Reliability Assessment of the EOS® Imaging in Clinical Evaluation of Lower Limb Deformity

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Introduction

Blount's disease is a developmental disorder associated with disordered growth of the proximal medial physis of the tibia—resulting in a progressive varus deformity. While the incidence rate in the U.S. is estimated to be less than 1% of the population,[1] higher incidences are associated with the African American and Scandinavian races, early walking age, and obesity.[2]

Diagnosis of Blount disease is based on a physical examination, history, and radiographs. Varus deformity is based on tibiofemoral varus angle on a standing hip-to-ankle anteroposterior radiograph. The treatment of Blount disease depends on the age of child, stage of disease, and severity of deformity. For children under the age of three, bracing is recommended while surgery is recommended for children over the age of three with a tibiofemoral angle greater than 13°.

Computed tomography technique is considered to be the gold standard in 3D measurement of bone deformity. However CT scans taken in the supine position can alter bone alignment while exposing patients to high radiation dose. The new slot scanning radiography technique (EOS imaging) allows upright standing X-rays with 20 times less radiation. Another feature of EOS imaging is synchronized AP and lateral X-rays to generate 3D reconstructions of bone.

Method

A total number of six lower limb sawbones with deformities (three models of tibia and three models of femur) were selected. The deformity of each bone is summarized in Table 1. These models were assembled into three leg models in a Plexiglas scaffold that permits axial rotation and flexion of the models (Figure 1). The scaffold was placed in the EOS machine and three posterior-anterior and lateral X-rays were taken from each model in 0, 15, and 30 degrees of axial rotation. Similarly bi-planar X-rays were taken in 0, 15, 30 degrees of knee flexion.

Computed tomography scans of the models were registered. Three different techniques were used to measure the geometrical parameters of the models *i.e.* femur mechanical length, tibia mechanical length, femur deformity, tibia deformity. In the first technique PA and lateral X-ray images were used. Geometrical parameters

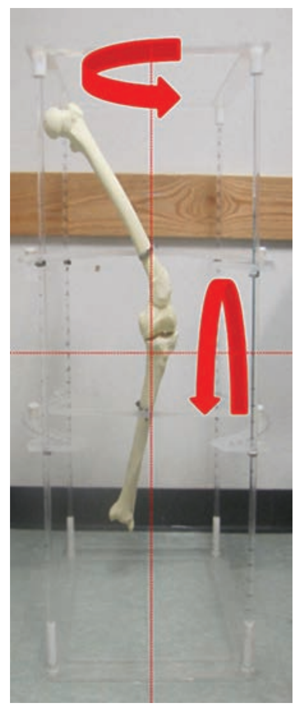

Figure 1. Sawbone model mounted in the scaffold. The scaffold allows 55° of axial rotation 110° of flexion.

Table 1. Sawbone models of femur and tibia with deformity.

Model	Deformity Description
Tibia Model 1	25° varus
Tibia Model 2	Blount disease & tibial plateau oblique plane
Tibia Model 3	30° varus deformity of proximal end
Femur Model 4	10° external rotation, 25° distal valgus
Femur Model 5	Proximal neck malunion, distal valgus 30° malunion
Femur Model 6	20° distal valgus

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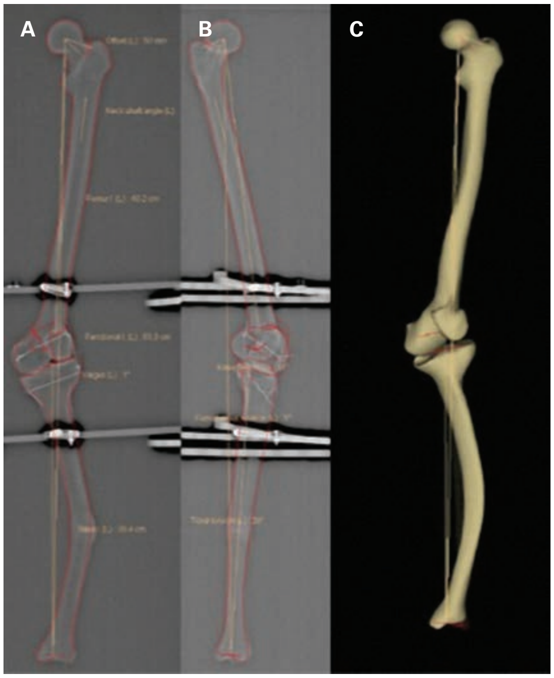

Figure 2. Measurement techniques: (A) 2D measurement in iSite, (B) 2D measurements from sterEOS, (C) EOS 3D reconstruction.

were measured in a DICOM viewer software (Philips iSite® Enterprise) using the method explained in Paley, 2002 (Figure 2a).[3] These measurements were repeated by two observers. In the second and third techniques the 3D reconstruction of the X-ray images were generated in sterEOS (EOS imaging, Paris). Digitized landmarks were used to calculate the 2D and 3D geometrical parameters using the sterEOS software (Figures 2b & 2c). These measurements were compared with the data from the CT scans of the same bone. A linear mixed model was used to compare the three measurement techniques.

Results

The 2D and 3D parameters *i.e.* length and deformity angles did not significantly vary as the measurement techniques changed $p < 0.05$. Leg deformity angle in the frontal view was significantly different between the CT measurements and 2D X-ray measurements only at the level of $p < 0.1$. The 2D EOS measurement on the AP X-rays showed higher variation in X-ray measurements 154.2° ± 8.1° than the CT measurements 160.5° ± 7.5°, $p = 0.06$. In the lateral view these measurement were 168.2° ± 9.2° and 174.5° ± 4.6° for EOS X-rays and CT scans, respectively $p = 0.09$. 2D and 3D EOS length measurement were not significantly different ($p < 0.05$) (Figure 3) although a higher variation in the X-ray measurement was shown when the results were compared to the parameters calculated in sterEOS software.

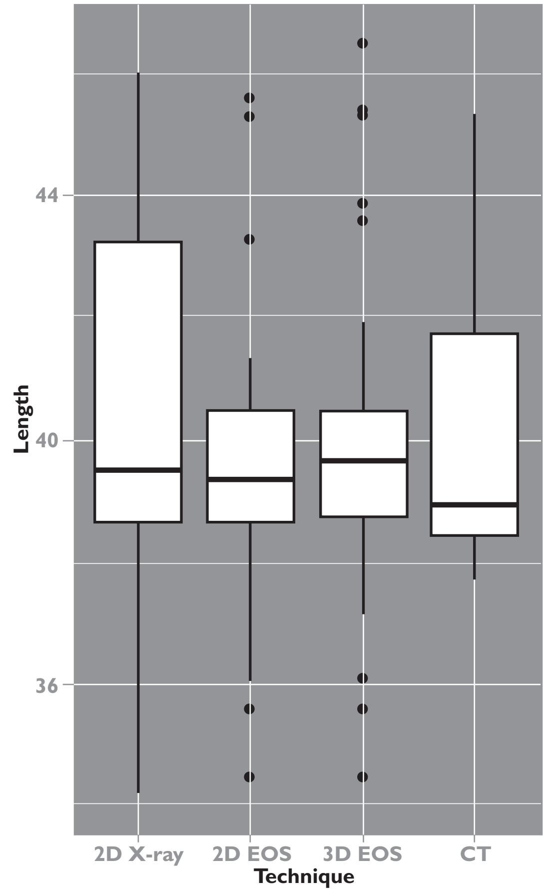

Figure 3. Statistical comparison of the femur and tibia lengths (cm). The lengths between different techniques were not significantly different $p < 0.05$.

Discussion

The reliability of the EOS imaging system in measurement of leg deformity parameters, *i.e.* length and deformity angles, was assessed. The results showed no significant difference between the EOS measurements and CT scans. Using the sterEOS 3D software decreased the variation in measurement as the position of the sawbone models was changed inside the EOS machine. For future direction a numerical method will be developed to calculate the bone deformity angle from the EOS 3D reconstructions.

Conclusion

The reliability of EOS system in 2D and 3D assessment of the lower limbs deformity was validated. The 3D reconstruction of the lower limb deformity decreased the intra-observer variability.

References

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