2005 ASME International Mechanical Engineering Congress and Exposition
November 5-11, 2005, Orlando, Florida USA

IMECE2005-81797

An Ultrasonic Based System to Measure Inter Spinous Process Distance in Humans: A Pilot Study

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ABSTRACT

The objective of this research project was to develop an ultrasonic based testing system and evaluate its application on human volunteers to locate and assess the distance between adjacent lumbar vertebrae. Tests were performed on ten volunteers aged between 19 and 29 years old during two sessions. The participants were asked to lie face down on a table with lower back section uncovered while the tests were executed. A computer controlled ultrasonic system was designed for this application. A single element 3.5 MHz immersion transducer held by a customized assembly was used to propagate and receive the ultrasonic signals. The transducer was moved along the assembly to fully scan at least two contiguous spinous processes. A Lab view based program was designed to generate a two-dimensional image (B-scan) that display the shape and position of the bone tips as well as the distance between them. The standard deviation obtained from the measurements of the distance between the tips of the spinous processes of human subjects, in a given session ranged from 0.1-0.48mm. The difference between two sessions had a mean of 0.85-0.95 mm and a standard deviation of 0.87-1.03mm with reliability coefficients greater than 0.95. The study demonstrated the viability of utilizing ultrasound to precisely measure the distance between spinous processes of adjacent lumbar vertebrae.

INTRODUCTION

Low back pain is a major health problem to society in terms of cost and lost work days. Low back pain patients seek chiropractic care for pain relief and return to normal activities. This study is part of a large project that aims to measure the variation in the intervertebral distance of human patients treated by the Flexion-Distraction Chiropractic technique. Under this technique, muscles, tendons, ligaments and other tissues around the spine are stretched by series of controlled mechanical motions. These events result in a change in the height of the discs, which in turn modifies the separation between adjacent vertebrae. Ultrasound has been used by several investigators for medical applications on the human body and spine (1-8). The objective of this study was to develop an ultrasonic based testing system and evaluate its reliability to locate and assess the distance between adjacent lumbar vertebrae in human subjects.

METHODS

A computer controlled ultrasonic system, US Ultratek-PCIUT3100, was used for this application. A single element 3.5MHz immersion transducer held by a customized assembly propagated and received the ultrasonic signals. The transducer was moved along the assembly to fully scan at least two contiguous spinous processes. The displacement of the transducer was

tracked by an incremental encoder, US digital-S1-360 CPR. A B-scan image was built to display the shape and position of the bone tips as well as the distance between them (Figure 1). The cited distance and the shape of the reflections of each trial were compared to determine the repeatability and reliability of the design.

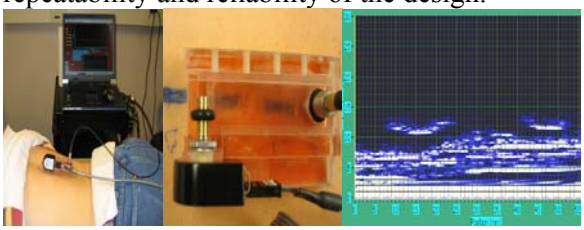

Figure 1. Experimental set-up for Ultrasound scanning

A total of ten volunteers aged between 19 and 29 years old were recruited from the student population of the National university of Health Sciences. All subjects signed an informed consent forms approved by the institutional review boards (IRB) of National University of Health Sciences and the Auburn University. The participants lay face down on a chiropractic table while ten measurements of specific vertebral segments, L1-L2 or L2-L3, were taken. The intervertebral distance was measured using the separation of contiguous spinous processes (S.P.) as the land marks two times on two separate days.

RESULTS AND DISCUSSION

The measurements between the two sessions of the subjects had a mean difference of 0.85-0.95mm with a standard deviation of 0.87-1.03mm with reliability coefficients greater than 0.95.

Some cases there were difficulties discriminating whether signal came from spinous process tips or from any other surrounding tissue. The fact was more significant when scanning overweight subjects since waves were exposed to a longer path. The subjects could have different distances based on the activities and the time of the day Ledsome et.al. (1). The design was found unsuited to measure the intervertebral distance in the lower lumbar area of real subjects (sections L3-L4 and L4-L5) due to the high curvature of the spine. The physical contexture of the subjects also affected the applicability of the technique obtaining better results on subjects with athletic build. Most of the disadvantages and sources of error present in the design-procedure can be minimized using phase array technology. The trade-off of such a system would be high cost and less portability. The design was found unsuited to measure the intervertebral distance in the low lumbar area (sections L3-L4 and L4-L5) due to the high spine curvature.

CONCLUSIONS

We are able to use this system successfully on human subjects. Improvements and further testing need to be done to implement in a clinical situation.

ACKNOWLEDGMENTS

We would like to acknowledge Cox funds at national University of Health Sciences for supporting this work.

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