Three-dimensional motion analysis of elbow joint and pseudojoint of non-united lateral condyle of humerus

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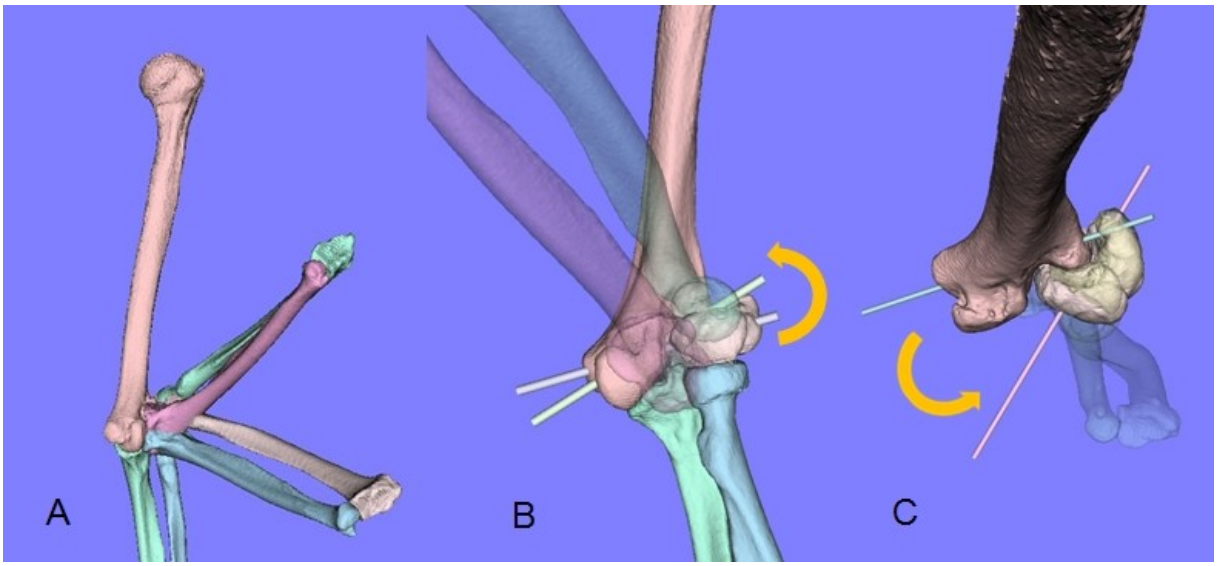
Introduction: Non union of lateral condyle fracture combined by cubitus valgus deformity often causes painful elbows with cosmetic problem. But the treatment is still debate. Recently good result was reported in internal fixation of non united lateral condylar fragment. But high rate of complication also has been reported. In vivo study and three-dimensional investigation of elbow motion in non union of lateral condyle fracture of elbow are rare. In this study, we attempt to analyze the motion of elbow and pseudo joint of non united lateral condyle. The goal of this study is to understand the underlying mechanism of the motion to elucidate indication of operation for appropriate treatments with biomechanical consideration.

Method: Three healthy volunteer and 6 non united lateral condyle of elbows were scanned using a CT (Light Speed Ultra 16; General Electric Waukesha, WI, USA) with a low radiation dose Scans were performed at three different degrees of elbow flexion (full flexion, 90° flexion full extension). First, we used a commercially available software (Bone Viewer™, Orthree Co. Ltd., Osaka, Japan) to construct three-dimensional surface models of the humerus, ulna, radius and non united lateral condylar fragment. By superimposing the total of three position of humerus (Fig A), we calculated the rotational axis of humero-ulna joint in the position of full extension-90° flexion and 90° flexion-full flexion (Fig B). This calculation was carried out based on semiautomatic adjustment by using independent implementation of interactive closest-point algorithm for surface-based registration, which is implemented on commercial software (Bone Simulator™, Orthree Co. Ltd., Osaka, Japan). The same procedure was applied to the lateral condylar fragment. Based on the calculation, we analyzed the motion of rotational axis of humero-ulna joint of elbow and pseudojoint of affected humerus and lateral condylar fragment.



Result: Rotational axis of normal elbow showed minimal positional change during flexion. The rotational axis of normal elbow penetrates from lateral epicondyle to medial epicondyle within 5° on coronal plane and axial plane. Otherwise, those of elbow joint of non united lateral condyle of

humerus rotated to valgus on coronal plane (Fig B) and rotated externally in axial plane. Movement of the rotational axis of bony fragment varies case by case. In three cases, lateral condyle moved along the similar course of the elbow. In two cases, it rotated externally in axial plane (Fig C), and in one case it moved in the opposite direction (extension during elbow flexion).

Discussion: In the simulation study, the rotational axis of normal elbow demonstrates hinge joint movement without motional change. In case of non-union, valgus deformity aggravates during flexion which means valgus instability followed by potential destruction of joint surface. From the simulation results, we confirmed positive consideration of osteosynthesis of non-united bony fragment based on the motion analysis of bony fragment, not only for corrective osteotomy for correction of the valgus deformity but also for reconstruction of joint congruency for painless stable elbow. Bony fragment of lateral condyle which has similar motion with elbow joint considered was to be a good indication for arthrodesis of pseudo joint in non united lateral condyle of humerus.

Reference

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