Distribution of Bone Mineral Density at the Proximal Tibia in Knee Osteoarthritis

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Abstract. One hundred and thirteen knees with osteoarthritis (OA) were studied to assess the distribution of bone mineral density (BMD) in the proximal tibia and the potential relation between osteoarthritis and osteoporosis in evaluating hip BMD. All patients had severe knee pain and were diagnosed with Kellgren and Lawrence grade IV osteoarthritis. According to the magnitude of the axial deformity, four categories were created: varus > 10° (28.3%), varus 4–10° (38.9%), aligned 180 ± 3° (13.3%), and valgus > 4° (19.5%). For each category, the medial and lateral proximal tibial density were assessed. BMD was measured at the femoral neck and at 14 regions of interest (ROI) in the proximal part of the tibia using dual X-ray absorptiometry. Based on the femoral neck BMD, patients were classified according to the World Health Organization (WHO) definition of osteoporosis. The mean knee BMD was positively correlated with the hip BMD value (knee BMDm = 0.38 + 0.73 × hip BMD, r = 0.60, P < 0.001). The knee BMD distribution of the 113 patients was negatively correlated with the axial deformity (BMDMT-LT = 5.15–0.027 × HKA, r = 0.77, P < 0.0001). In the varus deformity, BMD of the medial side was higher than that of the lateral side with an important asymmetry (0.587 g/cm²). This asymmetry was also found in the valgus deformity for the lateral side but was less important (~0.112 g/cm²). With equal deformity, the asymmetry of BMD was higher in varus deformity (0.587 g/cm²) than in valgus deformity (~0.112 g/cm²). Asymmetry of the knee BMD distribution revealed that progression of the deformity (either varus or valgus) with joint space narrowing led to an increase in the mediolateral difference of the proximal tibia density. Lesser severity of Kellgren and Lawrence grades may reveal different results. Twenty patients with osteoporosis developed knee osteoarthritis (OA) and the relation between osteoporosis and knee OA remains unclear.

Key words: Axial deformity — Bone mineral density — DXA — Knee osteoarthritis — Osteoporosis

In the osteoarthritic knee, changes of osteosclerosis under the tibial compartment affected can be identified as an area of increased bone mineral density (BMD) adjacent to the articular surface. According to Wolff’s law [1], the bone architecture of the proximal tibia is dictated by the mechanical stresses applied to the bone. Studies [2–4] have confirmed that functional loading to the bone induces variations of bone mass. The BMD of the proximal tibia is a good indicator of the bone strength of the tibia [5].

There have been many studies on the relationship between osteoporosis and osteoarthritis, especially with hip osteoarthritis (OA) [6–8] or hand osteoarthritis [9]. Osteoporosis and OA rarely occur together and it has been suggested that there may be an inverse relationship between them [10, 11]. The association between BMD measurements and OA of the knee remains uncertain. Different studies suggested that the femoral BMD [12] or lumbar spine BMD [6] was higher in patients with osteophytes at the knee but was not necessarily associated with the narrowing of the joint space. Yokozeki et al. [13] found that spine BMD was significantly higher in patients with severe osteoarthritis than in normal patients. On the other hand, Malluche et al. [14] observed osteoporosis in all of their 12 patients who had total knee arthroplasty for degenerative arthritis. It has been established that at least 30% of BMD changes are required before they are detectable radiographically. Dual X-ray absorptiometry (DXA) has become a standard and reliable method for screening and follow-up of osteoporosis at the lumbar spine and at the proximal femur. However, there have been few studies on BMD of the tibia in patients with knee osteoarthritis.

The purpose of our study was (1) to examine the effect of knee osteoarthritis on the distribution of BMD in the proximal tibia in an antero-posterior projection,
and (2) to compare the knee BMD OA with the hip BMD measurement in order to evaluate a potential relationship between knee OA and osteoporosis.

Materials and Methods

Between September 96 and December 98, 113 consecutive patients with severe knee pain, primary osteoarthritis, who were scheduled for a total knee arthroplasty Jade® (Stryker-Howmedica Co., Rutherford, New Jersey, USA) were included in this study which was approved by the local ethics committee. The inclusion criteria were initial age over 55 years, severe knee pain, primary osteoarthritis with a narrowing of the joint space greater than 50% on weight bearing anterior-posterior view compared with the unaffected knee, no other pathology in the ipsilateral leg, and not taking fluoride-containing medications. Patients with a history of total hip replacement who were pain free for more than 5 years were also included (4 cases). Exclusion criteria included rheumatoid arthritis, corticosteroid medication, and history of a fracture.

One hundred and thirteen patients entered the study (42 men and 71 women). The right side was affected in 62 cases and the left side in 51 cases. The mean age was 71 ± 5 years, mean height was 164 ± 9 cm, and mean weight was 77 ± 15 kg. The mean age was similar for men and women. The mean body mass index (BMI) was 28.6 ± 4.8 kg/m² and was not influenced by sex. Before surgery, all patients were assessed clinically and radiographically according to the International Knee Society score [15]. This score with a total of 200 points was divided into two subscores: the Knee score (normal = 100 points) and the Function score (normal = 100 points). The Knee score focused on pain, range of motion, and stability. The Function score focused on the walking distance, stairs climbing, and crutches. The mean Knee and Function scores were 35 ± 17 and 46 ± 16 points, respectively. The mean range of motion before surgery was 104 ± 17°.

Standing anteroposterior X-rays and long cassette lower extremity views were taken. The knee radiographs were graded for OA based on the involved knee according to Kellgren and Lawrence [16] criteria (grade 0 = normal; grade I = possible osteophytes only; grade II = definite osteophytes and possible joint space narrowing; grade III = moderate osteophytes and/or definite narrowing; and grade IV = large osteophytes severe joint space narrowing and/or bony sclerosis). For each knee, three angles were measured to assess the axial deformity of each knee (Fig. 1): the femoro tibial angle (HTA) between the mechanical axis of the femur (hip joint centre-knee joint centre) and the anatomical axis of the tibia (knee joint centrelateral joint centre), the femoral angle (HTI) between the tangent to knee joint and the mechanical axis of the femur and the tibial axis (AKI) between the tangent to the knee joint and the anatomical axis of the tibia. These angles were by convention always measured inside and the normal values were respectively: 180°, 90° and 90°. A patient with severe varus deformity had a lower HTA angle. On the contrary, a patient with a severe valgus deformity had a higher HTA angle.

All 113 patients were Kellgren and Lawrence grade IV. The mean femoro tibial (HTA) angle was 176 ± 9°, the mean femoral mechanical angle (HTI) was 91 ± 5°, and the mean tibial mechanical angle (AKI) was 85 ± 6°. Most of the patients had varus deformities (67%). According to the magnitude of the axial deformity, four categories were created: varus > 10° (32 cases (28.3%)) varus (4–10° (44 cases (39.9%)), aligned (180 ± 3°) (15 cases (13.3%)), and valgus > 4° (22 cases (19.5%)).

The day before surgery, two DXA scans were performed using a Hologic QDR 4500 A® (Hologic, Waltham, MA, USA) for measurement of BMD (g/cm²). Daily quality controls were performed on the machine using the Shewhart Rules with a standardized phantom provided by the manufacturer and a stairs step phantom. For each patient, the hip BMD, assessed by the measure of the femoral neck, was performed to assess the global mineral status compared with the mean of young healthy men or women [T-score, expressed in number of standard deviation (SD)] and to the mean of an age-adjusted reference group (Z-score). The normative database used for assessment of the T-score was extracted from the NHANES III (Looker et al.) [17]. Three categories previously defined by the WHO [18] were used: normal (NL, T-score > −1), osteopenia (OPN, −1 ≥ T-score > −2.5), and osteoporosis (OPR, T-score ≤ −2.5). They were applied for women and men (Selby et al. [19]). DXA scan for the involved knee was performed on each patient in supine position, with the affecte knee extended. The foot was fixed in an upright position in a foot holder to ensure correct

Fig. 1. X-ray analysis of the femoro tibial angle.