Citation: Saveh AH, Shabani AB, Zali AR, Kermani S, Seddighi AS, et al. (2017) *In vivo* Kinematics Assessment of Bulged Disk Cervical Vertebral. J Ergonomics 7: 193. doi:10.4172/2165-7556.1000193

confirmed by MRI studies. However, a Kinematic (dynamic) MRI (kMRI) has the ability to scan the patient's cervical spine at a weight-bearing position (either standing up or sitting). kMRI allows recording the patient's data at a motion such as flexion-extension motion, which, may help to investigate any kind of abnormalities at the kinematics of the spine.

In recent years, single plane fluoroscopy registration was used to create a 3D kinematics model for a knee prosthesis model [5,6], however, later in 2008 [7], the method was used for spine. The 2D-to-3D registration method was used to find the kinematics of the spine. The extracting 3D motion from the 2D radiograph is performed based on a technique which matches the single-plane X-ray imaging with 3D models. The kinematic measurements using this method comes with sufficient accuracy based on the precision of registration technique [8], The current study uses a fluoroscopic scanning method along with registration technique of a single-plane image to the 3D model [6,9] to obtain *in-vivo* dynamic CT data.

In previous study, Anderst et al. [10] have collected data from 19 healthy subjects in their research. They have created a three dimensional (3D) model of each vertebra from the segmented bone tissue using CT data. They have conducted a dynamic scanning to find the entire range of motion of the neck of subjects in the sagittal plane. In their study six degree-of-freedom kinematics between adjacent vertebrae were calculated and overall head range of motion in the sagittal plane relative to C7 was determined. However the subject participant of the Anderst et al. study all been healthy and there is no report to specify if there is any illness on the spine what would be the kinematics.

The objective of current study is to assess the motion of the bulged disks intervertebral in sagittal plane. The study is aiming to compare the kinematics of the bulged intervertebral with published normal results. It was hypothesized that there would be differences between normal and bulged intervertebral flexion-extension angles at an identical head orientation such as during flexion-extension motion [11].

Figure 1: MRI single slices of a 58 years old female with C5/C6 bulged disk.

Material and Methods

Bulging disc levels

The study uses a practical examination on subject patients with history of bulged disk in their cervical spine. The data was collected from five subject patients with average age of 45.5 years old. All of the patients had been suffered from a pain in their bulged disk levels. For all the patients, the bulged disk level found through a MRI of the patients' neck. Typical MRI image illustrating a bulging in their C5/C6 intervertebral levels are shown in Figure 1.

The patients were consent to take part in a clinical trial to check and record their cervical intervertebral kinematics involving flexion-extension of the head. All the examination has been performed in a clinical environment at the Shohada-e Tajrish Hospital in Tehran under the supervision of experts. All the stages of the practical examination of the patients were controlled by a risk assessment policy of the local medical authorities and the hospital. The experiment was ruled under an approved ethical procedure.

3D modeling

The study used a 2D-to-3D registration method for assessment of the bulged disks intervertebral kinematics. The cervical spine's CT data was obtained for each patient with slice thickness 0.6 (mm). Using the DICOME files of the CT data, the cervical bones were segmented using Mimics (Materialise, Leuven, Belgium) commercial software [8,12]. The segmentation process was performed on CT gray scaled images using a thresholding algorithm. The models then segmented in each level and smoothed without losing the original size. 3D model of each vertebra was generated and assembled considering the original distance between each level. A typical 3D model of the vertebrae is shown in Figure 2.

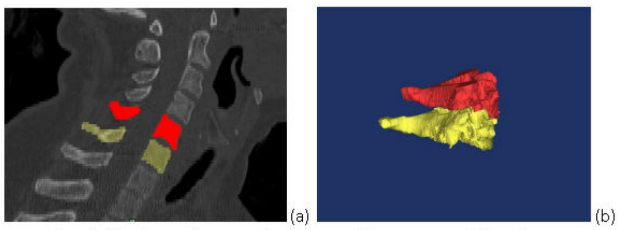

Figure 2: Thresholded C5 and C6 vertebral bones of the 58 years old female patient with intervertebral bulged disk (a); the segmentation of C5 and C6 bones for the same patient before smoothing (b).

Stereo fluoroscopic imaging

The study used an angiography scanning system to generate the stereo fluoroscopic images of the cervical spine. The cervical range of

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motion at bulged disk level was studied using the angio-fluoroscopy scanning system as shown in Figure 3. The angio-fluoroscopic unit which was used for this study had a digital detector with an automatic calibration system. Therefore, no further calibration [12] was needed after the scanning process.

The position of the patient at the time of the experiment has shown in Figure 3. The subject patient asked to perform continuous head flexion-extension movements while fluoroscopic radiograph is collected. The motion of the patient's head and neck was assumed to be only in the sagittal plane. The rate of image recording was set to 15 images per second.

Figure 3: Cervical range of motion of the 58 years old patient recorded using an angio-fluoroscopic scanning at Masih Daneshvari Hospital in Tehran.

Fluoroscopic radiographs were collected using an INNOVA 4100 (GE) with a 400×400 (mm^2) detector at 15 Hz (X-ray parameters: 73 kV, 2 mA). The duration of the subject's movement took no more than 24 s. Dosimeters measured about 0.9 Gy cm^2. Pixel size was 0.43 mm by 0.43 mm and images were digitized with 256 gray levels.

2D to 3D registration

The collected stereo fluoroscopic images were exported in DICOM format and were converted to TIFF format using the freeware ImageJ (https://imagej.nih.gob/ij/) commercial software.

Using JointTrack (https://sourceforge.com) software the 2D TIFF image of the selected vertebral bone were matched with 3D model of the same vertebral bone. The 2D-to-3D registration was continued to get best match [13], and then the relative displacement of the vertebral bones were calculated for the corresponding fluoroscopic frame. The registration was continued for all fames to determine the relative displacement [9], between the vertebral bones during the sagittalflexion-extension motion.

The registration of the plain (2D) fluoroscopic image to the 3D model was continued for C5/C6 to determine the changes on the position of C5/C6 intervertebral bones during the head flexion-extension motion.

Figure 4 shows the stages of 2D-to-3D registration process performed for C5/C6 vertebral bones.

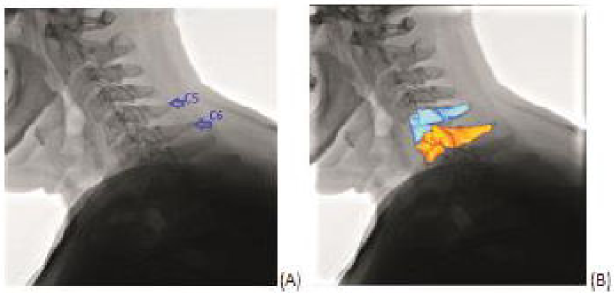

Figure 4: Typical 2D angio-fluoroscopic image in TIFF format for a selected frame captured during flexion-extension motion of the 58 years old patient with C5/C6 bulged disk (A); 2D-to-3D registration process on the same frame (B).

The result of the position change in form of the angle between the C5/C6 intervertebral bones was recorded for all frames to complete the head flexion extension process.

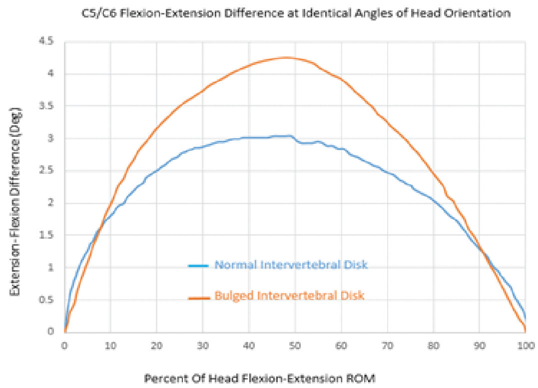

Figure 5: Kinematics of C5/C6 Level. The data of normal disk reproduced [10].

Results and Discussion

Comparison between normal and bulged disk: The initial plan of the study was to examine a number of healthy people against the result we gat for bulged disk patients but due to complexity of local protocols on hazardous of radiographic scanning at the time of the study we couldn't examine any normal/healthy volunteer. Therefore the study was decided to compare the obtained result with those already published in open literature. We have realized the study made by Anderst et al. [10] on 19 healthy subject volunteers has the potential for this comparison. Therefore we have reproduced their result and compare it with our finding.

In Figure 5 the results of the comparison of bulged and normal cases have been illustrated. The result reviled that the kinematics of bulged intervertebral in contrast to normal intervertebral disks is different. For bulged disks cases it is higher than normal cases.

In this *in-vivo* practice which performed on the head to create a flexion-extension motion, for C5/C6 bulged cases, the cervical segments flexed more. This may be referred to level of the degeneration of the disk and also the position of the degenerated disk. Although the kinematics of bulged disk intervertebral at some extent is close to the kinematics of normal disk intervertebral but the reaction of the healthy and bulged disk are not the same.

Comparison on flexion-extension paths: The result obtained by Anderst et al. [10] on normal cervical spine intervertebral kinematics indicates that there is a difference between flexion-extension paths and extension-flexion path. Our result also shows the path for bulged disk at flexion-extension and at extension-flexion are not the same.

Conclusion

All the subject patients participated in this study had history of bulged disk at C5/C6 level. This study was measured the kinematic of their cervical intervertebral using an *in-vivo* method. The result then was compared with those found by Anderst et al. on healthy patients. The result of comparison shows with the bulged disk intervertebral the extension-flexion difference is bigger than normal intervertebral. This indicates the patients with bulged disk are more under the risk of instability in their extension-flexion motion. Furthermore, the distribution of kinematics pattern for both normal and bulged disk is symmetry.

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