SUMMARY OF Ph.D. DISSERTATION

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Title

Development of Muscle Active Simulator and Musculoskeletal Lumboligamentous Model for Lumbar Motion Analysis

Abstract

Obtaining lumbar spine posture data is a fundamental subject for product design, work evaluation, and establishment of lumbar disease treatment and prevention. In this study, a muscle active simulator and a musculoskeletal lumboligamentous model were developed, and were worked in cooperation with each other to measure lumbar posture during motions. Muscle tensions are generated in the apparatus with a servo actuator system. The lumbar model consists of rigid bodies and springs, and estimate lumbar postures and muscle tensions during motions. By using the apparatus and the model, fresh cadavers were made to move as *in vivo*, and the cooperation between the apparatus and the model was validated. Additionally, the model was used to evaluate the spinal instruments for lumbar degenerative scoliosis of elderly persons.

Chapter 1 shows the necessity of the apparatus and the lumbar model, and the objectives.

Chapter 2 describes the design concepts of the muscle active simulator and the system characteristics. The muscle tensions were controlled as wire tensions by a servo actuator. Thorax and pelvis frames were set to cadaveric lumbar and towed by wires attached to the frame along the anatomical muscle lines. Responses of the simulator for ramp functions showed that the simulator can generate tensions for quasi-static motions.

Chapter 3 shows the construction of the musculoskeletal lumboligamentous model, and calculation method of lumbar postures and muscle tensions. The vertebrae were modeled as rigid bodies and ligament and intervertebral discs were modeled as 112 spring elements. The seven main muscles around the lumbar (rectus abdominis, obliquus internus abdominis, obliquus externus abdominis, and erector muscles of spine) were reproducted. Since muscle tensions are redundant when the lumbar moves, muscle tensions during motions were calculated by a numerical optimization to correspond to the objective motions.

Chapter 4 describes the measurement method and actual data of cadaveric lumbar postures. Vertebral motions with three reflective markers were measured by three opt-electronic cameras. Errors of measurement were in translation of 0.8 mm and rotation of 0.5 deg. When the muscle tensions during motions were applied to two fresh cadaveric lumbars, the cadavers moved as the same motions of 90 % as the objective motions. The results also showed that the seven muscles bent the cadavers to all directions, and the muscle tensions, muscle lines and the upper body weight were adequate.

Chapter 5 shows the evaluation of spinal instruments for lumbar scoliosis using the musculoskeletal lumboligamentous model with the spinal instruments modeled as rigid bodies and springs. When the screws were inserted into the right pedicles of all lumbar vertebrae, the scoliosis was not corrected enough. When the screws were inserted into both pedicles of L1, L3 and L5, the loosening of the screws was expected. Since these correspond to clinical knowledge, the lumbar and instrument models were validated for prior estimation of surgical methods and design of the spinal instruments.

Chapter 6 summarizes acquired knowledge and concludes the study.