Does the trapeziometacarpal joint function as a saddle joint?

Biomechanical analysis of the trapeziometacarpal joint and the impact of total replacement arthroplasty

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BACKGROUND
The trapeziometacarpal (TMC) joint is a complex joint with high intrinsic mobility and limited intrinsic stability offering a wide range of motion of the thumb. Thumb motion, in particular opposition, in which the palmar surface of the thumb is put in an opposed position to the palmar surface of the fingers (Fig. 1), is important in daily activities. This makes that pathologies of the TMC joint, such as osteoarthritis (OA; Fig. 2A,B), have a severe disabling impact. There is a high prevalence of osteoarthritis in this joint, with a higher occurrence in women (20-25% of females above 60) than in men, probably due to differences in joint congruity (Ateeshian et al. 1992), hormonal factors, and higher compliance of ligaments and tendons in females.

OBJECTIVES
1) to develop an accurate biomechanical model of the normal TMC joint,
2) to obtain a full insight in the biomechanical changes in the diseased TMC joint, and
3) to investigate the impact of a total TMC ball-and-socket joint arthroplasty on the biomechanics of the thumb.

METHODOLOGY
The study will consist of an in vitro, in vivo and in silico part. In a first step, a method will be developed to visualize the kinematics of the TMC joint in vivo using cone-beam CT (CBCT; Carelsen et al. 2005, 2009). In the in vitro study, a series of hand cadavers will be used to collect the necessary anatomical data and to validate the experimental setup. Next, a biomechanical model of the normal TMC joint will be developed (in silico) in collaboration with Prof. Jos Vander Sloten and Prof. Ilse Jonkers (K.U.Leuven). This model can be used to evaluate changes in the geometry and configuration of the TMC joint and of the implant during motion and prehension. Once validated, the in vivo setup will be used to collect kinematical data of TMC joints with OA and of total TMC joint arthroplasties in a group of patients (pre- and post-surgery). The data of the total joint arthroplasties will be incorporated in the biomechanical model and compared with the normal TMC joint.

EXPECTED OUTCOME
This study will lead to a better understanding of the biomechanics of the normal and implant TMC joint and highlight the biomechanical effects on joint function. This will give insight in the failure reasons of total TMC joint implant reconstruction and could ultimately improve the current designs of total joint arthroplasties with an implant concept more closely aligned to the normal TMC joint kinematics.


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