COMPARATIVE STUDY OF LIGAMENT MODELING TECHNIQUES IN A WRIST JOINT MODEL: THE EFFECT OF SCAPHOLUNATE LIGAMENT REMOVAL ON CONTACT PRESSURE DURING COMPRESSION FOCUSING ON CARPAL BONES

Sunjung Kim[1], Alfonso Mejia[1], Mark Gonzalez[1], Farid Amirouche[1,2]

[1]Department of Orthopedic Surgery
University of Illinois at Chicago
S Wolcott Ave, Chicago, USA
[skim6487, amejia, hand15, amirouch]
@uic.edu

[2]Department of Orthopedic Surgery
NorthShore University Health System
9669 Kenton Avenue, Suite 305 Skokie, IL, 60076, USA
famirouche@northshore.org

EXTENDED ABSTRACT

1 Introduction

Carpal tunnel syndrome (CTS) is a common disorder that affects the wrist and hand, leading to pain, numbness, and weakness. The development of CTS is often linked to the compression of the median nerve as it passes through the carpal tunnel, which is formed by the bones of the wrist and the transverse carpal ligament [1,2]. Previous studies have suggested that changes in wrist biomechanics may be a contributing factor to the development of CTS. Therefore, investigating the relationship between wrist joint mechanics and CTS could provide valuable insights into the underlying mechanisms of the disorder. The accuracy of wrist joint models used to study CTS depends on the modeling technique used for the ligaments. The aim of this study was to investigate the effect of modeling ligaments using solid elements, compared to using spring elements, on the contact pressure in the wrist joint during flexion and grip. The complexity of the writ joint is best suited for MBDS if proper constraints can be formulated, the contact between different bones is established and ligaments are modelled in their form and geometry. The focus in the first stage of this study is to look at a quasi-static model and address the effects of changes in stress in the presence of ruptured or incised ligaments at the wrist and further submit the writ to flexion-extension to evaluate the carpal tunnel pressure change.

2 Method

We developed a wrist joint model using Mimics and Ansys Workbench software, including the eight carpal bones, radius, and ulna bones. In the control model, the SL was included, and a compression force of 0 - 200 N was applied to the tip of the metacarpal bone, representing the load during gripping. In the experimental model, the SL was removed, and a moment of 20 Nm was applied to the carpal bones, representing the motion of wrist flexion for setting the hand on a surface. Solid elements were used to model the ligaments in the experimental model, while spring elements were used in the control model.

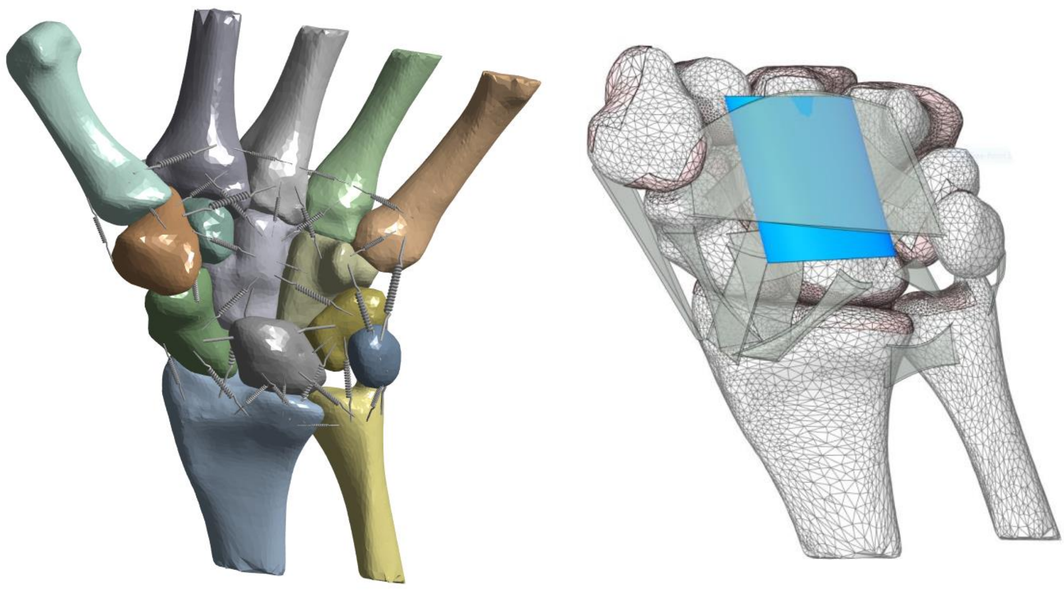

Figure 1: Comparison of contact pressure in the wrist joint during compression between a model using spring elements (left) and a model using solid ligaments (right), representing the control and CTS models, respectively. The control model included the SL and applied a compression force of 200 N to the tip of the metacarpal bone, while the CTS model removed the SL and applied a moment of 20 Nm to the carpal bones.

3. Result

The control model showed a contact pressure of 2.53 MPa at the radiocarpal joint adjacent to the lunate, while the experimental model showed a contact pressure of 2.82 MPa. These results suggest that removing the SL increases the contact pressure in the wrist joint during compression, focusing on the metacarpal bone only. Additionally, the modeling technique used for ligaments affected the results, with solid elements providing more accurate results than spring elements.

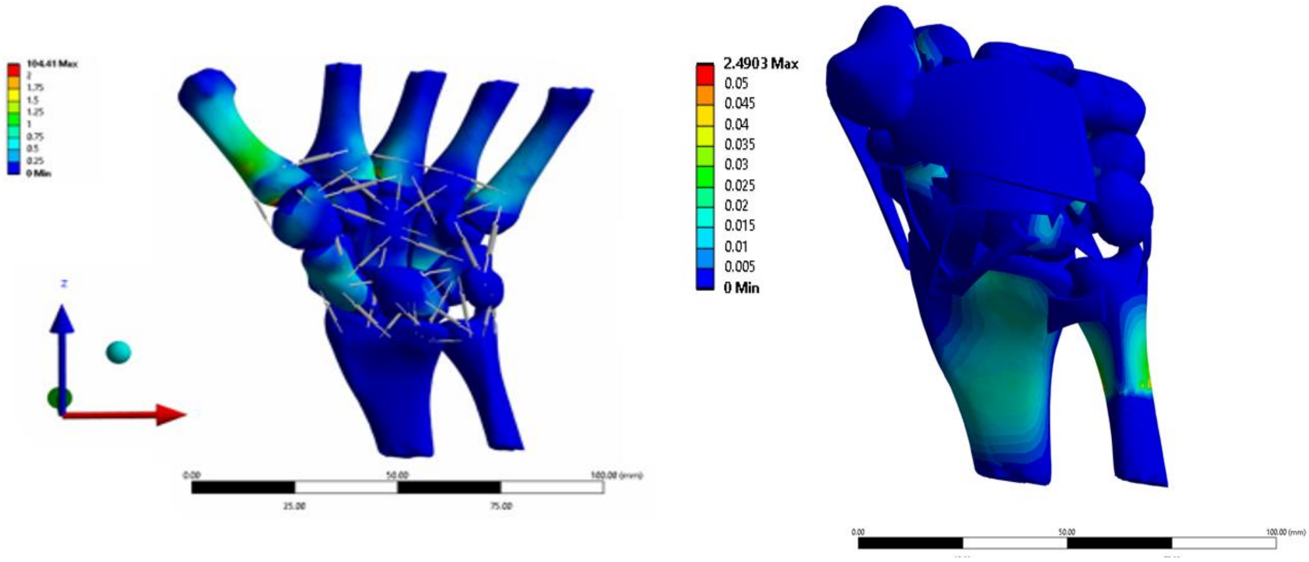

Figure 2: Comparison of contact pressure in the wrist joint during compression between a model using spring elements (left) and a model using solid ligaments (right), representing the control and CTS models, respectively. The control model included the SL and applied a compression force of 200 N to the tip of the metacarpal bone, while the CTS model removed the SL and applied a moment of 20 Nm to the carpal bones.

4. Conclusion

The study focused on the biomechanics of the wrist joint with the specific aim of understanding the underlying mechanisms of carpal tunnel syndrome (CTS). To achieve this, the study investigated the accuracy of modeling ligaments using solid elements compared to spring elements on the contact pressure in the wrist joint during compression. The results showed that the solid model provided a more precise representation of the wrist joint than the spring model, primarily due to its ability to better capture the complex interactions between the various ligaments in the wrist. The solid model also demonstrated more accurate stress distribution in the radius and ulna area compared to the spring model. Additionally, the study found that removing the SL (scapholunate) ligament increased the contact pressure in the wrist joint during compression which led to early arthritis and possibly contribute to CTS. These findings could have implications for the development of more effective treatments of CTS and how different therapies may increase or decrease the pathology of the writ joint. Further research is needed to validate these models in their current form.

Acknowledgments

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