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Relationships between tibial rim alignment and joint space width measurement reproducibility in non-fluoroscopic radiographs of osteoarthritic knees

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Summary

Rationale: Superimposition of the rims of the medial tibial plateau to within 1 mm is an aim of fluoroscopic knee positioning protocols for osteoarthritic (OA) knee radiography and has also been proposed as a measure of quality for non-fluoroscopic methods.

Objective: To evaluate the effect of tibial rim alignment (TRA) on reproducibility of joint space width (JSW) measurement, both were measured from radiographs taken with each tibial plateau at a range of angles determined by different non-fluoroscopic views.

Methods: TRA and JSW measurements were taken from both knees of 100 OA patients each radiographed in fully extended, schuss/tunnel, and MTP views. Degree of TRA was compared with JSW reproducibility using correlation, and between groups defined both by the 1 mm threshold and by TRA-defined quartiles.

Results: JSW reproducibility was dependent on the degree of TRA in the fully extended and schuss/tunnel flexed knee views, although the use of the specific TRA threshold of 1 mm was not supported. In the MTP view, JSW measurement was found to be highly reproducible across the full range of TRA values.

Conclusion: These results contradict claims that TRA to within 1 mm is essential for useful measurement of JSW. It is an arbitrary threshold, of use in quality control (QC) for protocols which explicitly require such alignment, and the choice of QC criteria for other protocols should be evaluated on a view-by-view basis. The results confirm previous studies showing the MTP view to afford highly reproducible JSW measurement.

Key words: Osteoarthritis, Knee, Radiography, Non-fluoroscopic, Joint space, Tibial rim alignment.

Introduction

Assessment of medial tibiofemoral joint space width (JSW) from weightbearing anteroposterior (AP) or posteroanterior (PA) knee X-rays, as a surrogate for cartilage destruction[1], remains the most sensitive, accurate, and practical method for monitoring the progress of osteoarthritis (OA)[2,3]. The reproducibility and clinical relevance of such measurements is highly dependent on the technique used to reposition the knee for radiography[4,5].

Fluoroscopic methods are able to achieve the desired levels of reproducibility by directly controlling the appearance of the radiographic image[6], and have been shown to be able to detect disease progression[7]. In recent years, there has been a move towards non-fluoroscopic positioning because it requires less expensive radiographic equipment and training of personnel[5,8]. These non-fluoroscopic methods have been evaluated by looking at the reproducibility and sensitivity to change of the resulting JSW measurements, and also by looking at the appearance of the tibial plateau in the compartment being measured[9–13].

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The radiographic appearance of the concave surface of the medial tibial plateau is typically that of three roughly horizontal lines corresponding to the floor of the plateau and the anterior and posterior parts of its rim[9]. In measuring JSW, it is the line corresponding to the floor of the plateau that provides the tibial landmark for measurement (Fig. 1). It is therefore essential that the floor is close to being parallel to the direction of X-ray projection through it, in order for such a line to be produced in the radiographic image. In contrast, the convex shape of the femur guarantees the existence of the edge line which serves as the other landmark for JSW measurement (Figs. 1 and 2).

The concept of aligning the images of the posterior and anterior rims of the medial tibial plateau (R1 and R2 in Fig. 1) was introduced as a way of achieving the horizontal plateau specified by the protocol for fluoroscopic semi-flexed positioning of the knee[6]. Superimposition of these lines to within 1 mm was subsequently published as a radiographic quality control (QC) criterion for clinical trials using the technique[14,15].

The use of this 1 mm threshold has since been proposed as an indicator of sensitivity to longitudinal change in JSW for other radiographic protocols both fluoroscopic (Lyon schuss and fully extended views[16,17]) and non-fluoroscopic (fully extended[10] and MTP views[11,13]). In the fluoroscopic techniques, close alignment of the tibial rim lines is the explicit aim of fluoroscopy, and so the applicability of such

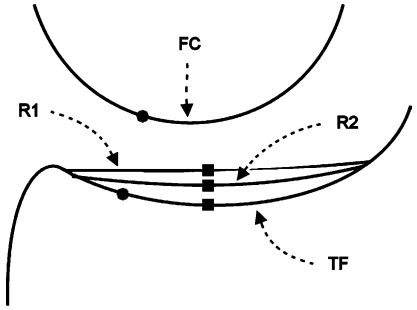

Fig. 1. Diagram of the typical AP radiographic appearance of the medial compartment of the knee, showing the lines representing the femoral condyle (FC), the tibial plateau (TF), and the anterior and posterior rims of the tibial plateau (R1 & R2). Note that which of R1 and R2 is anterior/posterior cannot always be ascertained from such a projection. The circles on FC and TF show the points between which the minimum JSW was measured. The squares on R1, R2, and TF show the points used for measurement of TRA.

a criterion can be assumed. However, since non-fluoroscopic techniques were not designed with the intention of exactly reproducing the view of a fluoroscopic method, the relevance of this ''1 mm criterion'' to non-fluoroscopic views is less clear. The aim of this paper is to examine whether there are grounds for using it as an indicator of radiographic quality in such views by examining the effect of tibial rim alignment (TRA) on short-term reproducibility of JSW measurement.

The hypothesis that the 1 mm criterion for TRA is a valid QC criterion for non-fluoroscopic knee radiography is examined in this paper by comparing continuous TRA values obtained using a new computerised method of measurement with computerised minimum JSW measurements. Measurements were obtained from the films taken for a previous study, which was unusual in that the knees of a group of OA patients were each radiographed using three

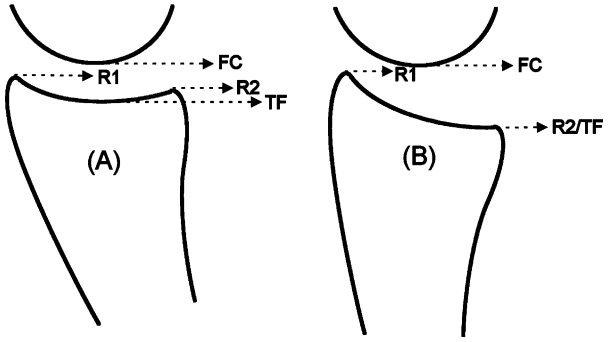

Fig. 2. Diagram of the lateral view of AP radiographic projections through the knee, in semi-flexed (A) and fully extended (B) positions. The arrows show the anatomical structures that create the radiographic features used for measurement of JSW and TRA. In the semi-flexed view (A) the tibial floor is close to being horizontal, so as to create three distinct tibial lines. This corresponds to the radiographic appearance shown in Figs. 1 and 3(B). In the fully extended view, the tibial floor can be tilted to the degree shown in (B), where the radiographic projection of that floor can become superimposed on that of the posterior rim [see also Fig. 3(C)]. If the tibial floor is tilted even further, this combined line may become totally indistinct [see Fig. 3(D)]. Because of the convex shape of the femoral condyle, the radiographic appearance of its edge is not dependent on the knee position.

different non-fluoroscopic protocols, providing three different tibial angles[9]. Thus, the appropriateness of the 1 mm criterion in assessing the quality of radiographs taken using these protocols could be investigated with regard to its effect on JSW reproducibility.

Patients and methods

PATIENTS AND KNEES

One hundred patients with knee pain and radiographic signs of OA (joint space narrowing and/or osteophytosis) were recruited to the study through a screening program for the disease in Wichita, Kansas. The 74 women and 26 men had a mean age of 66.1 (64.1, 68.1) years, a mean body mass index (BMI) of 29.3 (28.1, 30.5) kg/m, and a median disease duration of 10.1 (8.0, 12.1) years. All parenthesised intervals are 95% confidence intervals (CI).

Knees with lateral compartment disease, if identified as such by the rheumatologist (FW) from any of the study radiographs, were also excluded because of the different characteristics of that disease compared to the more common medial compartment version which lead to their normal exclusion from clinical trials[18,19], including the fact that JSW measurement has been shown to be more variable in the medial compartments of knees with lateral compartment disease[20,21]. Additionally, radiographs in which the JSW was found to be zero (bone-on-bone) were omitted, because their lack of further progression makes them unsuitable for clinical trials of OA therapies and because precise measurement of JSW and TRA from such knees was not possible. These omissions were made on a view-wise basis in order that the study radiographs would represent, as far as possible, those which would be used in practice in a clinical trial.

RADIOGRAPHIC METHOD

Both knees of each of the patients were radiographed twice on the same day and within a 2 h time interval, using each of three positioning protocols. All three protocols produced bilateral views using a film to focus distance of 100 cm and a vertical film cassette holder. In all three, the patients stood with the weight distributed equally on both feet; the central X-ray beam was directed halfway between the centres of the two knee joints; and a foot map was created on the first visit to facilitate repositioning. The three views differed as follows:

''AP'' was the AP fully extended view, with the feet together and the posterior surfaces of both knees placed as close as possible to the film cassette to minimise radiographic magnification and associated penumbral blurring[22].

''MTP'' or metatarsophalangeal view was a PA semi-flexed view in which flexion of approximately 7–10° was achieved by aligning the first metatarsophalangeal joints vertically below the front edge of the film cassette, with the feet externally rotated to about 15°, and having the patient bend their knees until the anterior surface of the knees touched the middle of the front of the film cassette[9].

''P20'' was a schuss/tunnel type PA view in which the fronts of the big toes were aligned with the front edge of the film cassette, with the feet externally rotated to about 15°. In this view, bending the knees until the anterior