RESEARCH ON THE IMPROVED IMAGE TRACKING ALGORITHM OF ATHLETES' CERVICAL HEALTH

PESQUISA SOBRE O ALGORITMO DE RASTREAMENTO DE IMAGEM APRIMORADO DA SAÚDE DO COLO DO ÚTERO DE ATLETAS

INVESTIGACIÓN SOBRE EL ALGORITMO DE SEGUIMIENTO DE IMÁGENES MEJORADO DE LA SALUD CERVICAL DE LOS ATLETAS

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ABSTRACT

Objective: With the increasing number and youth of patients with cervical spondylosis, people pay more and more attention to the cervical spine. Early diagnosis, intervention and treatment play an important role in the recovery of cervical spondylosis. With the continuous development of computer technology, the improvement of various modeling theories, and the application of image processing methods in orthopedics, new ideas are opened to observe cervical vertebra motion health. Methods: In this paper, the measurement of cervical motion is achieved by machine vision. A method of parameter measurement based on the constraint relationship of lower cervical motion is proposed. Based on image preprocessing, the left edge of the cervical vertebra was extracted and analyzed. Results: With the horizontal coordinate of registration point as the reference line, the changing trend of the angle between the left edge curve and the reference line of C4 and C5 vertebrae in the process of spontaneous flexion and extension of the cervical vertebrae was observed, and the movement rate of the cervical vertebrae was analyzed. Conclusions: It was found that the speed of the cervical vertebrae in the process of movement of the patients with cervical spondylosis showed jumping changes. ***Level of evidence II; Therapeutic studies - investigation of treatment results.***

Keywords: Triagem; Diagnostic imaging; Spondylosis.

RESUMO

Objetivo: Com o aumento do número e da juventude dos pacientes com espondilose cervical, as pessoas prestam cada vez mais atenção à coluna cervical. O diagnóstico, intervenção e tratamento precoces desempenham um papel importante na recuperação da espondilose cervical. Com o desenvolvimento contínuo da tecnologia computacional, o aprimoramento de várias teorias de modelagem e a aplicação de métodos de processamento de imagens na ortopedia, novas ideias se abrem para observar a saúde do movimento das vértebras cervicais. Métodos: Neste trabalho, a mensuração do movimento cervical é realizada por meio de visão artificial. É proposto um método de medição de parâmetro baseado na taxa de restrição de movimento cervical inferior. Com base no pré-processamento da imagem, a borda esquerda da vértebra cervical foi extraída e analisada. Resultados: Com a coordenada horizontal do ponto de registro como linha de referência, a tendência de mudança do ângulo entre a curva da borda esquerda e a linha de referência das vértebras C4 e C5 foi observada no processo de flexão espontânea e extensão do vértebras, vértebras cervicais e a taxa de movimento das vértebras cervicais. Conclusões: Verificou-se que a velocidade das vértebras cervicais no processo de movimentação de pacientes com espondilose cervical apresentou alterações de salto. **Nível de evidência II; Estudos terapêuticos- investigação dos resultados do tratamento.**

Descritores: *Triagem; Diagnóstico por Imagem; Espondilose.*

RESUMEN

Objetivo: Con el número creciente y la juventud de pacientes con espondilosis cervical, las personas prestan cada vez más atención a la columna cervical. El diagnóstico, la intervención y el tratamiento tempranos juegan un papel importante en la recuperación de la espondilosis cervical. Con el desarrollo continuo de la tecnología informática, la mejora de varias teorías de modelado y la aplicación de métodos de procesamiento de imágenes en ortopedia, se abren nuevas ideas para observar la salud del movimiento de las vértebras cervicales. Métodos: En este trabajo, la medición del movimiento cervical se logra mediante visión artificial. Se propone un método de medición de parámetros basado en la relación de restricción del movimiento cervical inferior. Sobre la base del preprocesamiento de imágenes, se extrajo y analizó el borde izquierdo de la vértebra cervical. Resultados: Con la coordenada horizontal del punto de registro como línea de referencia, se observó la tendencia cambiante del ángulo entre la curva del borde izquierdo y la línea de referencia de las vértebras C4 y C5 en el proceso de flexión y extensión espontánea de las vértebras *cervicales, y Se analizó la tasa de movimiento de las vértebras cervicales. Conclusiones: Se encontró que la velocidad de las vértebras cervicales en el proceso de movimiento de los pacientes con espondilosis cervical mostró cambios de salto.* ***Nivel de evidencia II; Estudios terapéuticos- investigación de los resultados del tratamiento.***

Descriptores: *Triaje; Diagnóstico por imagen; Espondilosis.*

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INTRODUCTION

With the acceleration of modern life rhythm, people's working pressure is increasing, and it is easy to obtain various occupational diseases.[1-3] Among them, cervical ridgeine syndrome has become a common disease in the masses. At present, the incidence of cervical spondylosis is often young.[4-6] In addition, the difference in cervical health problems can be easily causing many complications, such as hypertension, cervical heart syndrome, lower limbs, and many diseases that seriously affect people's physical and mental health.[7-10] Therefore, how to actively and effectively protect the health of the cervical spine in life has become a very important issue in the life and work of modern people. Using image processing methods, we can measure the relative motion parameters of each vertebra, detect the range of cervical spine, and determine whether the cervical spine moderate is abnormal, which has an important significance of abnormal motility evaluation, quantitative assessment of rehabilitation and subsequent treatment of surgery.

METHODS

With the continuous development of digital image technology, the three-dimensional finite element model of more and more cervical vertebrae has been established.[11-13] By giving the loading of different material properties and boundary conditions, the cervical spine of the cervical vertebrae under natural load can be more realistic.[14-15] The appearance of some pathological changes of the cervical vertebrae is simulated by the change and force of the applied load, and the cervical spinal treatment method is combined, combined with imaging diagnosis.

Measurement of cervical motion parameters

In this project, we need to collect infrared thermal images of the cervical vertebrae of many people as experimental data.[16-17] In this study, subjects were divided into healthy patients without cervical abnormalities and patients with cervical lesions.

The registration form of the tested person, the experiment protocol and the experiment process, as shown in Figure 1.

In the aspect of the analysis of cervical motion health and the research of cervical force, it is the first and the most critical step to measure the position of the mark points on the cervical spine. Only by measuring the position data with high precision, can we carry out the kinematic analysis and related health research of the posterior cervical spine.

This article uses geometric methods to measure the center of rotation of cervical spine. The detailed measurement method is as follows:

The lower edge of the lower bone is drawn from the X-axis labeled the entire image coordinate system, and the lower angle of the lower bone is used as the point of the coordinate system, and the line drawing the Y axis perpendicular to the X-axis of the coordinate system. The other three X-ray films overlap the template X-ray membrane such that the 4 X-ray membrane is completely overlapping.

Draw the line between the front and lower angles of the lower bone and the lower portion of the lower bone and the front angle of the upper vertebra and the upper angle, and two auxiliary point extension lines are drawn under 2 cm and 4 cm. Then, in the front and lower corners of the vertebral bone and the rear and superior angles of the upper vertebra and the rear portion and the excellent angle, two auxiliary points are drawn at 2 cm and 4 cm of the extension line. There are four auxiliary points. 16 auxiliary points were obtained by the operation of the remaining 3 X-ray membranes described above.

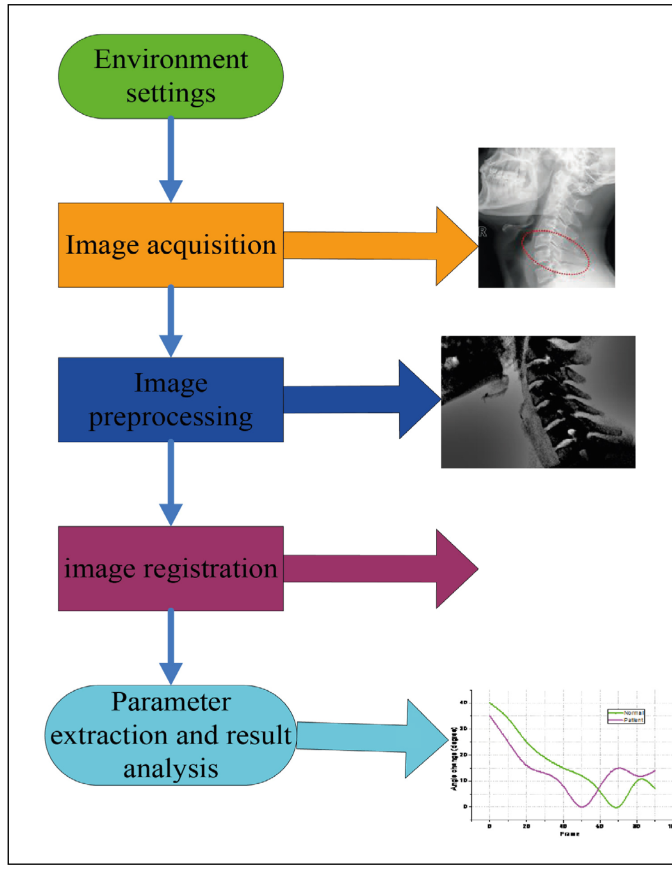

Figure 1. Experiment flow.

The above-described auxiliary point is transferred to the A4 size transfer paper, and the x-axis and the Y axis on the transfer paper are marked with a marker pen. The 16-assist point of the moving image of the upper body is disposed on the 8 line V shape on the transfer paper.

Two points at 4cm and 2cm from the posterior upper angle of the vertebral body and two points at 4cm and 2cm from the anterior upper angle of the vertebral body were calculated four times respectively, and the average value was taken.

The schematic diagram of rotation center measurement is shown in Figure 2.

RESULTS

Image-based analysis of cervical spine health

In this chapter, the movement trajectory of the left edge of the cervical vertebrae is extracted and observed by processing a plurality of consecutive cervical vertebra images.

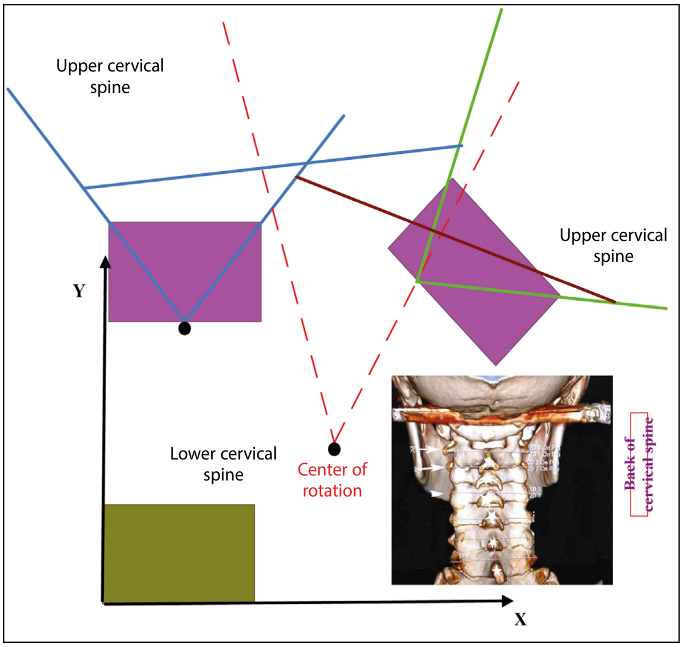

Figure 2. Measurement of cervical rotation center.

Preprocessing of cervical X-ray image

The minimum value of the image covering all positions from flexion to extension of the cervical spine is recorded as W, and the size is $u \times v$ pixels. u and v represent the size of the image at the minimum value respectively. u is the number of horizontal pixels, v is the number of vertical pixels. It can be seen from Figure 3 that although the influence of some images on the cervical spine is excluded in the process of selecting the region of interest, the gray distribution of the image is still very concentrated.

If the input image is $f(x,y)$ and the structure element is $g(i, j)$, then the gray scale corrosion can be defined as:

$$(f\Theta g)(x,y)=\min\left\{f(x+i,y+j)-g(i,j)\,|\,(x+i,y+j)\in Df;(i,j)\in Dg\right\} \quad (1)$$

Gray scale expansion can be defined as:

$$(f\Theta g)(x,y)=\max\left\{f(x-i,y-j)+g(i,j)\,|\,(x\text{-}i,y\text{-}j)\in Df;(i,j)\in Dg\right\} \quad (2)$$

Then the top cap bottom cap transformation is defined as:

Top cap change:

$$HAT(f)=f-(f\circ g)=f-\left((f\Theta g)\oplus g\right) \quad (3)$$

Cap change:

$$HAT(f)=(f\circ g)-f=\left((f\oplus g)\Theta g\right)-f \quad (4)$$

In this experiment, we choose the top hat and bottom HAT transform image enhancement algorithm based on morphology and the image enhancement algorithm based on Retinax theory for double enhancement. The enhanced image is shown in Figure 3.

After extracting the left curve of the cervical vertebra, this point is the maximum point of the vertical coordinate y value, and the coordinate is recorded as M_1 (X_1, Y_1). In the second frame, the point coordinates of the same position are recorded as M_2 (X_2, Y_2) , and so on. In the last frame, the point coordinates of the same position are recorded as M_n (X_n, Y_n). The registration distance difference is:

$$D_i(X,Y)=M_i(X_i,Y_i)-M_1(X_1,Y_1),i=1,2,3\cdots n \quad (5)$$

Registration process:

$$B_i(X_{ij},Y_{ij})=A_i(X_{ij},Y_{ij})-D_i(X,Y),i=1,2,3\cdots n;\ j=1,2,3\cdots m \quad (6)$$

The overall movement trend of the cervical vertebra, the physiological curve of the cervical vertebra and the maximum position of the posterior extension of the cervical vertebra can be observed. (Figure 4)

Continuous X-ray image parameter extraction

In this experiment, the fourth, fifth and fifth segments of the cervical spine were selected as the segments of interest. The seed points were

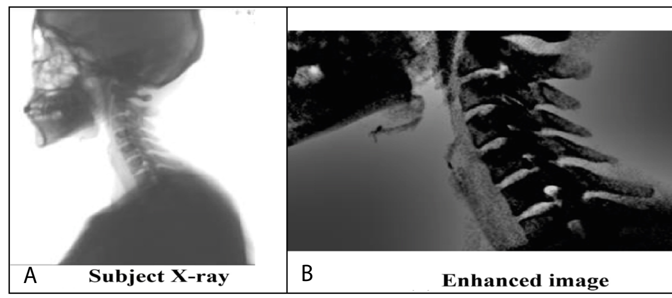

Figure 3. X-ray enhanced image of cervical spine.

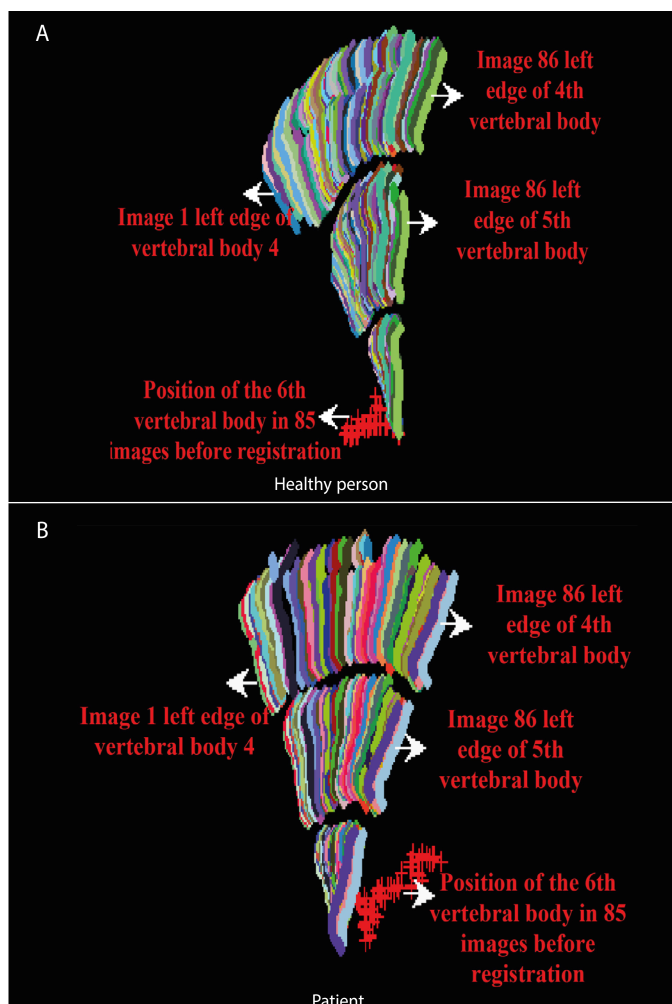

Figure 4. Curve of left edge of cervical vertebra.

selected from the left edge curves of the fourth and fifth cervical vertebrae, and the seed matrix was updated after each image was completed. Save and display the coordinates of all seed pixel points in matrix $C(u, v)$, as shown in Figure 4, red + represents the position before registration, and curves of different colors represent the position of the left edge of the cervical spine at different times.

In order to reduce the error, select all the data from the fifth row to the tenth row in matrix C, and calculate the average value relative fixed point coordinate NNN according to the column: $N_i\ (s_i, y_i),\ i = 1, 2, 3...$

In order to observe the movement trend of the fourth and fifth cervical segments, the transverse coordinates of the registration points were used as the reference line to calculate the angle between the left edge curve of the vertebrae and the reference line. The process was as follows:

$$\theta = \arctan \frac{X_1 - x_i}{Y_1 - y_i}, i = 1,2,3 \ldots \qquad (7)$$

The angle between the left edge of the fifth vertebral body and the reference line is shown in Figure 5. The small figure shows the angle between the curve of the left edge of the cervical vertebra and the reference line.

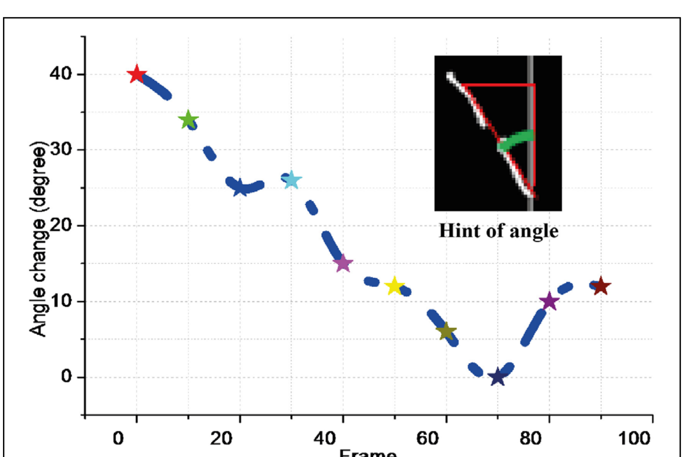

Figure 5. Analysis of the position of cervical spine segment.

Analysis of experimental results

The change of the angle between the C4 and C5 vertebrae of the patient group and the normal group during the movement is shown in Figure 6.

Take C4 and C5 vertebrae as examples to analyze the movement rate of cervical vertebrae, and the angle change is shown in Figure 6. For the discrete data in the figure, the difference operation is carried out, and the change of vertebral body movement rate is shown in Figure 7. See Figure 8 for the variance comparison of cervical spine movement rate between the patient group and the normal group. The variance of the patient group is 0.462, and that of the normal group is 0.331.

Observe the single vertebra movement track, analyze the angle between the left edge curve of C4 and C5 vertebrae and the reference line between the patient group and the normal group, and see Table 1 for the results of independent sample t test on the angles of C4 and C5 vertebrae in the patient group and the normal group. The angle of C4 and C5 vertebrae in the hyperflexion position of patients and normal group was statistically significant ($P < 0.05$), but there was no significant difference in the hyperextension position ($P > 0.05$).

When analyzing the change of relative position of adjacent single vertebrae, the change of C4 and C5 vertebrae angle is subtracted, and the data of C4 and C5 vertebrae relative position change is calculated and the template is fitted.

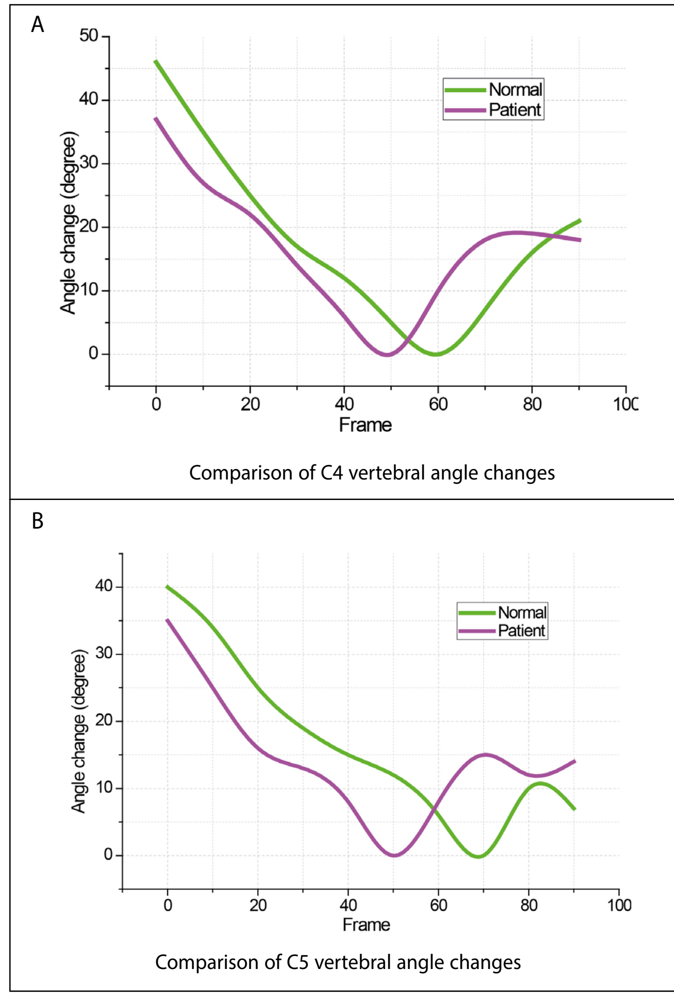

Figure 6. Comparison of vertebral angle changes between patients and normal people.

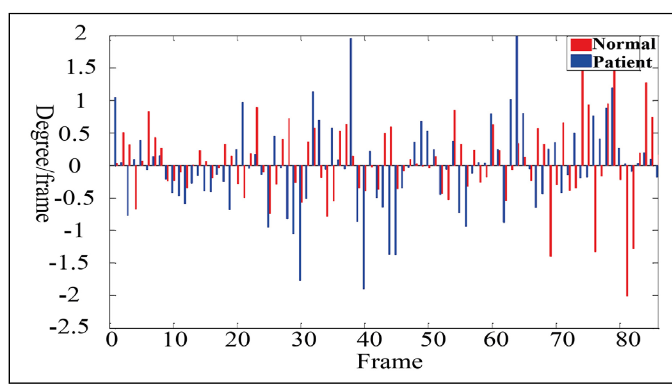

Figure 7. Change rate of vertebral angle between patients and normal people.

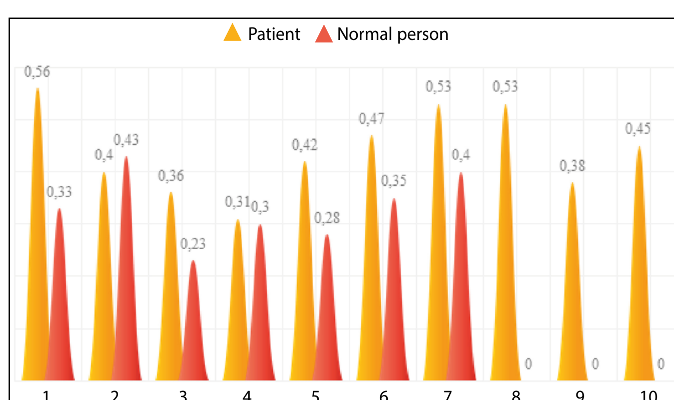

Figure 8. Variance of vertebral angle rate between patients and normal people.

Table 1. Comparison of the angle of C4-5 vertebral flexion and extension between the patient group and the normal group (Unit: degree).

Group	C4 vertebral body		C5 vertebral body	
	Flexion angle	Over extension angle	Flexion angle	Over extension angle
Patient group	26.74	16.67	22.92	12.62
Normal group	39.16	16.22	35.98	11.61
P value	0.01	0.93	<0.01	0.85

DISCUSSION

In this study, the angular difference between the left edge of the C4 and C5 vertebrae and the reference line reflected in the relative position of a single vertebra in the exercise process. Based on the dynamic characteristic analysis of continuous images, more data is provided to study single-vertebral body movement, and provide more reference information for diagnosing cervical spondylosis. Some of the results of some image processing are unsatisfactory, and the algorithm has a strong robustness, and the dependence on the image itself is large. The sample size is small, and due to individual differences, the relative position curves of C4 and C5 vertebrae in different patients are different in the motion process, and further studies need to be further studied.

The author declare no potential conflict of interest related to this article

AUTHORS' CONTRIBUTIONS: Jingjing Jiang analyzed and explained that intervention and treatment play an important role in the recovery of cervical spondylosis. With the continuous development of computer technology, the improvement of various modeling theories and the application of image processing methods in orthopedics have opened up new ideas for observing the health of the cervical spine.

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