CONTACT PATTERNS IN THE TRAPEZIOMETACARPAL JOINT DURING ISOMETRIC TASKS OBTAINED VIA MATHEMATICAL MODELING

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ABSTRACT

INTRODUCTION. A clinically relevant way to investigate the biomechanical behavior of the trapeziometacarpal (TMC) joint is to evaluate its contact patterns during isometric tasks. This will help us to obtain a better understanding of the onset of osteoarthritis (OA) and will eventually improve prevention and treatment strategies of this highly disabling disease.

METHODS. CT scans of the hand region of 20 female volunteers (mean age: 60.8 years) were taken in three different configurations: relaxed neutral, lateral pinch and power grasp, using a radiolucent jig with embedded load cell (Brown University, USA). Four subjects showing radiological signs of OA were excluded from the study. Scans were segmented using Mimics (Materialise, Belgium) and 3D models of the first metacarpal (MC1) and the trapezium were created. The articular area of each bone was quantified based on manual measurements performed on the 3D bone models. A custom-written Matlab code - based on the finite deformation biphasic theory[1] and cartilage deformation properties[1, 2] - was developed to evaluate the contact area and stress distribution of each bone. A quadrant division method[3] was used to identify articular sub-regions subjected to the highest stress.

RESULTS. Measurements of the total articular area of the MC1 and the trapezium presented no significant difference ($p > 0.1$). A slightly smaller contact area was calculated for the trapezium compared to the MC1, however, this was only statistically significant in the lateral pinch position ($p < 0.05$). Similar amounts of stress were reported in the neutral and lateral pinch configurations, while the power grasp configuration displayed the highest stress levels. Very consistent results for high stress location on the volar/radial articular sub-region were found in the neutral and power grasp configuration. More variation was reported during lateral pinch.

DISCUSSION. The findings suggest that a power grasp task elicits higher contact stresses and might therefore represent a more critical configuration for clinical evaluation of the TMC joint. Lateral key pinch, on the other hand, might create a higher joint instability and is less reproducible. The mathematical model presented in this paper offers the possibility to predict contact patterns within the TMC joint based on in vivo CT scans. Such a model can provide relevant results which can help to achieve a better understanding of joint functioning, and is also particularly important in establishing new prevention approaches.

REFERENCES. [1] Kwan et al., J. Biomech, 23: 145-155, 1990; [2] Koff et al., J Hand Surg, 28A: 597-604, 2003; [3] Momose et al., J. Hand Surg, 24A: 491-495, 1999

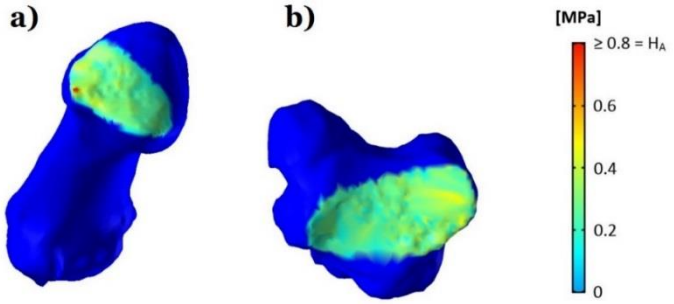

Figure: Contact stress pattern of one subject during power grasp: a) MC1; b) Trapezium (right hand)