Improving Reliability in Forearm Fracture Angular Displacement Measurements Using a Computer Algorithm that Measures Three-dimensional Deformity from Plane Radiographs

Benjamin Alman[1], Robert Kamiel Lark[2]
[1]Duke University Medical Center, [2]Duke University Med Center

INTRODUCTION:

Determining changes in angulation is important in managing forearm fractures especially when treated using cast immobilization. However, changes in the radiographic techniques make determinations of angular changes less reliable. For instance, radiographs are rarely orthogonal, and the axial angle at which radiographs are taken frequently changes from one visit to the next. A computer algorithm for analysis of radiographs could be used to correct for changes in how radiographs are obtained to improve the reliability in fracture angular measurement.

METHODS:

Virtual mock forearm fractures with 0 to 60 degrees of angulation at axial rotations from 0 to 90 degrees from an AP direction were used to initially train a computer algorithm to assess the angulation from two virtual plane radiographs taken at nonorthogonal angles ranging from 45 to 89 degrees apart. The shapes of the bones were used to initially train the algorithm, which was then further trained on angulated forearm fractures from patients that had both plane x-rays and CT data available. A CT can be used to accurately assess the true angulation as it contains three-dimensional information. Following this, the program was further trained on 1,000 pediatric both bone fractures. The reproducibility of the algorithm was then determined on an additional 1,000 clinical radiographs.

RESULTS:

The training resulted in an algorithm that coverts two dimensional images into three-dimensional angular data using the shapes of the bones to correct for non-orthogonal radiographs. The data can be presented as angles of the bones in the true AP and lateral planes, or as maximal angulation in the axial rotational direction. The algorithm had a +.97 agreement with the angulation calculated from the CT data, and a +.98 reproducibility when measuring the 1,000 fractures.

DISCUSSION AND CONCLUSION:

Here we developed a computer algorithm that reliably measures angulation in a three-dimensional manner from non-orthogonal plane radiographic images. The algorithm can be easily sued with any digital radiographic data. There is a very high agreement with data from CT-scan images, which obtains three-dimensional data and as such can be considered a gold standard.

By correcting for differences in radiographic technique, this algorithm can reliably determine changes in angulation in forearm fractures. The computer algorithm assesses angular deformity as well as a CT scan with a lower cost and less radiation exposure. Furthermore, plane radiograohs have a greater accessibility for patients than CT scans. We intend to provide this algorithm in an open access platform that can be readily utilized in patient care.

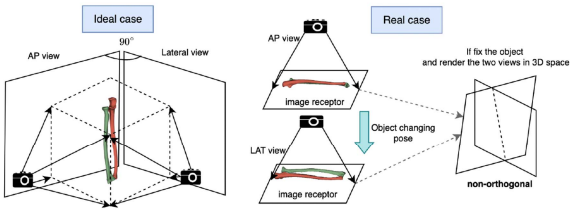

Figure One: In real life it is are to get perfectly orthogonal radiographs, and changes in the angles the x-rays are taken at can alter the measured angulation. Thus, changes in angulation when following radiographs could be due to changes in radiographic technique as opposed to true loss of reduction or change in alignment.

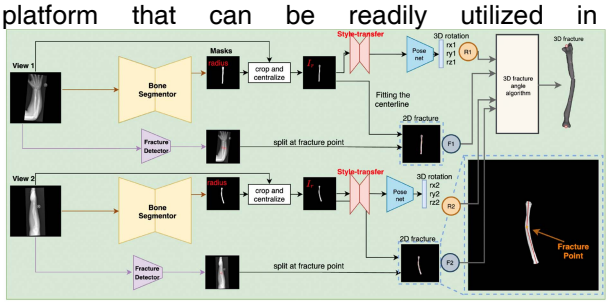

Figure Two: Diagrammatic representation of the algorithm to calculate angulation. A "bone segmentor" algorithm function is used to match the ends of the bones to true rotation, and this the then used to calculate the angle of the fracture in true orthogonal planes. Thus, changes in angulation due to radiographic technique are eliminated.