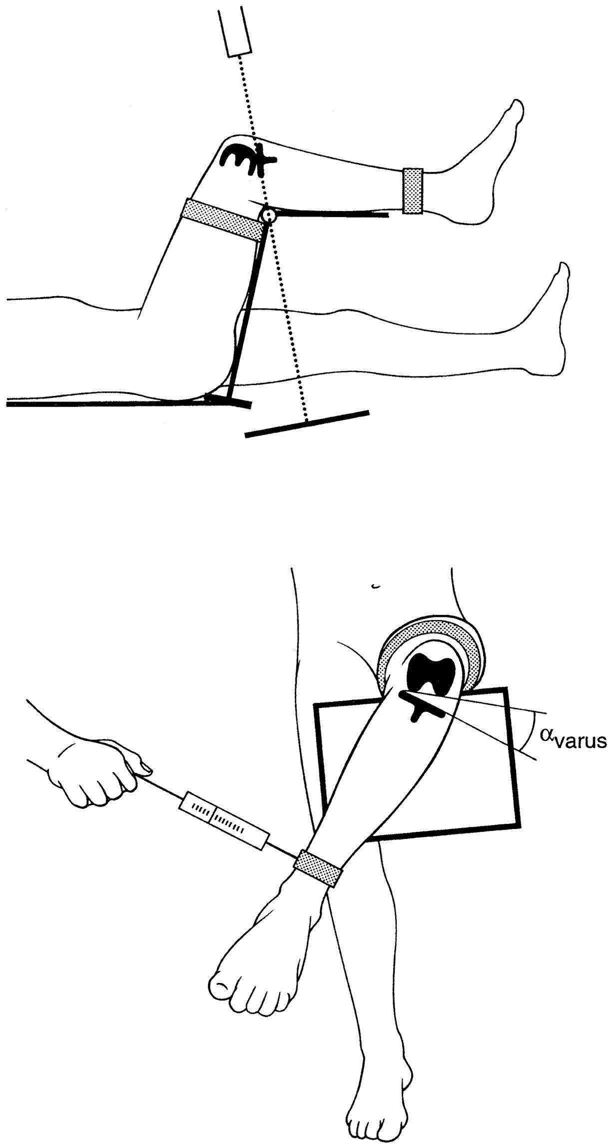

Fig. 1. The radiographic examination was performed with the patient lying on a radiolucent board consisting of 3 parts connected by hinges with the hip and knee joints flexed to 80°.

tilted 5° craniocaudal from the vertical. The fluoroscopy emission time until X-ray capture at 70 KV and 80 to 250 mAs was usually less than 3 seconds per radiogram. On the radiogram, the angle between the tangent of the femoral condyles and the tibial plateau (α_{varus}, α_{valgus}) was measured.

We use this method regularly in patients with knee pain after TKA for an unknown reason, instability in the clinical examination after TKA, and for planning revision arthroplasty. In 12 patients, the testing procedure and the measurements were performed independently by an orthopaedic surgeon (T.S.) and a radiologist (C.P). The patients gave informed consent to participate in the ethical approved study. The reliability of repeated measurements was assessed by determining the intraclass correlation coefficient. To examine the level of agreement between the 2 raters, the method recommended by Bland and Altman [2] was also used.

The intraclass correlation coefficient was 0.93 (95% confidence interval 0.84 to 0.97), which is high and shows that the measurements made by the 2 raters were well correlated. The bias or systematic error between the 2 raters was −0.5° (95% confidence interval, −0.1 to 1.2), which is minimal. The standard deviation (SD) of the differences between individual pairs of measurements, also denoted as SD of bias (precision value), was 1.6°. Thus, the "limits of agreement" (given by the bias ± 2 SD) were 2.7° to −3.7° (Fig. 3). This means that in 95% of cases, rater one could be expected to yield values that were between 2.7° higher and 3.7° lower than rater two.

With the present technique, an external moment was applied to the knee at a magnitude similar to that used during the clinical examination for varus/valgus stability [3]. This moment was well tolerated, without causing pain in most of the patients examined. Therefore, induced muscle contraction and subsequent tibiofemoral stabilization (falsely) decreasing the joint opening could be minimized without use of local anesthesia.

Flexion gap laxity evaluation is normally performed in 90° flexion. However, fluoroscopic examination in 90° flexion was not possible, because in this position, the soft tissues of the thigh and

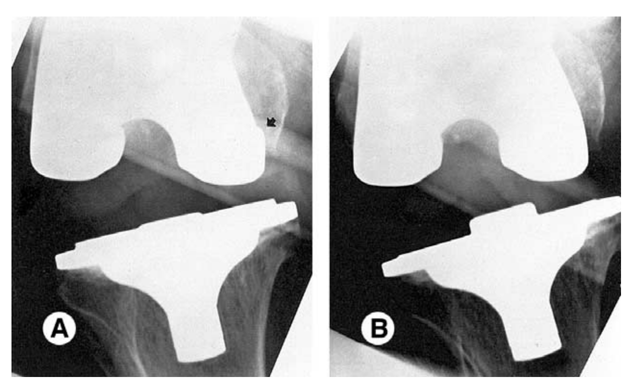

Fig. 2. Varus stress radiograms with two different projections of the femoral component. (A) The dorsal end of the femoral component forms a sharp convex contour (arrow) indicating insufficient positioning of the thigh in the adduction-abduction plane for a strictly sagittal radiograph. (B) The sharp convex contour has disappeared indicating correct positioning.

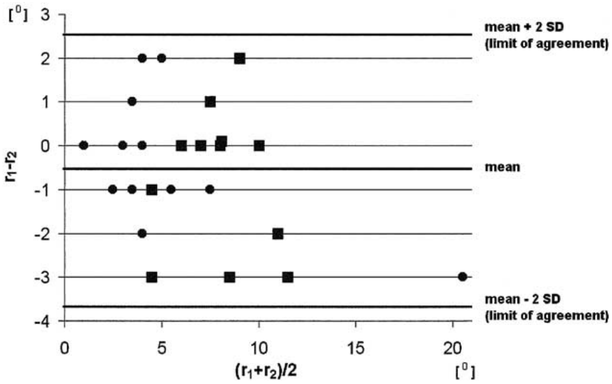

Fig. 3. Diagram for the mean of repeated measurement values (of r_1 and r_2) and the differences between repeated measurement values. Black box represents α_{varus} values; black diamond represents α_{valgus} values.

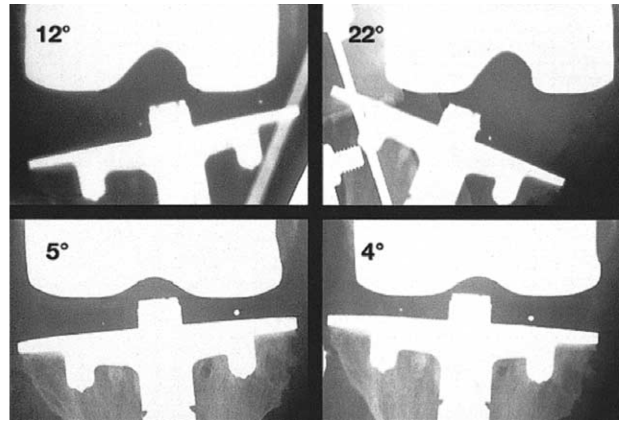

Fig. 4. Radiographs of one knee of an obese patient. A varus moment (radiographs on the left side) and a valgus moment (radiographs on the right side) were applied in knee flexion (top radiographs) and extension (bottom radiographs). The radiographs in extension were performed with the same external force application as in flexion (15 Nm). The radiographs in flexion show high joint opening (α_{varus}: 12°; α_{valgus}: 22°) and major displacement as the valgus moment is applied. These findings are not present in the radiographs in extension. These findings were also missed in the clinical examination performed independently by three of the authors (T.S., O.K., J.R.). The top radiographs show screw and stripe artifacts from the first generation device.

buttocks cover the condyles of the femoral component in the radiographic projection. We assume, however, that the difference in joint opening at 80° knee flexion, as measured with the present technique, is negligible.

This simple method helps to detect instability in knee flexion, which may otherwise be overlooked in the clinical examination (Fig. 4).

References

1. Insall JN, Dorr LD, Scott RD, Scott WN: Rationale of the Knee Society clinical rating system. Clin Orthop 248:13, 1989
2. Bland MJ, Altman DG: Statistical methods for assessing agreement between two methods of clinical measurements. Lancet 1:307, 1986
3. Grood ES, Nowes FR, Butler DL, Suntay WJ: Ligamentous and capsular restraints preventing straight medial and lateral laxity in intact human cadaver knees. J Bone Joint Surg Am 63:1257, 1981