

# DYNAMIC STUDY OF THE CERVICAL REGION OF VERTEBRAL COLUMN IN VARIOUS AGES

E. SHARAF, L. EL-ADWAR, H. SALIB AND F. IBRAHIM

*Departments of Anatomy and Orthopaedic Surgery*

*Faculty of Medicine, Alexandria University*

## INTRODUCTION

Previous anatomical, histological and radiological studies of the cervical region of the vertebral column revealed that degenerative changes started in the second decade and increased progressively with age (Sharaf, 1965 & Sharaf et al 1971). This was attributed to the continuous strain to which the cervical vertebrae were subjected throughout the day by the repeated antero-posterior movement of the cervical vertebrae with the movement of the mandible, (Sharaf, et al 1973), with the movement of flexion and extension of the neck and also by the weight of the freely movable head. As it is generally known that there is no correlation between the degree of degenerative changes and the intensity of radi- cular pain, the dynamic study of the cervical region of the vertebral column could be performed to reveal the incipient disturbances of the mutual connections between the neighbouring vertebrae (Jan Jirout, 1956). This study aimed at finding the range of movement of the cer-

vical region as a whole, for each age group, as well as the normal range at each intervertebral disc, in order to diagnose any deviation from the normal.

## MATERIAL AND METHODS

This work was based on a study of fifty subjects; 37 males and 13 females. Their ages ranged from 9 to 70 years. Cases complaining of arthritic skeletal symptoms were excluded. Lateral radiograms of the cervical region of the column were taken in the neutral position (with the pupils directed horizontally), in full flexion and in maximal extension (keeping the shoulders fixed).

For examination of the range of movement of the whole region the tracings of the three radiograms were superimposed, with the 7th cervical vertebra taken as a base. Three lines were drawn extending from the top of the odontoid process to the middle of the base; one for each tracing. The two angles thus formed were measured, an

other of extension posteriorly. The other of extension posteriorly. The summation of the two angles corresponds to the total range of movement of the cervical region.

For examination of the range of movement at the cervical intervertebral discs, linear measurements of the anterior height of the intervertebral disc spaces were taken from the radiograms during flexion and extension; the difference between the two stands for the range of movement at a given disc (De Séze, 1951). The results were tabulated, and photographs and diagrams were given.

## RESULTS

*Total Range of Movements of the Cervical Column (Tables I & II) during the period of growth (1-25 years).*

From the age of 9-25 years, the radiograms showed minimal degenerative changes in the form of slight thinning and posterolateral osteophytes at  $C_5 - C_6$ .

The angle of flexion ranged between  $11^\circ$  and  $37^\circ$ ; diminishing with age, with an average of  $28.5^\circ$ .

The angle of extension ranged from  $8^\circ$  to  $41^\circ$  with average of  $29.6^\circ$ .

The range of movements of the whole cervical region from full flexion to full extension ranged between  $41^\circ$  and  $74^\circ$  with an average of  $58^\circ$  (Fig. 1). It diminished also with age, being free in the first decade (early years of growth).

*Adult Period :*

*A : 26-40 years.*

Radiogram belonging to this group showed moderate degenerative changes at least at one intervertebral space. This was in the form of narrowing of the intervertebral space indicating thinning of the disc (usually at  $C_5 - C_6$ ), in addition to anterior, posterolateral and posterior, small bony spurs and marginal lipping; of these the anterior ones were more common.

Angles of flexion ranged between  $15^\circ$  and  $39^\circ$  with an average of  $24.6^\circ$ . Angles of extension ranged between  $10^\circ$  and  $38^\circ$  with an average of  $24.1^\circ$ . The range of movement varied from  $30^\circ$  to  $60^\circ$  with an average of  $48.1^\circ$ .

In this group, the degree of mobility was not related to age, but to the amount of the degenerative process occurring at the discs.

*B : 41-70 years :*

Degenerative changes were apparent in the radiograms at more than one intervertebral space (Fig. 2).

Angles of flexion ranged between  $9^\circ$  and  $36^\circ$  with an average of  $24.3^\circ$ , while the angles of extension ranged from  $4^\circ$  to  $24^\circ$  with an average of  $13.8^\circ$ ; marked limitation of movement of extension than flexion if compared with group A. The range of movement varied from  $27^\circ$  to  $51^\circ$  with an average of  $38.1^\circ$ .

From Table I, it is evident that the movement of the cervical vertebrae in males diminished with age specially that of extension which was slightly greater at the period of growth.

Similar observations were seen in relation to female subjects (Table II), although in the adult period they showed wider range of movements.

Table I : Shows, in degrees, the angles of flexion and extension, and the range of movements (R) in a sagittal plane of the cervical spines in male subjects.

Period of growth				Adult period							
1 - 25 y. D : +				26 - 40 y. D : ++				41 - 70 y. D : +++			
Age	Fle- xion	Exten- sion	R	Age	Fle- xion	Exten- sion	R	Age	Fle- xion	Exten- sion	R
9	34	34	68	28	27	28	55	42	29	18	47
10	37	37	74	30	39	16	55	47	11	22	33
14	27	25	52	31	18	38	56	48	31	19	50
15	31	33	64	31	29	31	60	50	20	13	33
16	33	8	41	33	31	17	48	50	19	12	31
17	37	34	71	35	20	38	58	50	36	8	44
19	27	23	50	37	15	35	50	51	36	15	51
20	11	41	52	37	20	16	36	51	28	12	40
21	28	35	63	40	20	10	30	51	27	16	43
22	22	28	50	40	27	12	39	60	24	17	41
25	26	27	53	—	—	—	—	60	24	13	37
	—	—	—	—	—	—	—	60	23	4	27
	—	—	—	—	—	—	—	60	20	19	39
	—	—	—	—	—	—	—	63	26	7	35
	—	—	—	—	—	—	—	70	24	11	35
	—	—	—	—	—	—	—	70	26	4	30
	—	—	—	—	—	—	—	70	9	24	33
Mean	28.5	29.6	58		24.6	24.1	48.1		24.3	13.8	38.1

D = Degeneration.

Table II : Shows, in degrees, the angles of flexion and extension, and the range of movements (R) in a sagittal plane of the cervical vertebrae in female subjects.

Period of growth				Adult period							
1 - 25 y. D : +				26 - 40 y. D : ++				41 - 70. D. +++			
Age	Fle- xion	Exten- sion	R	Age	Fle- xion	Exten- sion	R	Age	Fle- xion	Exten- sion	R
16	30	29	59	30	23	32	55	41	24	17	41
16	44	24	68					42	24	18	42
17	28	23	51					51	13	28	41
18	39	26	65					60	23	22	45
19	19	28	47					60	27	14	41
19	22	17	39								
25	30	40	70								
25	40	25	65								
Mean	31.5	26.5	58		23	32	55		22.2	19.8	42.0

D = Degeneration.

Table III : Shows the average of the anterior height of the intervertebral spaces between the lower six Cervical vertebrae (in mm.), in flexion and extension, in subjects from the first seven decades of life.

Decades	space between C <sub>2</sub> & C <sub>3</sub>		space between C <sub>3</sub> & C <sub>4</sub>		space between C <sub>4</sub> & C <sub>5</sub>		space between C <sub>5</sub> & C <sub>6</sub>		space between C <sub>6</sub> & C <sub>7</sub>						
	F	E	F	E	F	E	F	E	F	E					
1st & 2nd	4.6	5.2	4.3	5.8	4.3	6	[1.7]	3.9	6.5	[2.6]	3.6	5.3	[1.7]		
3rd	3.3	4.3	[ 1 ]	2.8	3.8	[ 2 ]	3.3	5.5	[2.2]	3.3	6	[2.7]	2.8	4.8	[ 2 ]
4th	4.6	5.2	[0.6]	4.4	6	[1.6]	3.8	6	[2.2]	3.4	6	[2.6]	3.4	4.8	[1.4]
5th	3.3	4.3	[ 1 ]	3.2	5	[1.8]	3.5	5.5	[ 2 ]	3.2	5.5	[2.3]	3	4.7	[1.7]
6th	3.8	4.5	[0.7]	3.5	5	[ 2 ]	4.3	6.3	[ 2 ]	4	6	[ 2 ]	3.5	5.3	[1.8]
7th	4	4	[ 0 ]	3.5	5	[1.5]	3	4	[ 1 ]	3.5	4.5	[ 1 ]	3	3.5	[0.5]
			[0.7]			[1.7]				[1.8]			[2.3]		[1.5]

F. ; Flexion.

E. ; Extension.

R. ; Range at each disc.

### *Range of Movements at the Inter-vertebral discs :*

Table III shows that the range of movement was greatest at C<sub>5</sub>-C<sub>6</sub> and least at C<sub>2</sub>-C<sub>3</sub>. It also shows that the range of movement diminished in the following succession C<sub>5</sub>-C<sub>6</sub>, C<sub>4</sub>-C<sub>5</sub>, C<sub>3</sub>-C<sub>4</sub>, C<sub>6</sub>-C<sub>7</sub>, C<sub>2</sub>-C<sub>3</sub>.

Furthermore, the mobility at C<sub>5</sub>-C<sub>6</sub> originally maximum, diminished with age and this diminution was compensated for by a relative increase in the mobility at the previously less mobile discs. This was evident during the 6th and 7th decade. In the former, the range of movement at C<sub>5</sub>-C<sub>6</sub> diminished from 2.6 mm in the first two decades to 1mm. in the 6th decade, while it correspondingly increased at C<sub>3</sub>-C<sub>4</sub> from 1.5mm. to 2mm., at C<sub>6</sub>-C<sub>7</sub> from 1.7 mm. to 1.8mm., and even at the least movable disc, C<sub>2</sub>-C<sub>3</sub> from 0.6to 0.7mm. although the general pattern was a progressive diminution at the most movable discs. (Table III) (Fig. 2b).

### **DISCUSSION**

The mobility of the cervical column is relatively free due to the small size of the vertebral bodies, to the small and horizontally placed spines, to the narrow laminae, to disposition of the articular processes and to the shape of the central ends that approaches the heterocoelous type having beveled superior surface anteriorly. Furthermore, the relative thickness of the intervertebral disc as compared

to adjacent vertebra, being 80% at birth (Sharaf, 1965), the corresponding ratio was found by Peacock (1951) to be 50% for the lumbar disc.

The observed free mobility during the early period of growth could be attributed to the weak spinal ligaments, and their loose attachment to adjacent discs and vertebrae, to the delicate nature of the constituent fibres of the annulus fibrosus, and to the highly fluidy character of the nucleus pulposus observed in anatomical specimens in previous work, to the incomplete development of the lateral and anterior bony lips that characterise the cervical vertebrae, and to the relatively thick intervertebral discs and adjacent cartilagenous plates.

In the subsequent years of growth, there was continuous diminution of the range of movement which can be attributed to the development of the bony and ligamentous portions of the cervical region. The normal anatomical arrangement allows a slightly wider range of extension than flexion, inferior bony lips become more developed and limit the movement of flexion and afford stability in anteroposterior direction. The observed average range of movement of flexion was 28.5° and that of extension was 29.6°, the corresponding averages given by De Seze and Abdel Moola (1951) were 33° and 71.5°. Such difference could be

attributed to racial and habitual factors, while the wide range of both movements may be due to the prevalence of the young individuals in his series.

Subluxion or even dislocation are more common in the lower cervical region early in the period of growth, due to the small bony lips of the lower cervical vertebrae if compared with those of the upper ones which afford stability.

In adult life with moderate degenerative changes (26-40y), limitation of movement occurred. This limitation became more evident after the age of forty and progressed rapidly with the advance of the process of degeneration in the cervical discs and spinal ligaments. As the disposition of the bony spurs or marginal bony lipping are produced in response to intermittent postural tension (David 1957), they form at the point of insertion of the anterior longitudinal ligament, with the greatest incidence at the summit of the cervical curve (Sharaf, 1965). These bony spurs limit the movement of flexion, while the diminished elasticity, stiffness, the increasing thickness, calcification and even ossification of the anterior ligament, produced very progressive and marked diminution of the movement of extension. This has to be kept in mind when applying cervical collars and during physiotherapy as a treatment of disc lesions.

The range of movement at the cervical intervertebral discs was found to be greatest at  $C_5 - C_6$  and least at  $C_2 - C_3$ , this is why degenerative changes start very early in the former and become progressive with age. The range of movement along the cervical column was studied by De Séze, (1951), By Bakke (after De Séze). Comparing their results with the present ones, there is an agreement that  $C_5 - C_6$  is the most movable disc and that  $C_2 - C_3$  is the least movable one, while the ranges given by De Seze (1951) were more or less similar to the present ones. The differences obtained between the three readings in relation to the other discs could be attributed to habitual and constitutional factors, in relation to cervical column e.g. the length and the type of the cervical curvature. The succession of the range of mobility was found to be :

$C_5 - C_6, C_6 - C_7, C_3 - C_4, C_4 - C_5, C_2 - C_3$   
(Bakke, 1951).

$C_5 - C_6, C_4 - C_5, C_6 - C_7, C_3 - C_4, C_2 - C_3$   
(De Séze, 1951).

$C_5 - C_6, C_4 - C_5, C_3 - C_4, C_6 - C_7, C_2 - C_3$   
(the present findings).

The cervical column is a functional entity, diminution or loss of mobility at one intervertebral joint was found to be compensated in a more healthy segment which was noticed during the latter decades of life. Sometimes even the compensatory mobility was free at the discs which to start with were rela-

tively less movable. This has to be kept in mind in analysis of the radiograms in dynamic examination of the cervical spine. The observed slight increased mobility in females may be a sex difference in the cervical vertebrae or may be due to hormonal factors.

### SUMMARY

Lateral radiograms in neutral, maximal flexion and maximal extension of the cervical column of subjects free from symptoms, whose ages varied from 9-70 years were examined for the range of movement of the whole region and at the cervical discs. Angular measurements were performed on the tracings and linear measurements were obtained from the films. The findings could be summarized as follows :

The cervical column was freely movable early in the period of growth, flexion movement was equal to that of extension 35.5°, each).

...Diminution of the range of mobility occurred during the following years of growth due to developmental factors occurring in the ligamentous and bony elements of the cervical spine.

In adults progressive diminution of movements was seen as a result of the progress of the degenerative process, extension was more limited, because these changes affect the anterior more than the posterior longitudinal ligaments. The mechanisms underlying these changes were discussed.

C<sub>5</sub> - C<sub>6</sub> was the most movable disc and

hence the earliest and most degenerated disc.

Mobility at the intervertebral discs diminished in the following succession :

C<sub>5</sub> - C<sub>6</sub>, C<sub>4</sub> - C<sub>3</sub>, C<sub>3</sub> - C<sub>2</sub>, C<sub>6</sub> - C<sub>7</sub>, C<sub>2</sub> - C<sub>3</sub>.

The clinical importance of these findings was discussed.

### REFERENCES

1. David, A. : Movement of the lumbar spinal column J. Bone & Jt. Surg. 39 B : 339, (1957).
2. De Seze and Abdel Moula : Etude radiologique de la dynamique cervicale dans le plan sagittal : Revue du Rhumatism, 18<sup>e</sup> Année : 3 (1951).
3. Jan. J. : Studies in the dynamics of the cervical spine. Acta radiologica 4th Symposium neuroradiologicum (1956).
4. Peacock, A. : "Observations on the post-natal structure of the intervertebral disc in man. J. Anatomy., Lond. 85 : 162, (1951).
5. Sharaf, E. : Post natal changes of the cervical intervertebral disc in man. Unpublished M.D. Thesis, Faculty of Medicine, Alexandria University, (1965).
6. Sharaf, E., Mira, K., Ghonem, M. : The anatomical post-natal changes of the cervical intervertebral foramina in relation to root pain. Egyptian rheumatologist, 8/1 : 40 - 53, (1971).
7. Sharaf, E., El Sherbini, K., Massoud G. and Mansoury A., : Movements of the cervical column during mouth opening. Bulletin, Alexandria Faculty of Medicine IX/2 : 131 - 145, (1973).



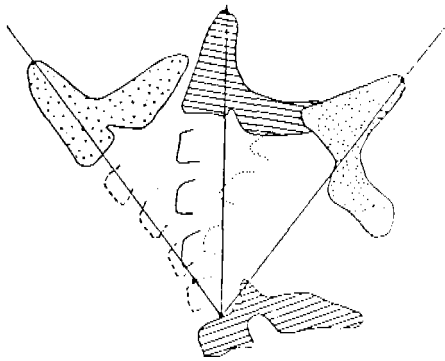
## EXPLANATION OF FIGURES

**Figs. (1.a, 1.b & 1.c).: Super imposed tracings of male subjects belonging to the 1st, 2nd, and 7th decades of life, showing diminution of the range of movements with age, specially the movement of extension.**

**Fig. 2 a :** Lateral radiograms of a male subject aged 9 years, with full

flexion (I) and full extension (II) of the cervical column, showing the wide range of movements.

**Fig. 2b :** Lateral radiograms of a male subject aged 70 years, with full flexion (I) & full extension (II) of the cervical column.



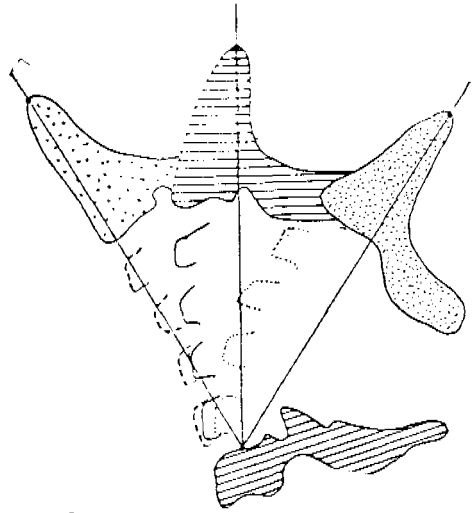
F 37° ----

E 37° ---

R 74°

I<sup>st</sup> Decade

Fig. (1. a)



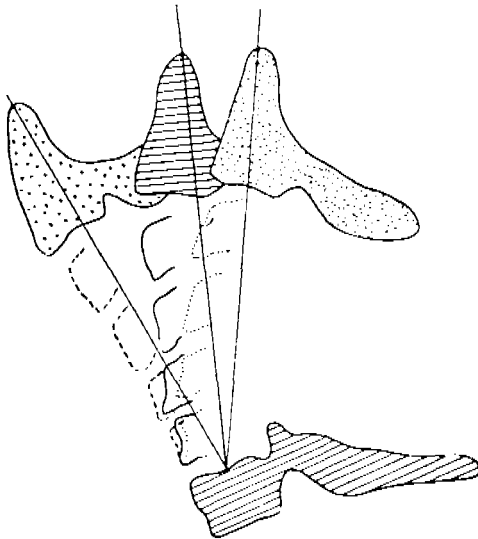
F 31° ----

E 33° -----

R 64°

II<sup>nd</sup> Decade

Fig. (1. b)



F 24° ----

E 11° -----

35°

VII<sup>th</sup> Decade

Fig. (1. c)

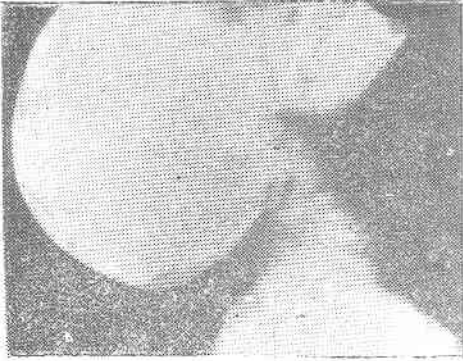


Fig. ( a. I)

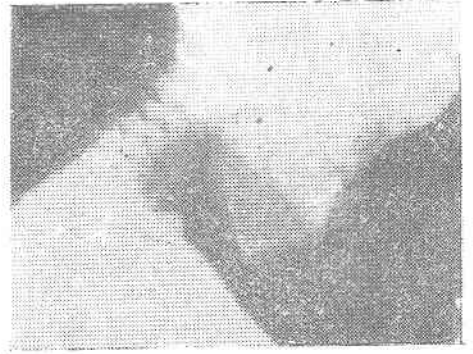


Fig. (2 a. II)

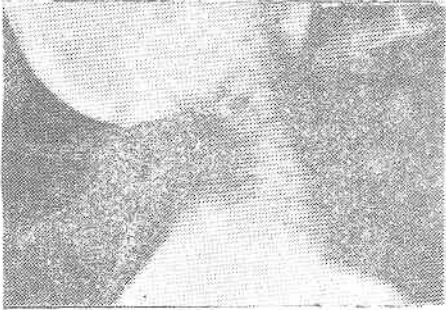


Fig. (2 b. I)

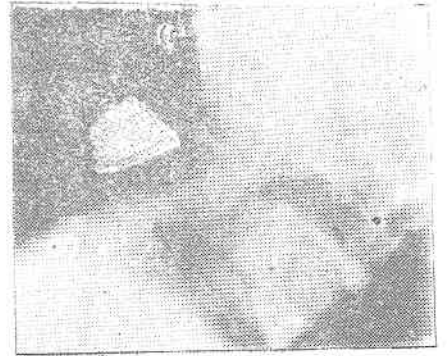


Fig. (2 b. II)