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A STUDY OF TRANSVERSE DIAMETER OF THE LUMBAR SPINAL CANAL IN NORMAL SOUTH INDIANS USING CR-35X DIGITIZER

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ABSTRACT

The present study was conducted on 150 plain antero-posterior radiographs of lumbar spine of 150 healthy subjects (88 males and 62 females) from South India between the age group of 20 to 50 years. The Transverse diameter of spinal canal (TDC) and Transverse diameter of vertebral body (TDB) were measured at levels L1 to L5 using CR-35X digitizer. The canal body ratio (CBR) was determined by the ratio of TDC and TDB. The results showed that the mean TDC and TDB increased gradually from L1 to L5 being minimum at L1 and maximum at L5. On comparing the TDC and TDB between male and female subjects, it was observed that both TDC and TDB were greater at all levels in the male subjects than that of female subjects and statistically significant. Canal body ratio was calculated by the ratio of TDC/TDB was Ratio between 0.56 to 0.59 in male subjects and 0.59 to 0.62 in female subjects from L1 to L5. The intersegment differences of TDC were calculated, which helps in detection of isolated segmental anomalies. All the above results of present were compared with studies of other workers. The present study confirms that there is racial as well as regional variation in the size of lumbar vertebral canal, thus emphasizing the need to have normal value and ranges for the TDC and TDB for our population.

Key Words: *Spinal Canal, Lumbar Vertebrae, Transverse Diameter, Vertebral Body, Canal Body Ratio*

INTRODUCTION

The vertebral column of humans is unique among the animal species in both function and aging patterns. Humans are the only few species that engage in bipedal locomotive behavior, and the only species that uses bipedalism exclusively. Back ache is an extremely common human phenomenon, a price mankind has to pay for their upright posture. Low back ache, sciatica or nerve root compression has reached an epidemic proportion. It is a common cause of occupational and domestic disability in industrialized societies. The pattern of behaviour of the normal back and the nature of the events and incidents which lead to derangements have intrigued the practitioner since primitive times. Various causes have been attributed to low back ache, but lumbar spinal canal stenosis as a causative factor for backache is of great interest. Though there is a wide variation in the capacity of the spinal canal in patients who are clinically and radiologically normal, it is said that those with smaller canals are more likely to have symptoms from nerve root compression. Reduced Transverse diameter of spinal canal (TDC) is one of the primary cause of narrowing of the spinal canal (Nelson, 1973). Many cases of spinal canal stenosis are related to the anatomical variants with varying degrees of reduction of spinal canal (Epstein *et al.*, 1977). In the opinion of Lumbar canal stenosis can be present at birth as a congenital malformation in disorders like achondroplasia or it can be developmental, appearing during childhood and adolescents or can be acquired in certain skeletal disorders like Paget's disease (Larsen, 1980).

Back pain is a very common symptom in the population. Even though the problem of low backache is equally prevalent all over the universe, we see little studies done on lumbar vertebrae in Indian context. It is well established that the morphometrical data varies within different sex, race, ethnic and regional groups. Population based normal variations of TDC in South Indian population is not well documented in literature. Hence, there is a need for our own metrical data. Since the normal variations in TDC are not

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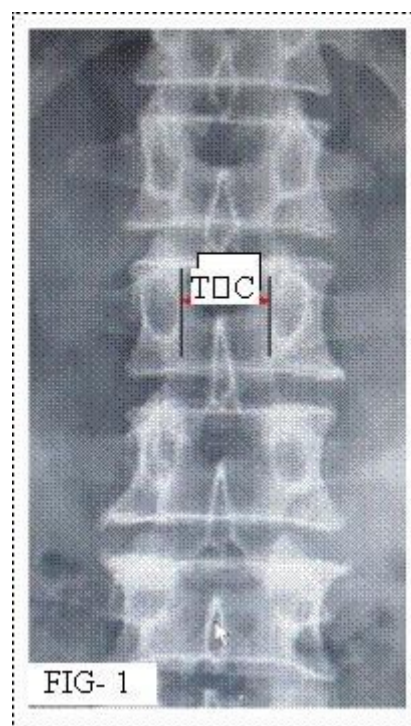
known, the present study was undertaken. The main objective was to compile a database of TDC valid for healthy male and female subjects in the age range of 20-60 years in South Indian population.

MATERIALS AND METHOD

Plain radiographs (antero- posterior view) of the lumbar spine of 150 healthy subjects of known sex (88 males and 62 females) between the age group of 20 to 50 were examined in the present study. In order to avoid uncertainty of measurement caused by secondary ossification centres of vertebrae before 20 years and osteoporosis after 50 years, subjects between 20 to 50 years were selected. No individuals were again exposed to X-rays for this study, rather the radiographs were collected from the patient's records whose radiographs were taken as part of investigations for abdominal conditions or intravenous pyelography from the department of Radiology, K. S. Hegde Medical Academy and Kasturba Medical College, Mangalore, Karnataka after patients consent. Only those subjects without any symptoms from the spine were selected. The radiographs were screened for readability and an attempt was made to eliminate subjects with significant vertebral anomalies and other problems likely to influence the growth and development. All the radiographs were taken in the lateral recumbent position with the hips and knees flexed to 45°. The X-ray beam was centred on L3 and an anode-film distance of 100 cm was maintained. The magnification resulting from the use of this technique was negligible. These radiographs were scanned by CR 35-X digitizer and then the following parameters were measured.

The TDC was measured as the minimum distance between the medial surfaces of the vertebral pedicles in millimetre (Figure-1).

Figure 1: Antero-posterior radiograph of the lumbar vertebrae illustrating the landmarks for measuring Transverse diameter of spinal canal (TDC)



The Transverse diameter of vertebral body (TDB) is measured as the minimum distance across the waist of the vertebral body, which is midway between the upper and lower surfaces of the vertebral body

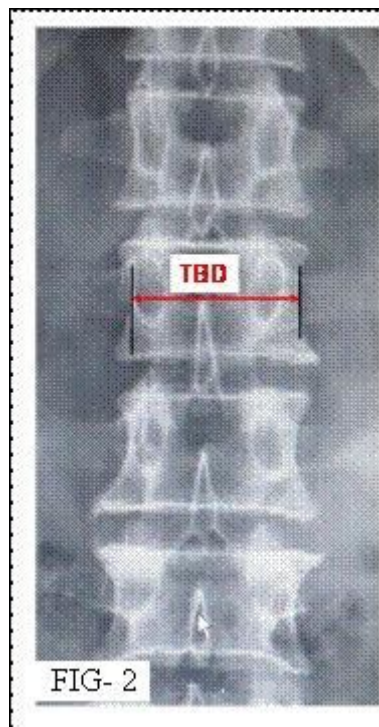
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(Figure- 2). From the above measurements the mean values and standard deviations were computed for each vertebral level separately for both male and female subjects. Differences between the mean TDC and TDB in males and females at all the five lumbar levels were statistically evaluated.

The Canal body ratio (CBR) was calculated by the ratio of TDC / TDB. By calculating this ratio, it is possible to determine whether the individual measurements are within normal limits for the respective vertebral body size or not.

The Intersegmental differences of TDC between the adjacent segments of lumbar vertebrae were calculated for both sexes.

Figure 2: Antero-posterior radiograph of the lumbar vertebrae illustrating the landmarks for measuring Transverse diameter of vertebral body (TDB)



This was calculated as the difference between the TDC of the consecutive lumbar vertebra. By calculating this ratio, it is possible to determine whether the individual measurements are within normal limits for the respective vertebral body size or not.

RESULTS AND DISCUSSION

The TDB gradually increases cranio-caudally from L1 to L5 (Table-1) being minimum at L1 (41.71mm in males and 37.31mm in females) and maximum at L5 (52.45mm in males and 48.41 in females).

The differences in mean TDB between male and female subjects were found to be very highly significant at all the vertebral levels showing sexual dimorphism. The standard deviation is highest at L5 level, suggesting greater variation in the size of TDB at L5 level. On comparison of present study with the study of other workers (Eisenstein, 1977; Koufi, 1982 and Nirvan *et al.*, 2003), it showed that there is gradual increase in TDB cranio-caudally from L1 to L5 in both the sexes in all the studies. This is probably because of the increase in load bearing from above downwards. The mean TDB in males in the present study was higher than that of the study by Eisenstein, (1977) and lower than that of study by

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Nirvan *et al.*, (2003); Amonoo- Koufi (1982) (except at L5 level). In females, the TDB of the present study is lower than all the other previous studies at all lumbar levels suggesting smaller diameter of the vertebral body in the South Indian population. The present study confirms the conclusion of the study done by Nirvan *et al.*, (2003) that there is ethnic as well as racial variation in the size of lumbar vertebrae, thus emphasizing the need to have normal values for the TDB for different populations.

Table1: Mean Transverse diameter of vertebral body (TDB in mm) and Standard deviation (SD) of the lumbar vertebrae

LEVEL	Male		Female	
	TDB	SD	TDB	SD
L1	41.71	4.1	37.31	2.93
L2	43.63	3.96	39.51	3.58
L3	46.68	3.96	42.15	3.39
L4	49.67	4.16	44.98	3.95
L5	52.45	4.4	48.41	5.08

The mean TDC gradually increases from L1 to L5 (Table-2) being minimum at L1 and maximum at L5. On comparing TDC between male and female subjects, TDC was statistically significant at L2 level and very highly significant at all other vertebral levels. The standard deviation is highest at L5 level, suggesting greater variation in the size of TDC at L5 level. On comparison of present study with the study of other workers it was observed that the mean TDC increased steadily from L1 to L5 in all the populations. The mean TDC of present study in male subjects are comparatively lower at L1, L2, L3 and marginally higher at L4 and L5 level than that of the study by Hinck *et al.*, (1966). But in females, the mean TDC are lower at L1, L2, L3 and higher at L4 and L5 lumbar levels when compared with the present study. It is evident that TDCs in the study of Amonoo- Koufi, (1982) are comparatively lower than the TDCs of present study in both sexes. The mean TDCs of present study are lower at L2, L3 and marginally higher at L1, L4, L5 in males and lower at all lumbar levels in females than that of the study by Nirvan, (2003). Table 6 & 7 confirms the finding of ethnical difference in the different races of world and supports the statement “There are no mean values of the vertebral dimensions that are valid for all populations”. Thus, there are marked differences between the mean values reported for the populations of different geographic areas. The reasons for these differences are not clear, but interplay of racial, ethnic and environmental factors can be considered.

Table 2: Mean Transverse diameter of spinal canal (TDC in mm) and Standard deviation (SD) of the lumbar vertebrae

LEVEL	Male		Female	
	TDC	SD	TDC	SD
L1	24.6	2.36	22.97	1.66
L2	24.93	2.46	24.05	2.02
L3	26.27	2.16	24.85	2.33
L4	28.47	2.98	26.74	3.24
L5	31.09	3.18	29.3	3.37

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Calculation of CBR for different segments helps in specifying whether an individual's measurement on spinal canal are within normal limits for the respective vertebral body size or not, thus helping to identify a spinal canal stenosis. The CBR was determined by the ratio of mean TDC and mean TDB for all five lumbar levels (Table- 3). The ratio was found to be between 0.56 to 0.59 in male subjects and 0.59 to 0.62 in female subjects from L1 to L5. On comparison of CBR of present study with the study of other workers (Amonoo Koufi 1982; Chhabra *et al.*, 1991 and Nirvan *et al.*, 2003). it was observed that CBR was approximately constant at 0.6 in most of the study groups. The results showed that as the size of vertebral body changes, the TDB also varied, maintaining a ratio of 0.6 at each vertebral level in both the sexes.

Table 3: Canal body ratio (CBR) in male and female subjects

Level	Male			Female		
	TDC (mm).	TDB (mm).	CBR	TDC (mm).	TDB (mm).	CBR
L1	24.60	41.71	0.59	22.97	37.31	0.62
L2	24.93	43.63	0.57	24.05	39.51	0.61
L3	26.27	46.68	0.56	24.85	42.15	0.59
L4	28.47	49.67	0.57	26.74	44.98	0.59
L5	31.09	52.45	0.59	29.3	48.41	0.61

Thus any deviation of the CBR from its approximate value of 0.6 to one or the other side indicates possibility of intraspinal tumour or spinal canal stenosis.

On comparison of intersegmental differences of TDC between present and previous studies (Table 4) (Hinck *et al.*, 1966; Amonoo Koufi, 1982; Pierra, 1988; Amonoo Koufi, 1990; Chhabra, 1991 and Nirvan *et al.*, 2003). It was observed that, the intersegmental difference of TDC gradually increased from L1/L2 to L4/L5 both in male and female subjects which is similar in all the other studies.

Table 4: Comparison of intersegmental differences of Transverse diameter of spinal canal (TDC) between present and previous studies

	Male				Female			
	L1/L2	L2/L3	L3/L4	L4/L5	L1/L2	L2/L3	L3/L4	L4/L5
Hinck et al. 1966	0.6	0.3	0.8	3.1	0.6	0.5	1	2.6
Amonoo Koufi 1982	0.1	1.8	1.5	2.7	1.2	1.2	1.7	3
Piera et al. 1988	0.6	1.16	1.34	3.42	0.59	1.28	2	3.8
Amonoo Koufi et al. 1990	0.2	0.9	1	3.7	0.55	1.2	1.7	2.1
Chhabra et al.1991	1.7	2	2.8	4.9	1.6	1.6	2.8	4.3
Nirvan et al. 2003	1.4	1	1.5	3	1	1.5	1.2	2.8
Present Study	0.33	1.34	2.2	2.62	1.08	0.8	1.89	2.56

Knowledge of the magnitude of the inter-segmental differences between the diameters of the adjacent segments could be of value in the detection of isolated segmental changes.

Conclusions

Data in this study shows that morphometry of the lumbar spine differ from the other studies. In the present study the mean TDB and TDC gradually increases cranio- caudally from L1 to L5 in both sexes

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being higher in male subjects than female subjects suggesting larger vertebral body in and larger spinal canal in males. The mean TDC between males and females was statistically very highly significant at all the lumbar levels. The lowest TDC is 18.9mm in males and 18.3mm in females. The mean TDC below 18.9mm in males and 18.3mm in females may be considered to be stenotic. The CBR ratio was between 0.56 to 0.59 in males and 0.59 to 0.62 in females. This ratio specify whether an individual measurements on spinal canal are within normal limits for respective body size or not, thus helping to identify stenosis or dilatation of the spinal canal. The intersegmental difference of TDC of adjacent vertebrae gradually increased from L1/L2 to L4/L5 both in male and female subjects. This could be helpful in the detection of isolated segmental changes.

The findings of the present study will be helpful to the clinicians, therapists and researchers as ready references to measure the TDB and TDC in South Indian population. Any deviation from this value should be correlated with clinical findings. It is hoped that these morphometrical findings on lumbar vertebrae could be of some use possibly in cases of suspected stenosis and intraspinal tumors. However, for the purpose of authentic use further progressive study in the same direction is desirable. The result of the present study can help in understanding the spine pathologies and management of the spinal disorders.

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