

Impact of a proximal radial shortening osteotomy on the distribution of forces and the stability of the elbow

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Abstract – The human arm consists of the humerus (upper arm), the medial ulna and the lateral radius (forearm). The joint between the humerus and the ulna is called humeroulnar joint and the joint between the humerus and the radius is called humeroradial joint. Lateral and medial collateral ligaments stabilize the elbow. Statistically, 2.5 out of 10,000 people suffer from radial head fractures [1]. In these fractures the cartilage is often affected. Caused by the injured cartilage, degenerative diseases like posttraumatic arthrosis may occur. The resulting pain and reduced range of motion have an impact on the patient's quality of life. Until now, there has not been a treatment which allows typical loads in daily life activities and offers good long-term results. A new surgical approach was developed with the motivation to reduce the progress of the posttraumatic arthrosis. Here, the radius is shortened by 3 mm in the proximal part [2]. By this means, the load of the radius is intended to be reduced due to a load shift to the ulna. Since the radius is the most important stabilizer of the elbow it has to be confirmed that the stability is not affected.

In the first test (Fig. 1 left), pressure distributions within the humeroulnar and humeroradial joints a native and a shortened radius were measured using resistive pressure sensors (I5076 and I5027, Tekscan, USA). The humerus was loaded axially in a tension testing machine (Z010, Zwick Roell, Germany) in 50 N steps up to 400 N. From the humerus the load is transmitted through both the radius and the ulna into the hand which is fixed on the ground.

In the second test (Fig. 1 right), the joint stability was investigated using a digital image correlation system to measure the displacement of the ulna. Here, the humerus is fixed with a desired flexion angle and the unconstrained forearm lies on the ground. A rope connects the load actuator with a hook fixed in the ulna. A guide roller is used so that the rope pulls the ulna horizontally when a tensile load is applied. This creates a moment about the elbow joint with a maximum value of 7.5 Nm. Measurements were performed with varying flexion angles (0°, 30°, 60°, 90°, 120°). For both tests and each measurement, seven specimens were used. Student's t-test was employed to determine whether the mean values of the measurements in native specimen and operated specimens differ significantly ($p \leq 0.05$).

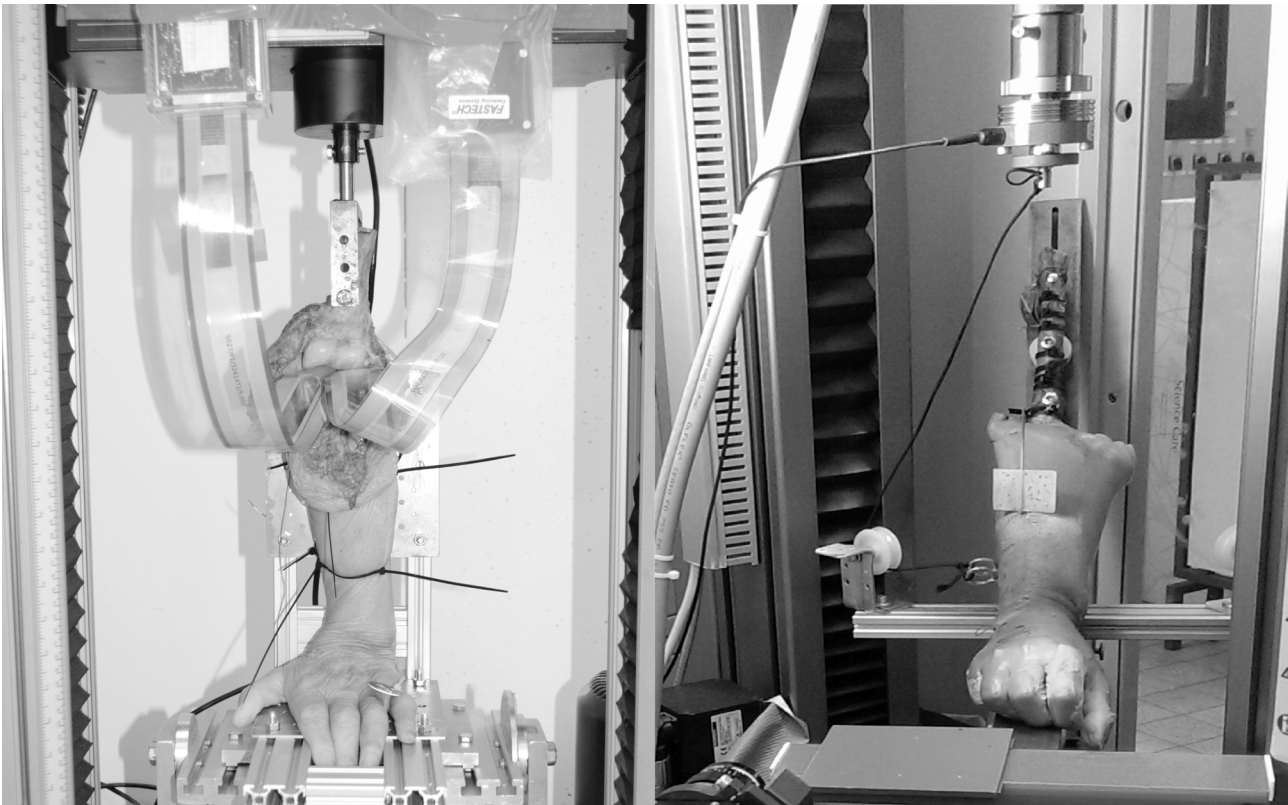


Fig.1: Experimental setups of the first (left) test and second (right) test.

The pressure test showed that up to 250 N the ratio of radial load to total load is significantly lower in the shortened radius. Ratios of 0.6 were found regarding the native joint which corresponds to literature [3]. The stability test confirmed that the joint stability is not significantly ($p > 0.24$) affected by the proximal shortening. Ulnar collateral ligaments might compensate the loss of stabilization caused by the shortened radius.

The present results demonstrate that in monotonic tests the mechanical effects are in agreement with the idea behind the new surgical approach. In the next step cyclic tests will be performed in order to study the long-term effects. Finally, a clinical study needs to figure out whether the progress of arthrosis can be decelerated.

References

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