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FINITE HELICAL AXIS BEHAVIOR IN CERVICAL KINEMATICS

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BACKGROUND AND STUDY AIM

Although a far more stable approach and very common in spacecraft dynamics and graphic imaging, the Finite Helical Axis (FHA) struggles with interpretational and representational difficulties especially in clinical context and among medical professionals. The dispersion of the 3D-motion axis has been used to express the stability of the motion in knee kinematics and cervical spine analyses. The aim of the present study is to investigate the effect of noise and angle intervals on the estimation of FHA parameters and to introduce a novel approach for the quantification of the FHA behavior.

METHODS

A sample of 10 healthy subjects was studied, five males and five females, ranging in age from 21.5 to 28.9 years (24.4 ±1.8 years). Cervical movements were registered with the Polhemus-G4, a non-invasive 3D-electromagnetic device at 120Hz. The subjects were asked to perform three series of movements of the head at a natural spontaneous speed (Cattrysse et al., 2012). Each series consisted of five consecutive pair of opposite planar movements (flexion-extension, left-right rotation, left-right lateral bending). Each movement was portioned in 4 phases, between neutral and extreme left and right rotation.

Minimum Convex Hull method and the angle between IHA (instantaneous Helical axis) and FHA were calculated as a measure of dispersion (figure 1).

The effect of angle steps was calculated on the estimation global FHA-parameters.

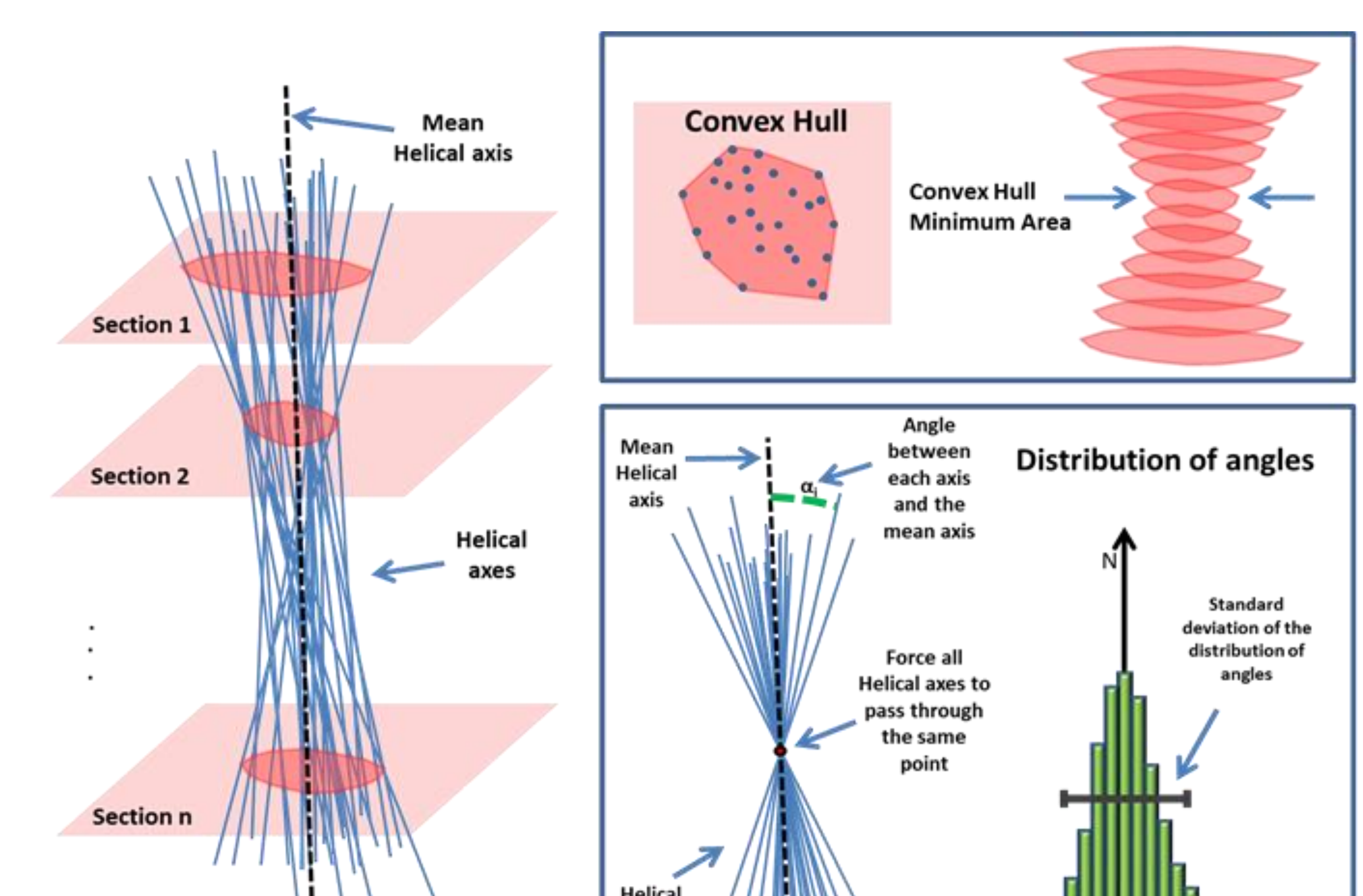

Fig. 1: Convex Hull and Angle dispersion representation

RESULTS

Figure 2 shows the effect of angle intervals on the estimation of global parameters extracted from groups of helical axis: mean angle between each axis and the main axis (Mean Angle), convex hull area (area CH). The mean angle between the main helical axis and each of the helical axis computed with different angle intervals did not depend from the angle interval. The convex hull area dramatically decreased with increasing angle steps. The optimal compromise, which was selected for further analysis was a 10 degree angle.

Figure 3 shows the comparison between global helical axis parameters during different planar movements of the head and different movement phases using angle steps of 10°. The movements are flexion extension, lateral bending and axial rotation. The movement phases are: neutral to flexion (N→F) flexion to neutral (F→N) neutral to extension (N→E) and extension to neutral (E→N) for the first movement, while for the lateral bending and axial rotation the phases were: and neutral to left (N→L) left to neutral (L→N) neutral to right (N→R) and right to neutral (R→N).

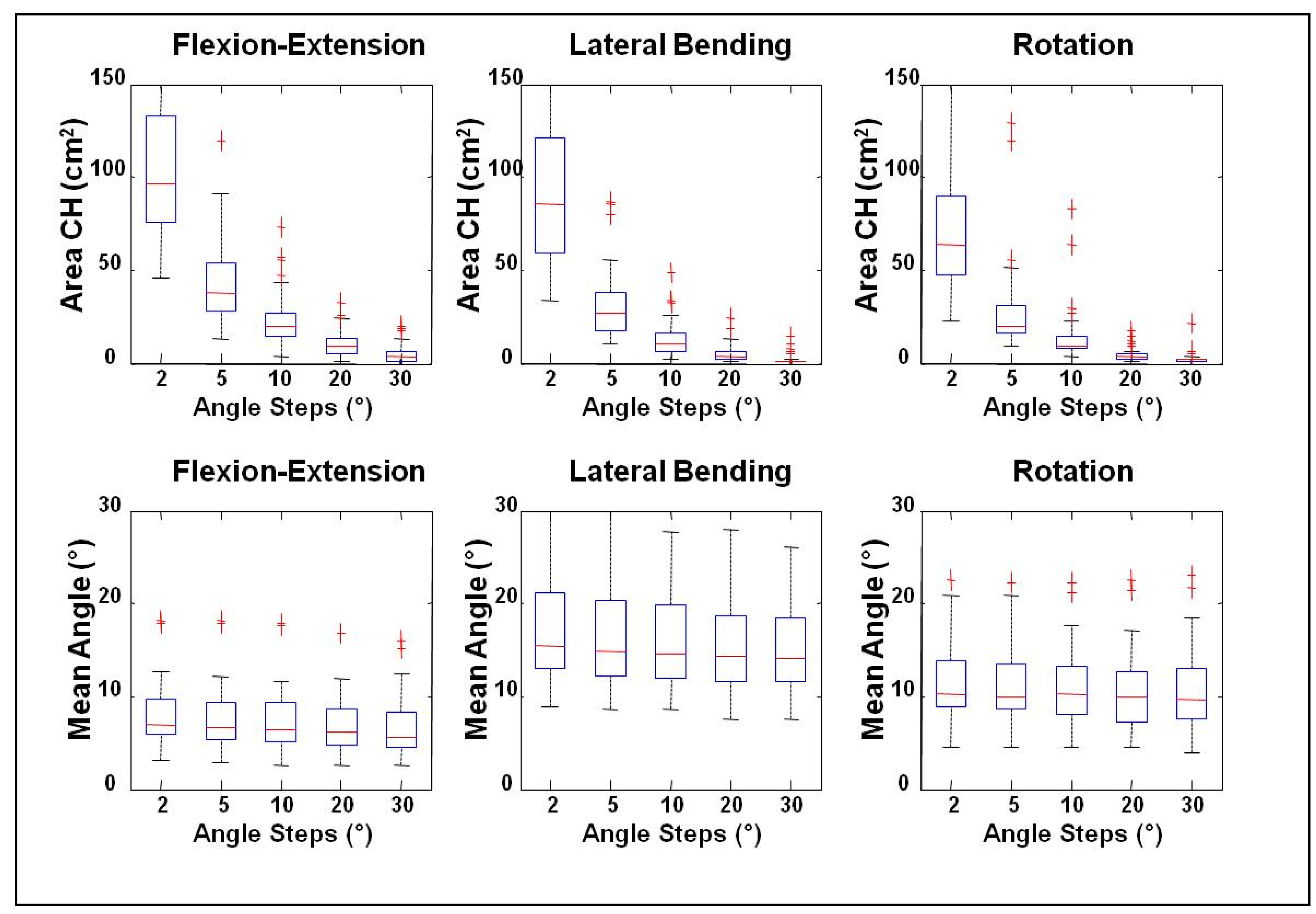

Fig.2: The effect of angle steps on FHA-estimation

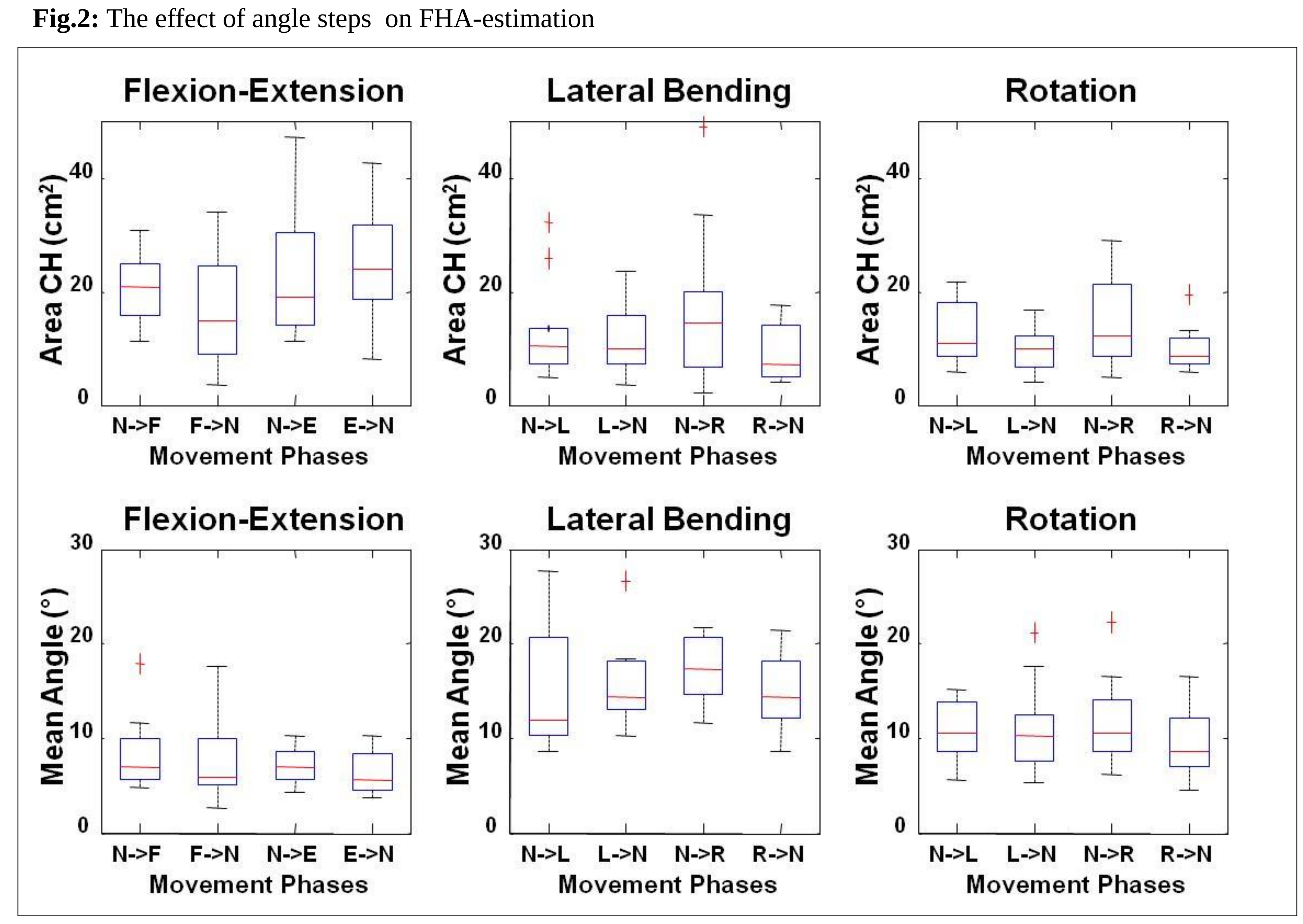

Fig. 3: The effect of movement phase on FHA-estimation

CONCLUSION

The FHA dispersion can be represented by the minimum convex hull and the distribution of angles of the IHA relative to the FHA.

The optimal compromise, which was selected for further analysis was a 10 degree angle step to estimate global FHA parameters.

No significant differences were observed between movement phases for mean angle and convex hull area.

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