KINEMATIC ANALYSIS OF THE CERVICAL SPINE

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INTRODUCTION

Neck pain can be debilitating, significantly reducing a patient's range of motion and his/her ability to perform normal neck motions. Degeneration of the intervertebral disks is found to be one of the major factors leading to severe neck pain. Commonly, the lower levels of the cervical spine are susceptible to disc degeneration. It has been hypothesized that the fusion process, while successful, may change the normal motion patterns of the cervical spine. Previous kinematic studies on the human spine have been conducted under in vitro conditions, but recently fluoroscopy has been used on other joints to determine in vivo kinematics (Dennis et al, 1996; Dennis et al, 1998; Komistek et al, 1998). This study focuses on the determination of the in vivo cervical spine kinematics during active neck flexion.

PROCEDURES

Six subjects (two normal cervical spines, two degenerative cervical spines, and two 2-level fused cervical spines) were analyzed under fluoroscopic surveillance. The subjects having a fused spine were fused at the C5-C6 and C6-C7 levels. Both two-level fusion cases were deemed successful by the surgeon who performed the surgery. Fluoroscopic images were downloaded directly to a workstation computer to maintain the high resolution of each image. Each patient was analyzed at ten various increments of spinal flexion/extension (Figure1).

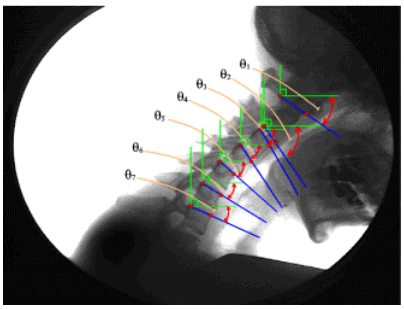

Figure.1 Digitization Method

These images where analyzed using a two-dimensional digitization technique (Komistek, et al, 1998). During the digitization process constant points on each of the seven cervical spine vertebrae were tracked throughout the range of motion. The points were analyzed to determine the rotation angle of each individual vertebra. The rotation of each vertebra relative to the subsequent vertebra was plotted with respect to time and the data was curve-fit to obtain a temporal function that represented the motion pattern. Using a mathematical model, the relative velocities were obtained and used to determine the partial angular and linear velocities. These velocities lead to the determination of generalized speeds and relative interaction forces (Komistek, et al, 1998). Subjects having similar cervical spine conditions were compared to each other. Once this comparison was made, subjects having different cervical spine conditions were then compared against each other.

RESULTS AND DISCUSSION

As hypothesized, motion patterns varied between the normal, degenerative, and fused cervical spines. Normal cervical spines showed a smooth, arc like motion depicting proper function of the articulating surfaces (Figure 2). In contrast, degenerative cervical

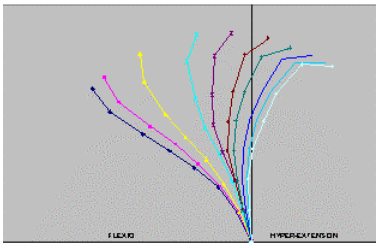

Figure.2 Normal Spine Motions

spines demonstrated inconsistent motion patterns especially at the C5, C6, and C7 vertebrae (location of the degeneration) (Figure 3).

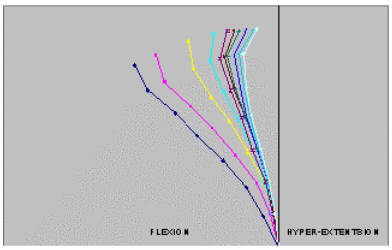

Figure.3 Degenerative Spine Motions

It should be noted that both of the degenerative patients expressed extreme levels of pain. This pain could be one of the factors contributing to the inconsistent motion.

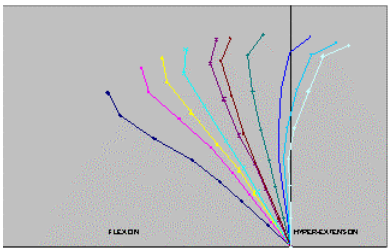

Figure. 4 Fused Spine Motion

The two-level fusion patients demonstrated similar motion patterns to those of the normal patients except in the C5-C6 and C6-C7 levels (Figure 4). No motion was observed between the fused vertebrae, but there were variations at the C4-C5 level (level above fusion). Using the angular motion data, the relative angular velocities demonstrated significant differences between the normal, degenerative and fused subjects. As hypothesized, the subjects having a fused spine experienced a significant change in the relative angular velocities above the fused joint, which may lead to an increase in the reaction force at this joint.

SUMMARY

This present study has shown that fluoroscopy can be used to determine the in vivo motions of the cervical spine. This analysis determined that there is a significant difference in the normal cervical spine motion compared to a degenerative or fused cervical spine. Quite possibly, this change in motion may lead to increased forces at the articulate, degenerative disk, which may attribute to cervical disk failure. Further work needs to be conducted before a definitive conclusion can be made. Therefore, our future work will include the analysis of more subjects, and the determination of the 3D cervical spine kinematics using our previously accepted 3D model-fitting software package.

REFERENCES

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