Heiner Martin*, Michael Stiehm, Ingmar Rinas, Niels Grabow, Thomas Mittlmeier

Testing of dynamic wrist joint external fixator mobility and reaction moment

Abstract: For the investigation of reaction moments of wrist joint with external fixator, a test device was developed that allows a well-defined investigation of the joint loads during hand flexion movements. The reaction moments are considered as a measure for the joint loads due to the constraint forces, which occur with differences of the rotation axis of the fixator device from the physiological rotation axis of the wrist joint.

The developed test device allows a dynamic momentum load application into the wrist by a servohydraulic testing machine. This testing device converts the force to a moment by a constant lever arm and allows thereby the measurement of the reaction moments by the force load cell of the testing machine. Measurements on cadaveric wrist joints with external fixator can be thereby performed under reproducible conditions.

The cadaveric wrist joints can be integrally casted into bone cement and thereby clamped to the testing device. Preliminary experiments with artificial bones showed that forces within the measuring range of the load cell of the testing machine can be measured. The design of the test device is presented. Hence, the requirements for measurements of the reaction moments with wrists with external fixator for distal radius fractures under dynamic loads are created.

Keywords: Experimental biomechanics, wrist, fixator external

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1 Introduction

The dynamic external fixator is a way for the treatment of unstable distal radius fractures allowing for early motion at the wrist joint after surgery. Devices with different principles of guiding the wrist movement are available [1]. The anchorage of the fixator in the wrist is a mechanical vulnerability. In order to investigate reaction moments in the anchorage of the wrist during hand movements with a fixator, a test device had to be constructed to allow investigations of the bone load during dynamic wrist flexion.

This test is based on the assumption that the measurement of reaction moments allows a conclusion on the anchorage loads due to constraining forces. These constraining forces are caused by deviation of the fixator rotation axis to the physiological rotation axis of the wrist.

Some measurements in the literature [2] are based on the measurements of the bending moments in the pins by strain gauges. This method has the advantage that it is possible in vivo, but it does not allow a defined application of bending moments to the anchorage and the wrist. Therefore, the aim of the investigations presented here was to develop a test device that allows well defined, reproducible measurements in wrist ex vivo.

2 Material and Methods

If the physiological rotation axis of the wrist differs remarkably from the rotational axis of the external fixator, an increase in the measured reaction moment can be expected. Due to the anatomy of the wrist, movement of the wrist in the axis of rotation during healing must be ensured. In radius fractures, the external fixator provides stabilization of the physiological axis of rotation during the healing process. Twisting the fixator would lead to wedging with delayed healing and can be measured by an increase in reaction moments.
This hypothesis has to be tested by measurements on cadaveric wrists. Therefore, a testing device was developed that allows a defined clamping of cadaveric wrist joints and the application of a time variable moment load with a defined rotational axis. The test device consists of an adjustable clamping device for forearm and hand bones and a device for moment application by a pivoted slider. The test device can be mounted on a universal testing machine.

The cadaveric bones should be clamped by casting them into bone cement, which is used in the veterinary applications range and fixing the cast blocks. The corresponding casting moulds also were also manufactured.

3 Results

The developed test device is shown in Figure 1. This test device was proven in a universal testing machine MTS Systems GmbH (Berlin, Germany) with artificial bones. In addition to the functionality in principle, it was also possible to measure the reaction force within the measuring range of the load cell of the universal testing machine. The essential design principle is based on a constant lever during wrist load and the reaction moment is therefore proportional to the measured force.

4 Discussion and Conclusion

As a next step, experiments with cadaveric bones are planned, which should allow dynamic measurements of the reaction moments with low-frequency flexion motions of the wrist with fixator. By the developed test device the prerequisites for these measurements with fixator for distal radius fractures are created, that allow an analysis of reaction moment changes due to changes of rotation axis under dynamical loads on wrist joint.

Author Statement

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References
