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LUMBAR PEDICLE MORPHOMETRY IN SOUTH INDIANS USING CR-35X DIGITIZER

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ABSTRACT

The pedicle is the strongest part of the lumbar vertebra, which helps in transmission of body weight. Any structural deviation of the pedicle may result in interference of the weight transmission mechanism and compression of neural structures. Transpedicular fixation of the spine is a secure way of obtaining effective vertebral stabilization in the management of different spinal disorders. Thus, knowledge of pedicle morphology is essential for pedicle screw use and its designing. The aim of our study is to determine the mean pedicular width (PW) and pedicular height (PH) and to have a morphological database of the lumbar pedicles for South Indian population.

The present study was conducted on 150 plain antero-posterior radiographs of the lumbar spine of 150 healthy subjects (88 males and 62 females) from South India between the age group of 20 to 50 years. The PH and PW were measured at levels L1 to L5 using a CR-35X digitizer. As there was no significant statistical difference between the parameters of left and right side, the data of mean PH and PW of right and left side were pooled together. It was observed that the mean PH gradually decreased cranio- caudally from L1 to L5 being maximum at L1 (14.78mm in males, 12.95mm in females) and minimum at L5 (11.77mm in males, 10.22mm in females). The mean PW gradually increased cranio- caudally from L1 to L5 being minimum at L1 (7.4mm in males, 6.39mm in females) and maximum at L5 (11.65mm in males, 10.21mm in females) to enable in weight transmission.

On comparing the PH and PW between male and female subjects, it was observed that both PW and PH were greater at all levels in the male subjects than that in female subjects and statistically very highly significant. The present study confirms that there is racial as well as regional variation in the size of lumbar pedicles, thus emphasizing the need to have normal value and ranges for the PW and PH for our population. Racial morphometric differences in the pedicular size of the vertebrae must be taken into account when using international transpedicular screw systems. These results were compared with data from previous studies.

Key Words: Lumbar Vertebrae, Pedicular Height And Width

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. Various problems of the lumbar vertebrae such as its fracture, gross spondylolisthesis, resection of tumours in the vertebral bodies and in patients with lumbar instabilities or those who have been laminectomised require lumbar spinal fixation with pedicular screws. Transpedicular screw fixation of spine has developed as a very successful method of spinal fixation in the management of different spinal disorders. The success of spinal fixation technique depends on the ability of screw to obtain and maintain purchase of the bone within the body of vertebrae. This is based on the choice of size of the screw for a particular pedicle size and the presence or absence of osteoporosis in the pedicle. Regarding the size of the screw, they have reported that, larger diameter screws were stronger

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and gave better results, hence majority of the surgeons continue preferring as large a screw as possible for any given pedicle (Zindrick *et al.*, 1986). The pedicle screw fixation is the method of choice for stabilization of lumbosacral spine Zindrick (1991) described that the choice of pedicular screw diameter is determined by the minimum (horizontal) diameter of the pedicle, whereas the pathway of screw is determined by the transverse (width) and vertical (height) diameter of the pedicle (Singel *et al.*, 2004).

It is well established that the morphometrical data varies within different sex, race, ethnic and regional groups. Even though the problem of low backache is equally prevalent all over the universe, we see little studies done in Indian context. Since most of the spinal internal fixators have been developed in Western countries, it is questionable whether these techniques are suitable for Indian patients. Hence, there is a need for our own metrical data relevant to this region. This study will be useful for clinicians dealing with the problem of low backache, particularly due to bony abnormalities. Keeping these objectives in mind, the present study is undertaken. The study aims at determining the norms of pedicular width (PW) and pedicular height (PH) measured in plain antero-posterior radiographs of lumbar vertebrae. The main objective was to compile a database of normal PW and PH of lumbar vertebrae in healthy male and female subjects in the age range of 20-50 years in South Indian population.

MATERIALS AND METHODS

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, Mangalore, Karnataka after taking the patient's 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 parameters were measured. The maximum diameter of the pedicle in sagittal plane was recorded as PH (Figure- 1).

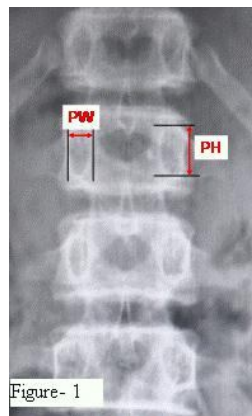


Figure 1: Photograph showing the landmarks for measuring pedicular width (PW) and pedicular height (PH) on plain Antero- posterior radiograph of lumbar vertebrae

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The maximum diameter of pedicle in horizontal plane at right angles to the vertical diameter was recorded as the PW (Figure- 1). From the above measurements the mean values and standard deviations (SD) were computed for each vertebral level separately for both male and female subjects. Differences between the mean PW and PH in males and females at all the five lumbar levels were statistically evaluated.

RESULTS

The mean pedicular height on right side (PHR) gradually decreases cranio-caudally from L1 to L5 in male subjects. In female subjects, the PHR decreased from L1 to L2, increased from L2 to L3, decreased from L3 to L5. The mean PHR is maximum at L1 (15.15mm in males and 12.9mm in females) and minimum at L5 (11.92mm in males and 10.03mm in females). The standard deviation (SD) is maximum at L5 in males and at L4 in females. The difference in the mean PHR between male and female subjects were found to be very highly significant at all lumbar levels.

In males the mean pedicular height on left side (PHL) gradually decreases cranio-caudally from L1 to L5. In females, the mean PHL decreased from L1 to L2, increased from L2 to L3, decreased from L3 to L5. Thus L2 is the transition vertebrae. The mean PHL is maximum at L1 (14.45mm in males and 12.88mm in females) and minimum at L5 (11.83mm in males and 10.36mm in females). The SD is highest at L5. The difference in the mean PHL between male and female subjects were found to be very highly significant at all lumbar levels.

The mean pedicular width on right side (PWR) gradually increases cranio-caudally from L1 to L5. It is maximum at L5 (11.33mm in males and 10.43mm in females) and minimum at L1 (7.25mm in males and 6.4mm in females). The SD is maximum at L5 (2.15) level in males and at L3 (4.36) level in females. The difference of the mean PWR between male and female subjects were found to be significant at L5, highly significant at L1 level and very highly significant at all other lumbar levels.

The mean pedicular width on left side (PWL) gradually increases cranio-caudally from L1 to L5. It is maximum at L5 (11.85mm in males and 10.58mm in females) and minimum at L1 (7.41mm in males and 6.64mm in females). The SD is maximum at L5 (1.87 in males and 2.43 in females). The difference of the mean PWL between male and female subjects were found to be highly significant at L1 level and very highly significant at all other lumbar levels.

Since there was no significant statistical difference between the mean PHR and PHL, both the data were pooled together as mean pedicular height (PH) and were compared with other studies (Table-1).

Table 1: Comparison of mean PH (in mm) between the present and the previous study

LEVEL	MALE		FEMALE	
	AK*	PS**	AK	PS
L1	19.4	14.78	16.3	12.95
L2	18.9	14.23	15.3	12.37
L3	19.3	14.13	15.9	12.48
L4	19.9	13.06	16.1	11.59
L5	20.7	11.77	17.5	10.22

*AK- Study done by Amonoo- Koufi.

**PS - Present study.

There was no significant statistical difference between the mean PWR and PWL, both these data were pooled together as mean pedicular width (PW) and were compared with other studies (Table-2).

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Table 2: Comparison of mean PW (in mm) between the present and the previous study

LEVEL	MALE		FEMALE	
	AK	PS	AK	PS
L1	10.3	7.4	8.7	6.39
L2	10.7	7.4	9	6.5
L3	12.1	9.03	10.5	7.67
L4	13	10.5	11.1	9.27
L5	14.2	11.65	12.5	10.21

DISCUSSION

The pedicle is the strongest part of the lumbar vertebrae. It helps in transmission of forces between the body and neural arch of the vertebrae. The lumbar region is the most mobile part of vertebral column, it is frequently involved during accidents, degenerative conditions, congenital defects and neoplastic metastases. Thus it may require instrumentation for its activity to be regained. Surgical intervention in this region requires a thorough knowledge of the anatomy to identify a suitable site for instrumentation aimed at spinal fixation. The vertebral pedicles are used for the placement of screws through them for management of unstable lumbar spines and such a procedure offers potential advantages over anterior instrumentation and hook-rod devices (Matsuzaki *et al.*, 1990). The knowledge of pedicle dimensions is helpful in transpedicular fixation. Transpedicular screw fixation of spine is a very successful method of spinal fixation. The fixation of lumbar spine is needed for spinal problems such as spinal fracture, spondylolisthesis and in laminectomized patients (Krag *et al.*, 1986). The success of technique depends on ability of screw to obtain and maintain purchase of bone within body of vertebra (Zindrick *et al.*, 1986). If the pedicle and screw size are mismatched the instrumentation may fail leading to cortex perforation or fracture of pedicle. If oversized pedicle screws are used it may cause dural tears, leakage of cerebrospinal fluid and injuries to nerve roots (Amonoo-Kuofi, 1995). Thus, appropriate pedicle size screw for pedicle fixation should be used. With the help of screws, several devices such as rods, plates or wires can be applied to the spine for immobilization or fixation (Amonoo-Kuofi, 1995).

In pedicle screw insertion, the screw is passed through the posterior aspect of the pedicle into the body of the vertebra anteriorly. Since the success of this technique depends upon the ability of the screw to obtain strength within the vertebral body, the choice of the screw to be used is determined by the minimum diameter of the pedicle. Therefore, morphometric data concerning pedicles is useful in preoperative planning and also in designing pedicle screws and other implantable devices.

The findings of the present study are quite similar to those reported in a previous report by Lien *et al.*, (2007) stating that the values for the left and right pedicles of the lumbar vertebrae were nearly the same. This is the only reference available in which pedicle width was measured separately for the right and left sides. Since there was no significant statistical difference between right and left side these values were pooled together for comparison.

Amonoo- Kuofi, (1995) studied plain antero-posterior radiographs of lumbar vertebrae in 270 males and 270 females in the people of Saudi Arabia. He observed that the dimension of pedicles varies in different age groups and at different vertebral levels. The PW in the age group of 40- 49.9 years gradually increased cranio-caudally from L1 to L5 being minimum at L1 (10.3mm in males and 8.7 mm in females) and maximum at L5 (14.2mm in males and 12.5 mm in females) in both sexes (Table-5) which was similar to present study in both sexes .In the present study, the mean PW in both sexes was lower than that of the study by Amonoo-Koufi , (1995) at all lumbar levels indicating smaller diameter of pedicles in South Indian population than that of people of Saudi Arabia. In the present study, the differences in PW between males and females were statistically very highly significant at all lumbar levels. There is a

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statistic difference in PW of Westerns and Koreans Nam Hyum Kim (1994). Thus the size of lumbar pedicle varies in different regions.

The PH in the study of Amonoo-Koufi, (1995) showed that the mean PH (Table -6) is maximum at L5 level (20.7 mm in males and 17.5mm in females) and it increases from L3 to L5 in both sexes. But on the contrary, the PH in the present study gradually decreased cranio-caudally being maximum at L1 (14.78mm in males and 12.95mm in females) and minimum at L5 (11.75 mm in males and 10.22mm in females) in both sexes. This contrast can be because of the racial variation. Amonoo –Koufi, (1995) had studied the population of Saudi Arabia, whereas the present study is done on South Indian population. The difference in the PH between male and female subjects were statistically very highly significant at all lumbar levels in our study. In the present study, the mean PH in both sexes was lower than that of the study of Amonoo-Koufi, (1995) at all lumbar levels indicating smaller diameter of pedicles in South Indian population.

Singel *et al.*, (2004) observed that the PH decreased cranio caudally being maximum at L1 level in females (15.5mm) and maximum at L2 level (15mm) in males. The PH was minimum at L5 level in both sexes (13.4mm in males and 13.25 mm in females) which was similar to the present study.

Almost all studies have reported that the mean values of the PH and PW of the lumbar pedicle were higher in males than in females and this can be explained in terms of the greater upper body weight of males (Steffee *et al.*, 1986). The present study shows that there is ethnic as well as racial variation in the size of lumbar pedicle, thus emphasizing the need to have normal values for the PW and PH for different populations.

Conclusions

In the present study the mean PW increases gradually as we move cranio- caudally from L1 to L5 levels and the PW is maximum at L5 level. There were no pedicles with PW less than 5.4mm in males and 3.8mm in females at 2, 3 , 4 and 5th lumbar vertebrae. The PH in males decreases as we move from L1 to L5 being minimum at L5 and maximum at L1. In females it decreases gradually as we move from L3 to L5 levels i.e., at the lower lumbar levels and the height being maximum at L1 and L2 levels. The findings of the present study will be helpful to the clinicians, therapists and researchers as ready references to measure the PW and PH in South Indian population. Any deviation from this value should be correlated with clinical findings. It is hoped that these morphometric findings on lumbar vertebrae could be of some use possibly in designing pedicle screws. 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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