DETERMINATION OF THE PRECISION OF DUAL ENERGY X-RAY ABSORPTIOMETRY (DEXA) WHEN APPLIED AT THE KNEE

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Introduction: Dual energy x-ray absorptiometry (DEXA) is one of the most widely used methods measuring periprosthetic bone mineral density (BMD). Several reports have presented the precision of DEXA when used at the hip, whereas similar reports on factors influencing the precision at the knee are sparse. There are two noticeable aspects when measuring BMD at the knee. First, no software specific for the knee has been developed. In stead, the BMD measurements have to be performed by using software developed for the hip. Second, the limited amount of soft tissue around knee may cause problems for the densitometer to determine the baseline for the BMD measurement. Therefore different soft tissue equivalents (rice bags, Plexiglas rod) have been developed to aid the measurements. The effect of these on the precision has, however, not been presented. When using DEXA in analyzing the longitudinal bone remodeling around total knee arthroplasty (TKA) occurring after operation, knowledge about factors influencing the precision is required.
The aim of this study, therefore, was to analyze which factors influence the precision of DEXA when applied to the knee.
Methods: *Subjects:* 12 knees in 10 patients (6 women and 4 men, mean age 70 years) operated with TKA 1 to 3 years previously were investigated. In 3 of the patients the contra-lateral non-operated knee was also investigated. All prosthetic knees were operated with the Miller-Galante II TKA (Zimmer, Warsaw, Indiana, U.S.A.). The tibial component had 4 pegs but no stem. In 6 knees the implants were uncemented, and 6 were cemented.
Bone densitometer: A dual energy x-ray absorptiometer (DPX-L, Lunar Corp., Wisconsin, U.S.A.) with a fast 3000 μA scan model was used. To evaluate the effect of different soft tissue equivalents, scans were performed either with a 150-mm long Plexiglas rod positioned in the detector opening, or with rice bags placed around the knee.

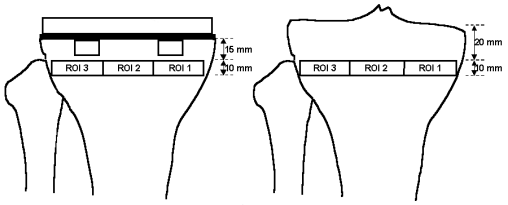

Fig. 1.

BMD measurements: All scans were performed in the frontal plane. The scan width was 150 mm, and the scan length was 90 mm starting about 60 mm below the knee. The ROI:s analyzed are shown in Fig. 1. We used the software "*Orthopedic*" (Lunar Corp., Wisconsin, U.S.A.), in the "*manual analysis*" mode. In all knees, 5 consecutive scans were performed using the Plexiglas rod as a soft tissue substitute. At the first scan the knee was positioned in neutral rotation. The second scan was performed immediately after the first with no repositioning of the knee. The third to fifth scans were performed with the knee in neutral rotation, 15° external rotation, and 15° internal rotation, respectively. Before performing each of these 3 latter scans the patients were allowed to ambulate. In 9 of the operated knees, a sixth and a seventh scan was performed with rice bags around the knee as a soft tissue substitute in stead of the Plexiglas rod. Between the 6th and the 7th scans the patients ambulated. The first (and 6th) scans served as the reference and the subsequent scans were compared with the reference, thus making up 4 + 2 different paired scans.
The *Orthopedic* software automatically sets up a base value (*BV*), which serves as an "attenuation threshold". The difference in base value (Δ*BV*) was calculated for each paired scan and compared with the coefficient of variation (C.V.) for that scan.
Statistics: Non parametric Friedman and Mann-Whitney U test.

Results: The precision in the respective ROI:s are displayed in Tables 1 - 3. Precision tended to be lower in ROI 2 where the BMD generally was lower.

Table 1. Precision (CV, %) in 12 prosthetic knees using Plexiglas rod

Scan	ROI 1	ROI 2	ROI 3	*P* betw. ROI:s	Overall
1st to 2nd	8.5	14.7	10.6	ns	10.2
1st to 3rd	7.9	12.5	10.8	0.046	9.0
1st to 4th	5.4	12.4	6.1	ns	5.1
1st to 5th	3.0	13.6	8.5	0.004	5.2
P betw. scans					ns

Table 2. Precision (CV, %) in 3 non-operated knees using Plexiglas rod

Scan	ROI 1	ROI 2	ROI 3	*P* betw. ROI:s	Overall
1st to 2nd	6.5	15.4	3.2	ns	7.0
1st to 3rd	10.4	16.9	6.1	ns	9.7
1st to 4th	3.2	10.5	7.6	ns	3.4
1st to 5th	4.7	10.8	6.2	ns	5.6
P betw. Scans					ns

Table 3. Precision (CV, %) in 9 prosthetic knees using rice bags

Scan	ROI 1	ROI 2	ROI 3	*P* betw. ROI:s	Overall
6th to 7th	7.0	10.1	8.2	ns	7.3

Comparison of the precision between the 12 operated knees (Table 1) and the 3 non-operated knees (Table 2) at each paired scan revealed no statistically significant differences. Comparison of the precision between the Plexiglas rod (Table 1, scan 1st to 3rd) and rice bags (Table 3, scan 6th to 7th) revealed no statistically significant differences between these two soft tissue substitutes.

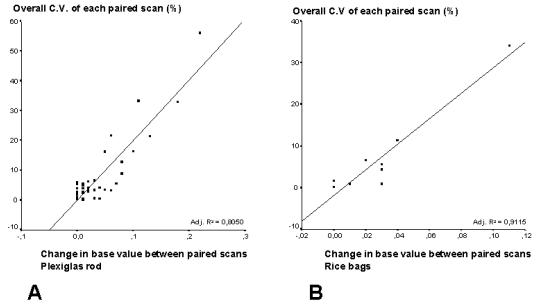

Fig. 2.

Linear regression analysis revealed a high correlation between (Δ*BV*) and the CV value at the corresponding paired scan, both with Plexiglas rod (Fig. 2A) and rice bags (Fig. 2B)..
Conclusion: The overall precision varied between different parts of the knee. Precision was higher in bone with high bone mineral density (BMD) and lower in bone with low BMD. Variations of 15° in external or internal rotation of the knee did not influence on the precision, which probably was caused by the use of rather large and regularly shaped regions of interest. There was no difference in precision between the Plexiglas rod and the rice bags. The presence of the metallic prosthesis in the scanning area did not affect the precision. The variation in precision was mainly explained by an inconsistency of the densitometer software in establishing a tissue baseline for the entire scan region. The seemingly spontaneous variation in tissue baseline value was highly correlated with the resulting precision. Whether this was caused by the use of a non knee-specific software or that the soft tissue substitutes were suboptimum could not be established.