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Relationship between Cervical Sagittal Parameters and Health Related Quality of Life in Cervical Degenerative Disc Diseases

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: The evaluation of the differences in radiological cervical sagittal parameters between symptomatic and asymptomatic individuals with radiologically- confirmed (CDDD) is fundamental for understanding the normal variation in sagittal plane parameter between individuals, to determine the age-related changes, to know the predictive sagittal parameters for unfavorable clinical symptoms and to determine the factors that participate in economic sagittal balance (compensation) in asymptomatic subjects. This will provide radiographic guidelines for the assessment and management of cervical spine patients.
Objectives: This study aimed to evaluate the relation between the radiological cervical sagittal parameter changes with the presence and severity of symptoms as well as quality of life in CDDD individuals, and provided radiographic guidelines for the assessment and management of cervical spine patients.
Methodology: The first 100 subjects who have visited the Outpatient clinic of Orthopedic Department in Tanta University Hospitals with radiologically-confirmed CDDD with or without

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clinical symptoms were reviewed. The individuals were divided into 2 groups for analysis and comparison. Group1 included the first 50 patients with symptomatic CDDD. Group2 included another 50 individuals with asymptomatic CDDD in their radiographs who visited the outpatient clinic as a relative to other patients or complained from other transient musclo-skeletal symptoms not affecting their quality of life.

Results: *In the Analysis of the relationships between the data of the 2 groups*: There were no statistically significant differences between each of the age, sex, occupations, and BMI in comparison between the 2 groups. The T1S angle was the only significant parameter in correlation between 2 groups. *In the Analysis of the relationships between the data in the symptomatic group:* There was a statistically significant increase in each of the T1S, C2-C7 lordosis, C2-C7 SVA with increasing the age. T1S was significantly lower in farmers and manual workers than in housewives and office workers. There was a significantly inverse correlation between each of the CL, T1S, T1S-CL and VAS. There was a significantly positive correlation between each of the CL, T1S, T1S-CL and modified EQ-5D-3L score. *In the Analysis of the relationships between the data in the asymptomatic group:* There was a significant increase in each of the TIA, T1S and NT with increase age, with an insignificant increase CL and with a significant decrease in C2-C7 SVA. There were insignificantly inverse correlations with each of the CL, TIA and T1S.

Conclusions: There is no difference in the C2–C7 lordosis curvature between the symptomatic patients and the asymptomatic individuals. The T1S is significantly lower in the symptomatic patients than in the asymptomatic individuals. So, Low T1S is a risk for the occurrence and development of cervical disc degeneration.

Keywords: Cervical sagittal parameters; health related quality of life; cervical degenerative disc diseases.

1. INTRODUCTION

The cervical spine is very complex as it allows the widest range of motion relative to the rest of the spine and also supports the mass of the head. This complex nature of the cervical region makes it self-susceptible to a variety of disorders and complications, many of which begin with, and inevitably lead to, alignment pathology that may warrant surgical consideration. Abnormalities of the cervical spine are usually very debilitating and induce adverse effects on patient [1].

Sagittal balance reflects the shape of the spine which is the result of the sum of the shapes of bony elements (the vertebrae), discs and muscles [2].

Bone resists compression and keeps its shape under physiological compressive forces. Discs are also resistant to compression, and can keep a definite shape under physiological compression forces [3]. The age-related changes and abnormal non-physiological loads on the disc result in disc degeneration.

A degenerated disc loses to some extent its ability to keep the disc space shape and deforms under physiological compression forces, being flexion the most frequent direction of the deformation (causing sagittal anterior displacement of the spine).Thus, an effect of aging on the spine is the trend toward loss of sagittal alignment [2].

A normal cervical sagittal balance is crucial to minimize the neck muscle effort necessary to maintain the upright posture. Any pathology that alters this balance produces sagittal malalignment and its compensatory mechanisms [4].

It has recently been reported that the health-related quality of life (HRQOL) deteriorates not only because of lumbar and pelvic malalignment, as most of studies focused on, but also because of cervical imbalance that did not get the same interest [5,6].

Cervical parameters change with age and the prevalence of cervical disc degenerative changes in asymptomatic individuals has been reported as more than 20% [7]. Therefore, the evaluation of the differences in radiological sagittal parameters between symptomatic and asymptomatic individuals with radiologically-confirmed (CDDD) is fundamental for understanding the normal variation in sagittal plane parameter between individuals, to determine the age-related changes, to know the predictive sagittal parameters for unfavourable clinical symptoms and to determine the factors that participate in economic sagittal balance (compensation) in asymptomatic subjects [8].

This study aimed to evaluate the relation between the radiological cervical sagittal parameter changes with the presence and severity of symptoms as well as quality of life in CDDD individuals and provided radiographic guidelines for the assessment and management of cervical spine patients.

2. METHODOLOGY

This cross sectional study was conducted in Tanta University Hospitals. It included the first 100 subjects who have visited the Outpatient clinic of Orthopedic Department during the first 6 months after the approval of the responsible institutional ethical committee and presented with radiologically-confirmed CDDD with or without clinical symptoms. The individuals were divided into 2 groups for analysis and comparison:

Group1: included the first 50 patients with symptomatic CDDD.
Group2: included another 50 individuals with asymptomatic CDDD in their radiographs who visited the outpatient clinic as a relative to other patients or complained from other transient musclo-skeletal symptoms not affecting their quality of life.

2.1 Inclusion Criteria

1. Age between 20 and 60 years.
2. No history of spinal surgery, trauma or tumours.
3. Symptomatic patients with cervical degenerative discs for group 1.
4. Asymptomatic participants.
5. T1 vertebral body or upper end of sternum clearly visible on lateral radiograph (not obscured by the shoulder contour).

2.2 Exclusion Criteria

1. Coronal deformities (Cobb angle > 10).
2. History of previous spine surgery.
3. History of hip or knee arthroplasty or any other realignment surgery of the lower extremities.
4. History of neuromuscular disorders or inflammatory diseases.
5. Pregnancy
6. Metabolic disorders.

Patients were subjected to the following:

2.2.1 Full history taking

Personal history (demographic data): name, age, sex, residency, smoking, occupation, duration of the complaint, medical history, co-morbidities, and drug history as the amount of drug intake of analgesics or muscle relaxants to control pain.

2.2.2 Clinical Examination

General Examination, local Examination as Full spine examination, neuro-muscular examination.

2.2.3 Evaluation

2.2.3.1 Clinical evaluation

The level of pain in group 1 was detected by VAS with mean 6.4 ± 2.059 [9].

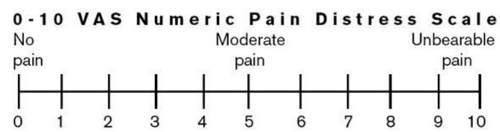

Fig.1. VAS [10]

2.2.3.2 Radiological evaluation

A standing lateral radiograph of the cervical spine was obtained with the subject in a neutral position (standing position, looking straight ahead with the hands placed on the clavicle a distance of 1.5 m between the X-ray tube and radiograph. The digitized radiographs were transferred as Digital Imaging and Communications in Medicine data to a computer. The following sagittal radiological parameters were measured on the cervical radiographs in both groups:

1-C2–C7 lordosis (CL): The Cobb angle between the lower endplates of C2 and C7.

Fig.2. Cobb (CL) angle

2-C2–7 sagittal vertical axis (C2–7 SVA): The distance in millimetres from the posterosuperior corner of C7 to a vertical line from the centre of the C2 vertebra.

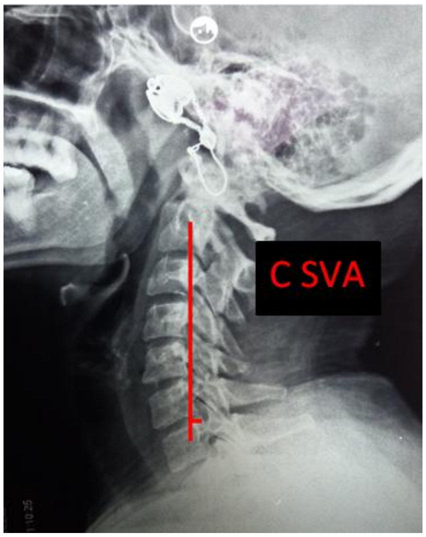

Fig.3. Cervical SVA

3-T1 slope (T1S): an angle formed between the upper endplate of T1 (T1UEP) and the horizontal.

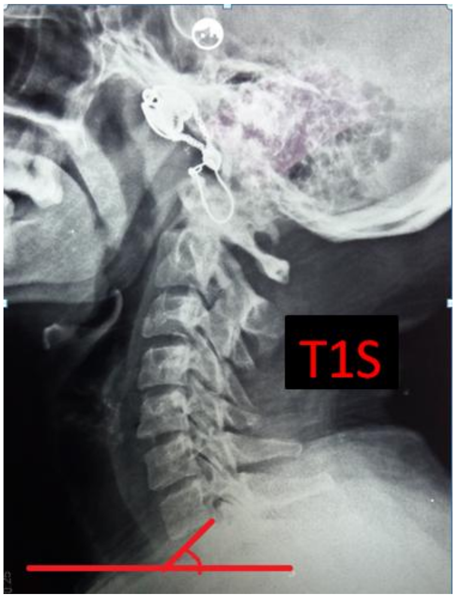

Fig.4. T1 slope angle

4-Neck tilt (NT): An angle formed by a vertical line from the sternum tip and a line connecting the centre of the T1UEP and the upper end of the sternum.

Fig.5. Neck tilt angle

5-Thoracic inlet angle (TIA): An angle formed by a vertical line from the centre of the T1UEP, and a line connecting the centre of the T1UEP and the upper end of the sternum.

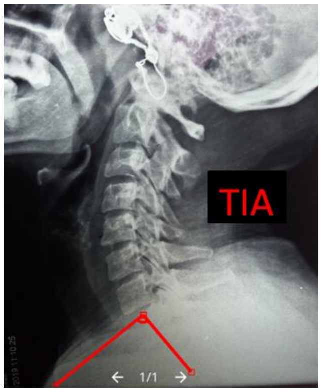

Fig.6. TIA angle

6-Cervical Tilting (CT): An angle formed between the vertical line from the centre of T1UEP and the line from the centre T1UEP to the centre of C2 vertebra.

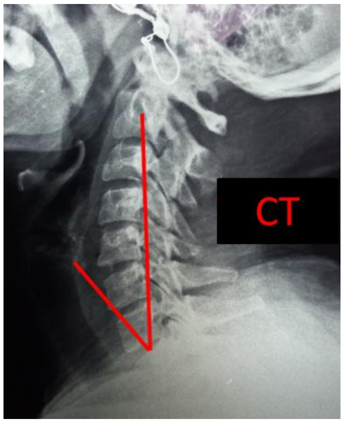

Fig. 7. Cervical tilt angle

7-T1S minus C2–7 lordosis (T1S-CL): the T1S angle minus the C2–7 lordosis. The mean was 14.14° ± 2.93° in group 1 and 15.47° ± 4.38° in group 2.

2.2.3.3 Functional evaluation

It was assessed by Modified Euro quality of life five dimensions three levels questionnaire (Modified EQ-5D-3L) [10] in group 1 with a mean of 0.641 ± 0.195.

Modified EQ-5D-3L is a short-form health survey used to assess HRQOL. It is a scale consists of five dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/ depression) with three levels in each. It is ascore of 0.3–1 indicates that one is perfectly healthy and a lower score indicates an unhealthy state by dividing the sum of the labelled levels of the questionnaire over the sum of all levels ($\frac{\text{The sum of labelled levels}}{\text{The sum of all levels (15)}}$).

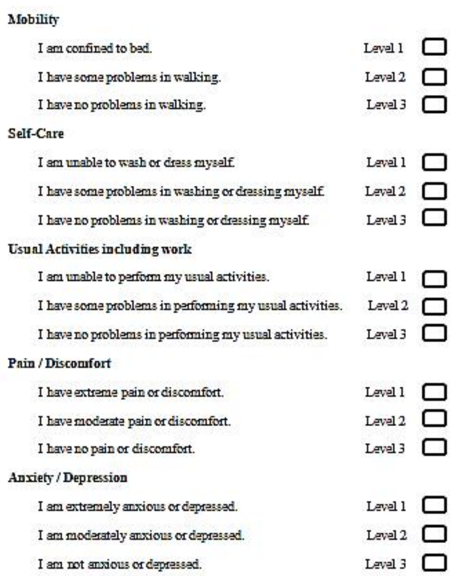
Mobility
I am confined to bed. Level 1
I have some problems in walking. Level 2
I have no problems in walking. Level 3
Self-Care
I am unable to wash or dress myself. Level 1
I have some problems in washing or dressing myself. Level 2
I have no problems in washing or dressing myself. Level 3
Usual Activities including work
I am unable to perform my usual activities. Level 1
I have some problems in performing my usual activities. Level 2
I have no problems in performing my usual activities. Level 3
Pain / Discomfort
I have extreme pain or discomfort. Level 1
I have moderate pain or discomfort. Level 2
I have no pain or discomfort. Level 3
Anxiety / Depression
I am extremely anxious or depressed. Level 1
I am moderately anxious or depressed. Level 2
I am not anxious or depressed. Level 3

Fig. 8 Modified EQ-5D-3L score [10]

2.2.3.4 Statistical evaluation

Data were and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation, median. Significance of the obtained results was judged at the 5% level. The used tests were: Chi-square test, Fisher's Exact or Monte Carlo correction, Student t-test, F-test (ANOVA), Pearson coefficient and Spearman coefficient.

3. RESULTS AND FINDINGS

3.1 Group 1 (Symptomatic Group):

This group included 50 patients with symptomatic CDDD. Their ages, ranged from 35 to 55 years old with a mean of 45.36 ± 4.49 Table 1.

The BMI ranged from 26.60 kg/m^2 to 35.0 kg/m^2 with a mean of 31.38 kg/m^2 ± 1.86 kg/m^2 Table 1. Clinical evaluation: By VAS ranged from 4.341 to 8.46 with a mean of 6.4 ± 2.059 Table 1.

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- Radiological evaluation: By measuring 7 cervical sagittal parameters which were: Table 2 C2–7 lordosis (CL) ranged from 11.90° to 17.50° with a mean of 14.99° ± 1.48°, C2–7 sagittal vertical axis (C2–7 SVA) ranged from 9.50 mm to 23.10 mm with a mean of 15.75 mm ± 3.29 mm, T1 slope (T1S) ranged from 21.80° to 36.90° with a mean of 29.13° ± 3.47°, neck tilt (NT) ranged from 46.60° to 57.30° with a mean of 52.15° ± 2.38 °, thoracic inlet angle (TIA) ranged from 72.10° to 90.80° with a mean of 81.28° ± 4.65°, cervical tilting (CT) ranged from 9.80° to 20.20° with a mean of 14.19° ± 2.97° and T1S minus C2–7 lordosis (T1S-CL) ranged from 7.40° to 21.50° with a mean of 14.14° ± 2.93°.
- Functional evaluation: by the (Modified EQ-5D-3L) ranged from 0.446 to 0.836 with a mean of 0.641 ± 0.195.

3.2 Group 2 (Asymptomatic Group):

This group included 50 individuals with asymptomatic CDDD, their ages ranged from 38 to 58 years old with a mean of 46.94 ± 4.10 Table 1.

The BMI ranged from 26.20 kg/m2 to 35.0 kg/m2 with a mean of 31.04 kg/m2 ± 2.14 kg/m2 Table 1.

- Radiologically evaluation: by measuring 7 cervical sagittal parameters which were: Table 2 C2–7 lordosis (CL) ranged from 9.40° to 25.40° with a mean of 16.06° ± 4.28°, C2–7 sagittal vertical axis (C2–7 SVA) ranged from 8.40 mm to 21.10 mm with a mean of 16.97 mm ± 3.49 mm, T1 slope (T1S) ranged from 26.30° to 39.20° with a mean of 31.53° ± 3.01°, Neck tilt (NT) ranged from 40.40° to 59.70° with a mean of 50.77° ± 5.27°, Thoracic inlet angle (TIA) ranged from 69.50° to 96.30° with a mean of 83.31° ± 6.92°, Cervical tilting (CT) ranged from 10.0° to 25.20° with a mean of 15.43° ± 3.82°, T1S minus C2–7 lordosis (T1S-CL) ranged from 3.70° to 24.50° with a mean of 15.47° ± 4.38°.

3.3 Analysis of the Relationships between the Data of the 2 Groups:

The mean of measurements of the cervical sagittal parameters was lower in symptomatic group than in asymptomatic one except NT angles were higher in symptomatic than in asymptomatic. In correlation between 2 groups, T1S angle was the only significant parameter in correlation between 2 groups Table 1.

3.4 Analysis of the Relationships between the Data in the Symptomatic Group:

There was a statistically significant increase in each of the T1S, C2-C7 lordosis, C2-C7 SVA with increasing the age in symptomatic group Table 2.

There was a significant relation between occupations and parameters in symptomatic group as T1S was significantly lower in farmers and manual workers than in housewives and office workers. Table 3.

There was a significantly inverse correlation between each of the CL, T1S, T1S-CL and VAS in symptomatic group Table 4.

There was a significantly positive correlation between each of the CL, T1S, T1S-CL and modified EQ-5D-3L score in symptomatic group Table 5.

3.5 Analysis of the Relationships between the Data in the Asymptomatic Group:

There was a significant increase in each of the TIA, T1S and NT with increase age, with an insignificant increase CL and with a significant decrease in C2-C7 SVA in asymptomatic group Table 6.

Table1. Correlation between the two studied groups according to different parameters

	Symptomatic (1) (n = 50)	Asymptomatic (2) (n = 50)	T	P
		CL		
Min. – Max.	11.90 – 17.50	9.40 – 25.40	1.684	0.097
Mean ± SD.	14.99 ± 1.48	16.06 ± 4.28		
		C SVA		
Min. – Max.	9.50 – 23.10	8.40 – 21.10	1.798	0.075
Mean ± SD.	15.75 ± 3.29	16.97 ± 3.49		
		T1S		
Min. – Max.	21.80 – 36.90	26.30 – 39.20	3.702*	<0.001*
Mean ± SD.	29.13 ± 3.47	31.53 ± 3.01		
		NT		
Min. – Max.	46.60 – 57.30	40.40 – 59.70	1.640	0.105
Mean ± SD.	52.15 ± 2.77	50.77 ± 5.27		
		TIA		
Min. – Max.	72.10 – 90.80	69.50 – 96.20	1.716	0.090
Mean ± SD.	81.28 ± 4.65	83.31 ± 6.92		
		CT		
Min. – Max.	9.80 – 20.20	10.0 – 25.20	1.815	0.073
Mean ± SD.	14.19 ± 2.97	15.43 ± 3.82		
		T1-CL		
Min. – Max.	7.40 – 21.50	3.70 – 24.50	1.778	0.079
Mean ± SD.	14.14 ± 2.93	15.47 ± 4.38		

*t: Student t-test; p: p value for comparing between the studied groups; *: Statistically significant at p ≤ 0.05*

Table 2. Relation between age and different parameters in symptomatic group (1)

	Age			F	P
	<40 (n = 4)	**40 – 50 (n = 37)**	**>50 (n = 9)**		
		CL			
Min. – Max.	12.30 – 13.50	11.90 – 17.0	14.80 – 17.50	13.482*	<0.001*
Mean ± SD.	12.85 ± 0.50	14.85 ± 1.30	16.49 ± 0.94		
		C SVA			
Min. – Max.	9.50 – 15.80	10.10 – 23.0	14.70 – 23.10	6.644*	0.003*
Mean ± SD.	12.55 ± 2.98	15.41 ± 3.0	18.58 ± 2.82		
		T1S			
Min. – Max.	21.80 – 28.20	22.20 – 35.60	28.30 – 36.90	8.523*	0.001*
Mean ± SD.	25.08 ± 2.62	28.81 ± 3.05	32.24 ± 3.08		
		NT			
Min. – Max.	50.60 – 55.90	46.60 – 57.30	47.20 – 57.30	1.175	0.318
Mean ± SD.	53.63 ± 2.21	52.24 ± 2.54	51.16 ± 3.72		
		TIA			
Min. – Max.	75.50 – 84.10	72.10 – 90.80	76.10 – 89.60	1.637	0.205
Mean ± SD.	78.70 ± 4.08	81.05 ± 4.74	83.40 ± 4.08		
		CT			
Min. – Max.	9.80 – 20.20	10.10 – 20.10	10.30 – 15.20	1.062	0.354
Mean ± SD.	13.28 ± 4.70	14.55 ± 2.98	13.11 ± 1.88		
		T1 –CL			
Min. – Max.	9.50 – 14.70	7.40 – 20.60	10.90 – 21.50	2.424	0.100
Mean ± SD.	12.23 ± 2.13	13.96 ± 2.67	15.76 ± 3.75		

*F: F for ANOVA test, comparison bet. more than 2 groups, p: p value for association between different categories, *: Statistically significant at p ≤ 0.05*

Table 3. Relation between occupation and parameters in symptomatic group (1)

	Occupation				F	P
	House wife (n = 30)	**Office worker (n = 5)**	**Farmer (n = 10) ↓**	**Manual worker (n = 5) ↓**		
			CL			
Min. – Max.	12.30 – 17.50	13.90 – 17.20	11.90 – 16.10	13.10 – 17.10	2.429	0.077
Mean ± SD.	15.12 ± 1.28	16.18 ± 1.33	14.19 ± 1.56	14.60 ± 2.02		
			C SVA			
Min. – Max.	10.60 – 23.0	11.40 – 23.10	9.50 – 16.20	10.50 – 21.20	2.263	0.094
Mean ± SD.	15.81 ± 2.94	17.88 ± 4.50	13.84 ± 2.69	17.10 ± 4.05		
			T1S			
Min. – Max.	21.80 – 36.90	30.10 – 33.0	24.90 – 29.30	24.30 – 28.30	4.034*	0.013*
Mean ± SD.	29.97 ± 3.84	31.10 ± 1.15	26.70 ± 1.53	26.98 ± 1.71		
			NT			
Min. – Max.	47.20 – 57.30	48.60 – 57.30	48.40 – 57.20	46.60 – 54.70	0.390	0.761
Mean ± SD.	52.31 ± 2.82	52.26 ± 3.31	52.28 ± 2.30	50.86 ± 3.31		
			TIA			
Min. – Max.	72.10 – 90.80	79.80 – 88.20	75.50 – 86.50	74.90 – 81.0	2.800	0.051
Mean ± SD.	82.28 ± 5.04	83.36 ± 3.38	78.98 ± 3.01	77.84 ± 2.85		
			CT			
Min. – Max.	9.80 – 20.10	10.30 – 16.20	11.20 – 20.20	10.70 – 17.30	0.573	0.636
Mean ± SD.	13.87 ± 3.11	14.02 ± 2.26	15.30 ± 3.08	14.08 ± 2.84		
			T1 –CL			
Min. – Max.	7.40 – 21.50	13.90 – 16.20	9.70 – 14.10	11.20 – 14.60	2.566	0.066
Mean ± SD.	14.85 ± 3.39	14.92 ± 1.04	12.51 ± 1.24	12.38 ± 1.46		

*F: F for ANOVA test, comparison bet. more than 2 groups p: p value for association between different *: Statistically significant at p ≤ 0.05*

Table 4. Correlation between VAS score and different parameters in symptomatic group

	VAS score	
	Symptomatic (n = 50)	
	r_s	P
CL (–)	-0.437*	0.002*
C SVA	-0.215	0.134
T1S (–)	-0.466*	0.001*
NT	0.033	0.821
TIA	-0.203	0.105
CT	0.229	0.110
T1-CL (–)	-0.317*	0.025*

*r_s: Spearman coefficient *: Statistically significant at p ≤ 0.05*

Table 5. Correlation between EQ-5D score and different parameters in symptomatic group

	EQ-5D score	
	Symptomatic (n = 50)	
	R	P
CL	0.294*	0.038*
C SVA	0.153	0.289
T1S	0.418*	0.003*
NT	0.034	0.813
TIA	0.144	0.312
CT	-0.124	0.391
T1 –CL	0.312*	0.027*

*r: Pearson coefficient *: Statistically significant at p ≤ 0.05; C) Analysis of the relationships between the data in the asymptomatic group*

Table 6. Relation between age and different parameters in asymptomatic group (2)

	Age			F	P
	<40 (n = 2)	40 – 50 (n = 37)	>50 (n = 11)		
CL (+)					
Min. – Max.	12.10 – 14.00	9.40 – 25.40	14.00 – 22.10	2.655	0.081
Mean ± SD.	13.05 ± 1.34	15.52 ± 4.48	18.44 ± 2.81		
C SVA (–)					
Min. – Max.	21.00 – 21.10	10.30 – 21.00	8.40 – 19.90	10.250*	<0.001*
Mean ± SD.	21.05 ± 0.07	17.75 ± 2.50	13.60 ± 4.35		
T1S (+)					
Min. – Max.	26.30 – 27.10	27.20 – 36.00	29.60 – 39.20	12.087*	<0.001*
Mean ± SD.	26.70 ± 0.57	30.94 ± 2.21	34.41 ± 3.41		
NT (+)					
Min. – Max.	43.40 – 58.40	40.40 – 59.70	50.90 – 58.90	4.918*	0.011*
Mean ± SD.	50.90 ± 10.61	49.56 ± 5.13	54.83 ± 2.48		
TIA (+)					
Min. – Max.	71.50 – 85.70	69.50 – 95.30	84.40 – 96.20	9.844*	<0.001*
Mean ± SD.	78.60 ± 10.04	81.50 ± 6.30	90.24 ± 3.55		
CT					
Min. – Max.	13.50 – 16.90	10.00 – 25.20	10.70 – 19.30	0.004	0.996
Mean ± SD.	15.20 ± 2.40	15.45 ± 4.15	15.44 ± 2.98		
T1 –CL					
Min. – Max.	12.30 – 15.00	3.70 – 24.50	11.50 – 21.60	0.240	0.788
Mean ± SD.	13.65 ± 1.91	15.42 ± 4.76	15.97 ± 3.33		

*F: F for ANOVA test, Pairwise comparison bet. more than 2 groups; p: p value for association between different categories; *: Statistically significant at p ≤ 0.05*

Table 7. Correlation between BMI and different parameters in asymptomatic group (2)

	BMI	
	Asymptomatic (n = 50)	
	R	P
CL	-0.031	0.832
C SVA	0.323*	0.022*
T1S	-0.039	0.787
NT	-0.233	0.104
TIA	-0.194	0.177
CT	-0.070	0.628
T1 –CL	0.003	0.983

*r: Pearson coefficient; *: Statistically significant at p ≤ 0.05*

There was a significantly positive correlation between BMI and C2-C7 SVA and insignificantly inverse correlations with each of the CL, TIA and T1S in asymptomatic group Table 7.

4. DISCUSSION

4.1 Analysis of the Relationships and Results between the Two Groups:

In this study, all demographic results were similar between the two groups, and this conforms was reported by Jouibari MF et al. [11], Xing R et al. [12], and Grob D et al. [13].

Regarding the occupations in the two groups, there were no statistically significant differences between the two groups, and this complies with what was documented by Williams FM et al. [14].

This work revealed that T1S angles in manual workers and farmers, as they are the main carriers and more susceptible to CDDD, were lower than in the housewives and office workers among the both groups, Mahbub MH et al. [15] also concluded that .head-load carriers are risky for developing CDDD. On the contrary, Bista P et al. [16] matched their findings to this and concluded that the prevalence of CDDD is significantly lesser in carriers than in non-carriers. There were no significant differences between the TIA among the two groups, but the mean TIA in the symptomatic group was about 81 degrees and in the asymptomatic group was about 83 degrees. So, it may be involved in the disc degeneration, and this conforms to what was documented by Jouibari MF et al. [11] as they compared between the neck pain group and the free-neck pain group.

On the contrary, Xing R et al. [12] compared between the normal and the degeneration groups that there were no significant differences between the TIA among the both groups, indicating that TIA was not involved in the development of cervical disc degeneration, which could be considered a constant parameter of approximately 70° in both groups.

In the present study, T1S angle was significantly lower in the symptomatic group than in the asymptomatic group. This highlights on the importance of morphologic Features of T1 vertebral body in the upright physiologic posture and the horizontal gaze of the participants as reported previously. [17]. It might be related to the effect of the shape and orientation of T1 vertebral body on the amount of lordosis required to keep the sagittal balance of the cervical spine. [18] Diminishing T1 slope to bring axis of head gravity closer to the base of cervical spine (T1) could be explained as a compensatory change in the sagittal parameters of cervical spine to prevent further contracture of para spinal muscles and decrease the muscle effort during upright position [19]. This might suggest that compensatory mechanisms in the symptomatic group pull back the axis of head gravity and lead to lower T1 slope angle in those patients. This is also in line with what was reported by Jouibari MF et al. [11] and Xing R et al. [12]

This also complies with what was discovered by Xing R et al. [12] who concluded that T1S was significantly lower in the degeneration group compared to the control group, hence T1S might be a risk of the occurrence and development of cervical disc degeneration and the presence of neck pain.

This also matches what was documented by Grob D et al. [13] as there is no difference between the two groups in global cervical lordosis (C2-C7 angle).

4.2 Analysis of the Relationships and Results in Group 1 (Symptomatic Group):

In this research, there was a statistically significant increase in the T1S, C2-C7 lordosis, and the C2-C7 SVA with increasing the age in the symptomatic group. The T1S, C2-C7 CL and CSVA parameters increase with age as the spine tends to assume positive sagittal alignment with increasing the T1S and so, in order to maintain the ability to look forward, the cervical spine has to increase the value of cervical lordosis, and this conforms to what was reported by Tang R et al. [20], Motta MM et al. [21] and Yukawa Y et al. [22]

On the contrary, Park MS et al. [23] discovered a similar age-related increase in the C2-C7 lordosis, but with a decrease in the T1 slope as they proposed that the T1 vertebra becomes more horizontal with age in order to permit compensatory hyperlordosis of the cervical spine to re-establish the horizontal gaze.

Benoist et al. [24] also described the progression of age-related spine degeneration, beginning with the degeneration of the intervertebral disc due to loss of normal cellular activity that replaces extracellular matrix. The resulting structural changes reduce stability and increase the risk of disc herniation.

In the current study, there were no significant differences between the sex, the BMI, and the cervical sagittal parameters in the symptomatic group, and this matches to what was documented by Oe S et al. [5] that there were no significant correlations between the male and the female BMI with C2-C7 SVA, T1S and T1S - CL. But, they also reported that C2-C7 SVA is greater in males in all age groups.

In this work, the T1S was significantly lower in the farmers and manual workers, which are the main head-load carriers, than in the house wives and office workers, and this conforms to what was reported by Oguntona SA et al. [25]. This also complies with what was documented by Jäger HJ et al. [26] that carrying heavy objects on the head is a very common practice in African countries, and load carrying on the head has also been documented to exacerbate a degenerative process in the cervical spine.

In this research, there was a significant inverse correlation between the CL, T1S, T1S-CL and the VAS. The higher the value of the CL, T1S, T1S-CL, the lower the value of the VAS obtained from the patient, (i.e., the less the pain of the patient). This is in line with what was reported by Motta MM et al. [21] that there was no significance between CSVA and VAS. On the contrary, they also said that there was no significance between CL, T1S, T1S-CL and the VAS and this is opposite to our study.

In this study, there was a significant positive correlation between CL, T1S, T1S-CL and the modified EQ-5D-3L scores: the higher the value of the CL, T1S, T1S-CL the higher the value obtained from the modified EQ-5D-3L score, (i.e., the better the functional ability of the patient).

On the contrary, what was documented by Oe S et al. [5] that there was a significant inverse correlation between CL, T1S, T1S-CL and EQ-5D-3L scores as they said that the EQ-5D-3L score decreased and became the lowest with C2–C7 SVA 40 or more, T1S 40° or more, and T1S–CL 20° or more which are not included in our study. This is mainly because of failure to increase cervical lordosis to compensate the increase in the T1S and this is considered as the maximum cervical malalignment and deformity that worsens the HRQOL.

Iyer S et al. [27] also documented that increasing CL, increasing TS, and increasing TS–CL were significantly correlated with decreasing NDI, but they divided the patients into two groups; myelopathy and radiculopathy groups. There was a significant correlation between the radiographic parameters and the NDI in the patients with myelopathy, but not in the patients with radiculopathy however, in the current study, the symptomatic group hasn't been subtyped.

This also was reported by Motta MM et al. [25] that there is a significant inverse correlation between the CL only and the NDI: the higher the value of the CL, the lower the value obtained from the NDI, (i.e., the better the functional ability of the patient), and this conforms to the present study, but they documented that there is no significance between T1S, T1S-CL and NDI and this is opposite to what was reported in this study.

4.3 Analysis of the Relationships and Results in Group 2 (Asymptomatic Group)

In this work, all sagittal parameters were discovered to increase with the age except the C2-C7 SVA which was significantly decreased. TIA, T1S and NT significantly increase with aging, with an insignificant increase in the cervical lordosis (CL) and with a significant decrease in the C2-C7 SVA which is required to balance the head over the thoracic inlet. If the relative position of T1 to manubrium unchanged, a lager T1 declination results in a larger TIA and T1S which yields a greater magnitude of cervical lordosis to obtain a horizontal gaze and the sagittal alignment of cervical spine with minimum energy expenditure and this conforms to what was documented by Chen Y et al. [28]

High T1 slope increases Cobb’s C2-C7 (CL) because when the T1 slope increases, the head center of gravity moves its position forward with anterior translation. Its overloading is compensated by reinforcing the cervical lordosis change. Increasing C2-C7 angle (CL) keeps the SVA C2-C7 decreased by a continuous and compensatory principle [29] Fig. 8.

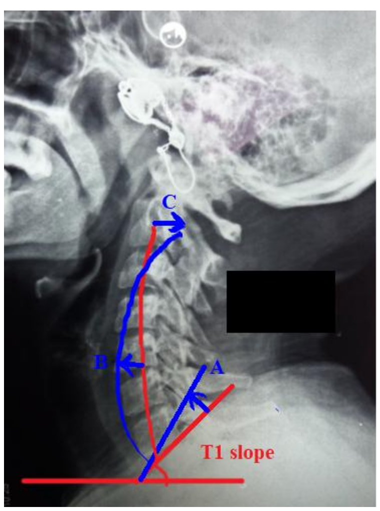

Fig. 9. Relationship between change in T1S, C2-C7 angle and C2-C7 SVA

With increasing T1 slope (A), the Cobb‘s angle C2-C7 (B) is getting higher. Consecutively, the SVA C2-C7 (C) is getting lower and closer to the center of one’s body. The T1 slope value has been changed in various positions and aging, so the T1 slope cannot be used as an absolute predicting parameter for cervical lordosis. This is in line with what was documented by Park JH et al. [29].

Similar results were reported by Iorio J et al. [30], who discovered that the T1S was significantly greater in older than younger persons especially above 60 years in asymptomatic North American cohort. An increase in the T1S with age was accompanied with a significant increase in the cervical lordosis CL as a compensatory measure and so no increase in the C2-C7 SVA or even decrease. Failure to increase the cervical lordosis with age would result in an impairment of horizontal gaze in addition to greater cervical offset as C2-C7 SVA increases beyond 40 mm and presumably worsens the HRQOL.

Similar results were also reported by Yokoyama k et al. [31], who documented that the TIA and the C2–C7 lordosis markedly increased with age and they considered that the increase in cervicothoracic curvature occurring along with thoracic deformation underlies the age-related changes in the spine.

It was also documented that the NT increases with age. Not only the TIA, but NT also was determined by the relative position of T1 to manubrium in sagittal plane. If the T1 declination unchanged, in other words, T1S unchanged, a descended position of T1 related to the level of manubrium, which means a decrease of vertical distance from T1 to the level of the end of manubrium, results in a larger TIA accompanied with a greater NT in this circumstance, and this also matches what was reported by Yokoyama k et al. [31].

Matsumoto M et al. [32] also concluded that the vertical decrease in vertebral dimension was age-associated throughout the life span which gives rise to the decrease of the height of thoracic spine. Definitely, the disc degeneration and space narrowing also contribute to the height loss in thoracic spine. As a consequence, a descended position of T1 related to the level of manubrium is inevitable, which leads to a larger TIA and NT.

On the contrary, Shao ZX et al. [33] suggested that there was no significant relationship between age and T1S, TIA, CL and C2-C7 SVA.

In this study, there was no significant relation between the sex and the cervical sagittal parameters, and this complies with what was documented by Shao ZX et al. [33]

In this research, there was significantly positive correlation between the BMI and the C2-C7 SVA and insignificantly inverse correlations with CL, TIA and T1S. The BMI is considered as a parameter used to quantify the tissue mass (muscle, fat, and bone) which has been less evident in previous research on cervical sagittal balance, and this is in line with what was discovered by Shao ZX et al. [33].

Oe S et al. [5] also suggested a correlation between the C2-C7 SVA and the BMI but they did not discuss the correlation further.

4.4 The Limitations of This Study Were

Population studies of cervical pain and cervical disc disease have lagged behind the studies of the lumbar spine. So, there is a need for more studies of the cervical degenerative disc disease.

In the present study, the cervical sagittal balance was measured using a lateral cervical X-ray and the global spinal sagittal measurements were not determined; therefore, the reciprocal influence of other spinal regions including lumbar and thoracic spine was not identified.

The participants of the symptomatic and asymptomatic groups were matched for anatomical variables as sagittal cervical parameters, patients' variables as age, BMI, sex and occupations; however, it is reported that other anatomical variables as canal-body ratio, canal diameter, vertebral body diameter of the cervical vertebrae and patients' variables as race, smoking have major roles in the incidence of chronic musculoskeletal pains. Therefore, it is suggested to consider these factors when matching participants for future studies.

The sagittal cervical parameters should be measured and analyzed with the cervical muscle strength at the same time and the imbalance between the cervical sagittal alignment and the paraspinal muscle strength should be considered as a possible cause of neck pain.

5. CONCLUSION

There is no difference in the C2–C7 lordosis curvature between the symptomatic patients and the asymptomatic individuals.

The T1S is significantly lower in the symptomatic patients than in the asymptomatic individuals. So, Low T1S is a risk for the occurrence and development of cervical disc degeneration.

There is not a strong relationship between cervical degenerative disc diseases and neck pain or disability. Manual workers and farmers are main head load carriers and the main risk groups for developing CDDD.

Many individuals with radiographic evidence of cervical degenerative disc diseases may be totally asymptomatic, and many of the symptomatic CDDD patients show little radiographic changes.

It is evidently clear that the ambiguity in identifying the definite risk factors in the diagnosis of the cervical degenerative disc diseases still persists.

CONSENT

As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

This study was approved by medical ethics committee of our hospital. Informed approval was gotten from all subjects involved in these investigations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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