LOADING ON THE SCAPHO-TRAPEZIUM-TRAPEZOID JOINT DURING GRIPPING

[1] M.K. Gislason, [2]B. Stansfield [1]D.H. Nash

[1]University of Strathclyde, email: magnus.gislason@strath.ac.uk

[2]Glasgow Caledonian University;

INTRODUCTION

The scapho-trapezium-trapezoid (STT) joint is believed to be highly vulnerable to wear and has been identified clinically as a high risk joint in arthritic patients. A theoretical model [1] of the load transfer through the wrist during gripping, suggests high activity in the STT ligaments in order to stabilize the carpus. During gripping complicated loading patterns are seen in the carpal bones and various intercarpal joints comprising the wrist joint.

The aim was to investigate contact stresses at the STT joint in comparison to those occuring at the radiocarpal joint. Finite element model was created of the whole wrist joint with physiological loading conditions applied.

METHODS

Three subjects were taken for an MRI scan. The scanner was a 3T clinical scanner with in plane resolution of 230µm x 230µm and slice thickness of 750µm. The scans ranged from the distal end of the radius and ulna to the proximal third of the metacarpals. The scans were imported into Mimics (Materialise) where the edge detection of the bones was carried out and three-dimensional objects created of each bone which were then meshed using surface triangular elements. The mesh was imported into Abaqus (Simulia) where the surface elements were converted into volume elements. The volumetric mesh was then imported back into Mimics where different stiffness regions were visually identified from the MRI scans and applied to the mesh. The mesh was re-imported into Abaqus where the assembly was created. Articular cartilage was created by extruding the mesh on each of the articular surfaces. Frictionless contact interaction was created between each articulating surfaces.

Biomechanical data was taken from the subject. Five 6-degree-of-freedom force transducers were used in conjunction with an 8 camera Vicon system to capture kinetic and kinematic data. The measured external forces were converted into joint contact forces using a biomechanical model relying on average anatomy. The finite element model was solved using an explicit solver, solved over a period of 0.1s. The analysis was run on a high performance computer (HPC) cluster.

RESULTS AND DISCUSSION

Calculated stress on the carpal bones showed higher values on the radial side than on the ulnar side. This was associated with input loading onto the digits of 39%, 19%, 16%,14% and 12% of the total load on the metacarpals ranging from the first to the fifth respectively representing maximum gripping force distribution. The total joint contact force acting on the metacarpals was calculated as 971 N as a compressive force acting in the proximal direction in the metacarpal axis system.

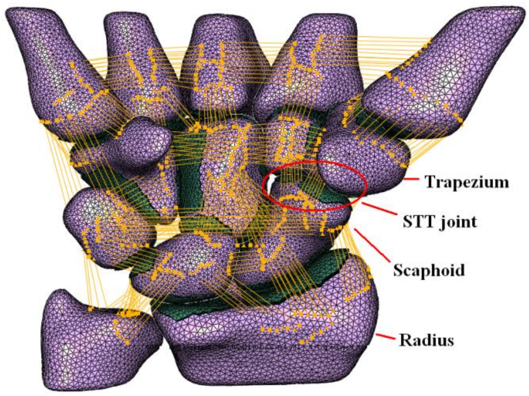

Figure 1: A finite element model of the wrist.

The results of the finite element model showed high contact pressure at the STT joint for all of the subjects compared to the average contact pressure of the whole radiocarpal joint which carried 78-93% [2] of the overall load through the whole wrist joint. The average contact pressure on the joints can be seen in table 1.

	Scapho-trapezium	Scapho-trapezoid	Radio-carpal
Contact pressure [MPa]	19.2	7.5	9.8

Table 1: Contact pressure on joints in the wrist

These high contact pressures can be explained by the fact that the first and second metacarpals carried high loading during gripping which was directly distributed through the STT joint. The contact area on the distal head of the scaphoid was small compared to other contact areas in the wrist joint, causing even higher pressures on the STT joint.

CONCLUSIONS

A finite element model of the wrist joint was used to calculate the loading on the STT joint during maximal gripping. High pressure was calculated at the scapho-trapezium joint in comparison with other joints providing evidence to explain clinical findings of joint degeneration.

ACKNOWLEDGEMENTS

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