MEASUREMENT OF THE OPTIMAL ELBOW AXIS FOR PLACEMENTOF ENDOPROSTHESES

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INTRODUCTION:

To enable the accurate positioning of elbowprostheses, quantitative information is needed on the position and orientation of the elbow Flexion-Extension (FE) axis, relative to easily definable bony landmarks. Previous research on cadaveric specimens has defined the FE-axis as passing through the center of the trochlea. However, kinematic measurements in vivo are rare, due to the difficulties in measurement and calculation. The aim of this study was to quantify the FE axis of rotation from in-vivo measurements, relative to anatomical landmarks.

METHODS:

The Flock of Birds™ six Degrees-of-Freedom electromagnetic device was used for the relative position and orientation of the ulna and humerus during flexion-extension movements.

Ten healthy subjects (5M, 5F, age 30.8±9.8 yrs) participated in the study. Each measurement consisted of two sessions : calibration and FE measurements. For each subject, one receiver was attached to the humerus, and one on the dorsal side of thedistal part of the forearm. During the calibration session, a third receiver was used as spatial digitizer.

Calibration: During calibration, bony landmarks were measured in conjunction with the orientations of related sensors on arm and forearm. Five landmarks on the scapula were measured to estimate the GlenoHumeral rotation center (GH) following Meskers (1). Landmarks on the arm and forearm and their local coordinates are listedin Table 1.

Table 1 : List of anatomical landmarks

Landmark	Local coordinates (cm)		
Glenohumeral Joint[1]	-3.5	28.2	0.0
Lateral Epicondyle	0.0	0.0	0.0
Medial Epicondyle	-7.1	-0.5	0.0
Proc. Styl. Ulnae[2]	1.7	-0.3	-26.0

[1] = derived from scapular landmarks
[2] = 90° flexion

FE measurements:

For each subject five full flexion-extension movements were recorded (Fs=6Hz.) One motion cycle took approximately 30 seconds.

Data processing:

Sensor data were transformed to a local humerus coordinate system. From the position and orientation of the modified ulnar sensor data, Instantaneous Helical Axes were calculated as described in (2). Data points with an angular velocity lower than 0.25 $r.s^{-1}$were excluded. Subsequently, the optimal position and direction vectors were obtained (2).

RESULTS AND DISCUSSION:

The optimal FE-axes were comparable between subjects (Table 2). Also, the average errors in the optimal axes were small (4.1° and 1.2 cm). Although results are comparable with previous in-vitro studies (2), it should be kept in mind that findings are highly dependent on accurate definition and measurement of bony landmarks. The procedure used in this study can be applied to determine the FE axis after placement of an endoprosthesis, to evaluate possible mechanical causes for aseptic loosenening. Also, data from this study may be used as help for the positioning of endoprostheses.

Table 2 : Mean (N=10) optimal FE-axes, relative to thepositions of anatomical landmarks.

	Direction vector	Position vector (cm)
mean (std)	.9646 (.0345)	-1.6 (1.3)
	.1338 (.0315)	0.8 (0.7)
	.2124 (.1183)	-1.9 (0.7)
mean error	4.1 (0.7) (°)	1.2 (0.4) (cm)

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IN VIVO COMPARISON BETWEEN AN INSTRUMENTED SPATIAL LINKAGE AND AN ELECTROMAGNETIC TRACKING DEVICE DURING SHOULDER MOVEMENT

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INTRODUCTION:

In vivo 3-D clinical measurement of the shoulder complex is relevant for patient follow-up after shoulder arthroplasty or reconstructive surgery. Electromagnetic tracking devices are commonly used as a kinematic measuring tool. They are considered reliable, accurate and precise. But some questions remain open about their accuracy during a full range of motion (latency, acquisition frequency). Instrumented spatial linkages (ISL) have been extensively used in biomechanical studies and have shown high accuracy to calculate kinematical parameters as helical axis, mean pivot point. This kind of device has never been used in an *in vivo* shoulder study and little information is published on the effects of device placement on angular results. The aim of this study was to compare as a function of time shoulder rotation values obtained by two six degree of freedom measurement systems: a home made ISL and a Flock of Birds (FOB), a magnetic tracking device using pulsed direct current magnetic field.

METHODS:

Ten healthy subjects were tested. Movements tested were flexion, extension, abduction, and abduction without any rotational restriction. Internal and external rotation at 90° of abduction and circumduction of shoulder complex were also tested. The FOB and the ISL were set on the same splints to reduce skin motion artifact. To express kinematic results, the ZYZ Eulerian angle sequence (plane of elevation, elevation and axial rotation) was used (An et al., 1991; Van Der Helm et al., 1991). To compare both devices, a data reduction method was applied using a fith-order polynomial between 20° of shoulder elevation and maximal elevation. Time was nomalized to 100% of movement. The choice of 20° for the motion beginning was made to avoid singularity near the reference position. To evaluate the relation between waveforms, adjusted coefficient of multiple determination R_a^2 was first calculated. However, R_a^2 gave only the strength of the relation. So, the agreement between both systems of shoulder measurement was assessed by the graphic method of Bland et al. (1986).

RESULTS AND DISCUSSION:

The agreement between both devices for *in plane* motion was good. Most of the differences were included between difference mean $\bar{d}$ -2.5° and $\bar{d}$ +2.5°. R_a^2 was around 0.99. For *out of plane* motion, the relation grew poorer. To give clinical approach of agreement, the kinematics of both devices was not calculated relative to the same laboratory reference system but to separate ISL and FOB fixed reference systems. The poor out of plane results were probably due to misalignemnt of these reference systems.

CONCLUSION:

A comparison between two 3-D measurement systems was made in *in vivo* conditions on the shoulder complex. Further investigation should deal with the definition of optimal placement of a 3-D device on the shoulder in clinical setting. Other parametrizations of the rotation matrix should be tested.

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