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A Morphometric Study of Lumbar Spine Pedicles in Nepalese Population

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ABSTRACT

Background and Objective: In this observational study, morphometric data were obtained and analyzed by taking plain x-rays in various age groups to establish the morphometric values in Nepalese population. **Methods:** All the pedicle dimensions were measured by taking plain x-ray AP (Antero-posterior) and Lateral view of the lumbar spine in 246 Nepalese of different age groups. Pedicle diameters (Vertical and Horizontal) and interpedicular distance were measured in AP radiographs and sagittal angle was measured in the lateral radiographs. Differences between mean dimensions of pedicles of male and female of various age groups were tested by using ANOVA, independent t-test was used to test the individual mean dimensions. **Results**: Mean values of the pedicle dimensions were found as: Horizontal diameter (L1=7.17mm, L2=7.26mm, L3= 9.50mm, L4= 10.57mm and L5=11.3mm), Vertical diameter (L1= 15.00mm, L2=15.28mm, L3=15.21mm, L4=13.44mm and L5= 12.59mm), Interpedicular distance (L1= 25.54mm, L2 =27.03mm, L3 = 27.70mm, L4 =28.62mm and L5= 31.29mm) and the sagittal angle (L1=17.83degree, L2=15.7degree, L3= 15.91degree, L4=13.94degree, and L5=12.97degree) respectively. **Conclusions**: Values of pedicle dimensions found in Nepalese population by this study can be guidelines for the transpedicular procedure and for further research activities.

Keywords: Interpedicular distance; Lumbar vertebrae; Pedicle; sagittal angle.

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INTRODUCTION

Transpedicular approaches are being widely used in many surgeries such as bone biopsy, bone grafting, pedicle screw fixation, vertebroplasty and kyphoplasty.[1]The pedicle has been described as "the force nucleus" of the spine, where the posterior elements converge before their communication with the more anterior vertebral body.[2]Several morphometric studies of vertebral pedicles were performed by using plain X-ray, CT scan and anatomic specimens,[3–9] and the significant difference between the pedicle dimensions of white and Asian populations (Indian, Chinese, Korean and Malaysian) as well as variations in different age groups, races, and ethnic groups have been documented.[3,5–7,10–16]. Those studies established that measurements obtained from the plain x-ray films correlated well with values measured from CT scan and cadavers,[4,7–9,17]since plain x-ray is the cheap and easily available method and whole lumbar spine (L1-L5) can be included in the single x-ray film, so that we have preferred this method for the measurement of

pedicle dimensions.

MATERIALS AND METHODS

This observational study was performed in the National Academy of Medical Sciences (NAMS), Shree Birendra Hospital Chhauni, Kathmandu and Bharatpur Hospital, Chitwan, Nepal within the period of 4 years (April 2010 to March 2014). Those individuals who visited in the OPD with minor complains of backache (Total = 246, male 127 =51.6% and female 119 =48.4%) of various age groups (>10yrs) were included. Peoples having history of spinal surgery, deformities and pre-existing spinal pathology were excluded. Plain x-ray lumbar spine AP (Antero-posterior) and Lateral view, which includes L1- L5, were obtained by maintaining the same FFD (Focus film distance) and SFD (Subject film distance). These distances (FFD and SFD) were maintained by taking the metal piece as a reference by maintaining the magnification factor as one in all the three institutions. Those x- ray films, which were reported by consultant radiologist as normal, were only kept for examination.

Measurements were performed by standard Scale of 1mm and Goniometer of one degree calibration. In AP radiographs pencil marks were placed on the limits of the pedicle and diameter was measured in two perpendicular planes (Vertical = V and Horizontal = H). Vertical diameter was taken as a maximum diameter in the sagittal plane and Horizontal diameter was taken as a maximum diameter in a plane right angle to the vertical. Interpedicular distance (IPD) was measured by horizontal line joining the innermost cortical border of the two adjacent pedicles of the vertebrae in the AP radiographs. Sagittal angle (SA) was measured by drawing one line along the axis of the pedicle and another line along the superior border of the vertebral body in the lateral radiographs (Figure 1). Illustrations of horizontal diameter, vertical diameter and sagittal angle to be measured are also mentioned here (Figure 2).[18]

Data was analyzed by using statistical program spss16. Mean dimensions, Standard error of means (SEM), Standards deviations (SD) and p- values of all the vertebral level were calculated separately.

Differences between mean dimensions of pedicles of male and female of various age groups were tested by means of analysis of variance (ANOVA). In combination with ANOVA, independent t-test was used to test the individual mean dimensions and 95% confidence limits were considered for both sexes and age groups at all levels.

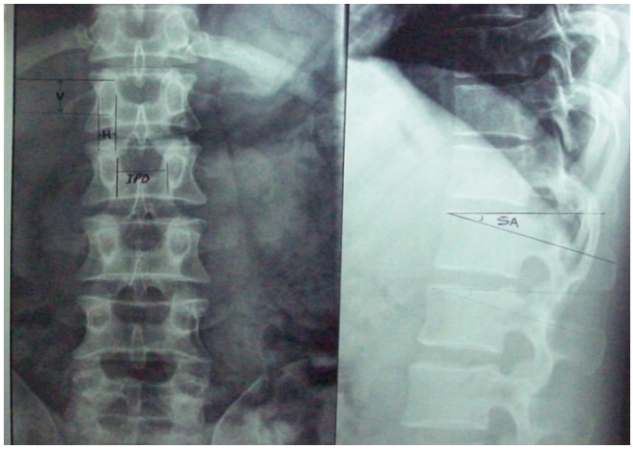

Figure 1: X-ray showing the methods of measurement of pedicle dimensions

Figure 2: Shows illustrations of horizontal diameter, vertical diameter and sagittal angle, which has been measured in x-ray film

RESULTS

In this study mean horizontal diameter ranges from 7.17mm to 11.30mm. Mean horizontal diameter increases from L1 to L5 level (L1=7.17, L2=7.26, L3= 9.5, L4= 10.57 and L5=11.30 mm). Mean vertical diameter ranges from 12.59 mm to 15.28 mm, maximum vertical diameter were measured at L2 (15.28 mm) and minimum at L5 (12.59 mm) but the diameters were not decreases linearly from L1 –L5 (L1= 15.00, L2=15.28, L3=15.21, L4=13.44 and L5= 12.59 mm). Horizontal and vertical diameters of the right and left side were measured and

compared separately at all levels. Dimensions of the right and left sides were found different at all levels but the difference was not found significant statistically. We found that the interpedicular distance (IPD) increases linearly from L1 to L5 and mean values were found as 25.54 mm at L1, 27.03 mm at L2, 27.70 mm at L3, 28.62 mm at L4, and 31.29 mm at L5. Sagittal angle of the Pedicles were directed cephaled in some vertebrae and caudal in others. Mean values of the sagittal angle were calculated separately for cephalic and caudal directed pedicles and found as follow: L1=17.83 degrees, L2=15.7 degrees, L3= 15.91 degrees, L4=13.94 degrees, L5=12.97 degrees (Table 1).

Table 1: Mean values of pedicle dimensions

Measurement	L1	L2	L3	L4	L5
Mean HD (mm)	7.17	7.62	9.50	10.57	11.30
Mean VD (mm)	15.00	15.28	15.21	13.44	12.59
Mean IPD (mm)	25.54	27.03	27.70	28.62	31.39
Mean SA (degree)	17.83	15.70	15.91	13.94	12.97

Out of 246 individuals most of the pedicles were found to directed cephalic (L1=198, L2= 203, L3= 203, L4= 173) except at L5 levels, where most of the pedicles (171) were found directed caudally. We also analyzed the sex related variations and significant difference was found between male and female except at few levels. Variation in the pedicle dimensions were also found in different age groups but the difference was not compared separately in each group.

DISCUSSION

Several studies regarding morphometric measurement of vertebral pedicles were performed by using X-ray, CT scan and anatomic specimens and a significant variation of pedicle dimensions were found in different age groups, sex, races, and ethnic groups.[1,4,5,8,13–16,19] Those studies had established that measurements obtained from the plain x-ray films correlated well with values measured from CT scan and directly measured from cadavers.[1,4,7,13,15,18,20,21] Amonoo-Kuofi HS et al[4] performed the similar study in 540 persons (270= male and 270 female) with age ranging from 10- 65 years by using plain X-ray AP view only to measure horizontal and vertical diameter of lumbar spine pedicles and found the significant variations between the different age groups and sex. Zindric et al[7]and Panjabi MM et al[19] also used plain x-ray to measure the pedicle dimensions and compared with morphometric measurement from cadavers and found that plain x-ray values are comparable to the directly measured values. We found that mean horizontal diameter ranged from 7.17 mm to 11.30 mm. Horizontal diameter increases from L1 to L5 level (L1=7.17 mm, L2=7.26 mm, L3= 9.50 mm, L4= 10.57 mm and L5=11.30 mm). Mean vertical diameter ranges from 12.59 mm to 15.28mm, maximum vertical diameter were measured at L2 (15.28 mm) and minimum at L5 (12.59 mm) but the diameters were not decreases linearly from L1 to L5 (L1= 15 mm, L2=15.28 mm, L3=15.21 mm, L4=13.44 mm and L5= 12.59 mm). Horizontal and vertical diameters of the right and left side were measured separately and compared at all levels. Dimensions of the right and left sides were found different at all levels but the difference was not significant statistically (P-value at 95% of confidence interval was >0.05 at all levels).

Our mean values were also compared with the previous Morph metric studies. In the study done by Zindric et al,[7] mean horizontal diameter ranged from 8.7 mm at L1 level to 18 mm at L5 level and mean vertical diameter ranged from 15.4mm at L1 level to 12.59mm at L5 level. Outer diameters of the most commonly used pedicle screws range from 5 mm to 7 mm so that the screw pitch, tooth profile, outer diameter, and depth of penetration should be considered while putting the pedicle screws.[15] In this Morphometric study, variations of the pedicle dimensions were observed between different sex and age groups. Pedicle diameters were also

compared between male and female sex at all levels (by using independent sample t-test at 95% confidence interval) and with the previous morphometric studies done by Olsewiski JM et al[15] and Mitra SR et al,[18]we found that mean horizontal diameter in male varies from 7.73 mm (L1) to 10.89mm (L5) and in female from 6.57mm (L1) to 11.94 mm (L5), mean vertical diameter in male vary from 16.23mm (L2) to 12.97mm (L5). Similarly Mitra SR et al[5] performed Morphometric study in the Indian population and found that mean horizontal diameter in male ranged from 7.05mm (L1) to 11.94mm (L5) and in female from 5.95mm (L1) to 10.61mm (L5). Olsewiski JM et al[18] (1990) found that mean horizontal diameter in male ranged from 9.00mm (L1) to 16.7mm (L5) and in female from 6.30mm (L1) to 13.5mm (L5), mean vertical diameter in male ranged from 16.8mm (L2) to 14.2mm (L4) and in female 15.4mm (L1) to 13.2mm (L5). Mean values of pedicle diameter in our study were found smaller than all the above studies at most of the vertebral levels but the values obtained by Mitra SR et al[15] were very similar to our study; it may be due to various socioeconomic, cultural and structural similarities between Nepalese and Indian population. All of these authors found that pedicle diameters differ significantly between male and female at all the levels as in our study (Figure 3, 4).

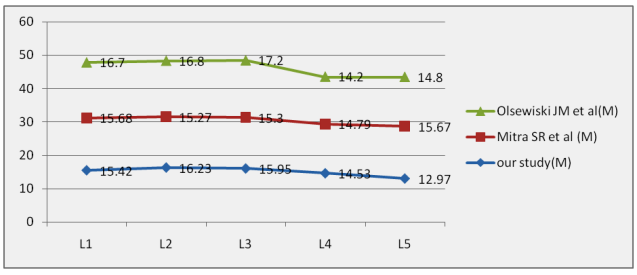

Figure 3: Graph showing the comparison of horizontal diameter (millimeter)

We found that the interpedicular distance increases linearly from L1 to L5. Mean interpedicular distance were found as L1= 25.54 mm, L2= 27.03 mm, L3= 27.70 mm, L4= 28.62 mm and at L5 =31.29 mm. These values also differed significantly between male and female and with different age groups. Similar pattern was observed by Mitra SR et al[15] but their values were larger than our values at all the levels. They found that the interpedicular distance in male at L1 = 32.4mm, L2=32.8mm, L3=33.4mm, L4=34mm, L5= 34.1mm and in female L1=32.5mm, L2=34.4mm, L3= 34mm and L4 = 35mm (Figure 5).

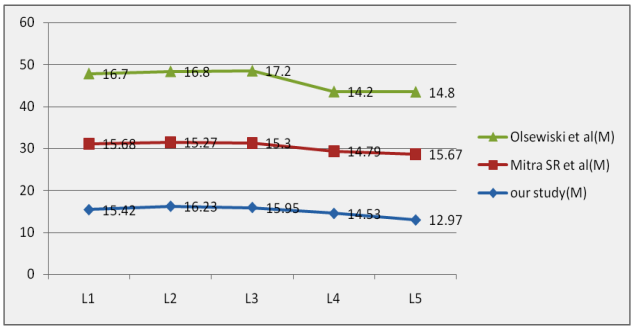

Figure 4: Graph showing the comparison of vertical diameter (millimeter)

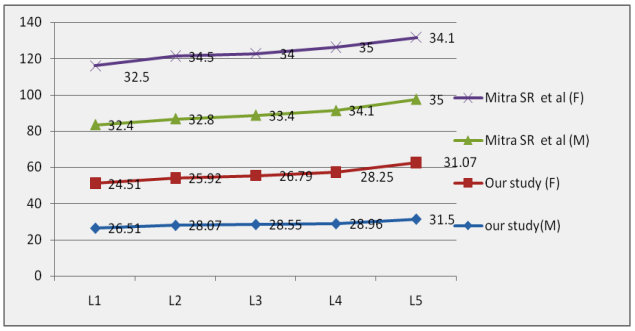

Figure 5: Graph showing the comparison of interpedicular distance (millimeter)

In this study sagittal angle of the vertebrae were also measured in plain x- ray lateral views. Pedicles were found directed cephalic in some vertebrae and caudal in others. Out of 246 vertebrae analyzed; most of the pedicles were directed cephalic (L1=198, L2= 203, L3= 203, L4= 173) except at L5 levels where maximum pedicles (171) were found of directed caudally. Similar pattern was observed by Marchesi D et al,[9] they found that in the sagittal plane, the pedicles were angled cephaled from T6 to L3 and slightly caudally at L5. In our study, mean values of the sagittal angle were calculated separately for cephalic and caudally directed vertebrae and found as follows: L1=17.83 degree, L2=15.7 degree, L3= 15.91 degree, L4=13.94 degree and

L5=12.97degrees. Similar studies were performed by Olsewiski JM et al[18] and Mitra SR et al,[15] but they considered values of cephaled directed pedicles as positive and caudally directed pedicles as negative and means were calculated by adding all the values together. Olsewiski JM et al[18] found that the mean sagittal angle of L1=5 degree, L2=6 degree, L3= 6 degree, L4 =7 degree and L5= 5 degree, similarly Mitra SR et al[15] found mean values as L1=8.4 degree, L2= 9.3 degree, L3= 10.4 degree and L5= 6.7 degree. Values obtained by both of these authors were smaller than our values, it might be due to the different techniques of calculation but in all the above studies it had been observed that values of sagittal angle were decreases as we go downwards from L1 to L5 vertebral levels. Our values are very similar to the values obtained by Fang D et al,[6] in which they mentioned that: Asian pedicles had a larger pedicle inclination angle from L1 to L4 (L1 = 16 degrees, L2 = 16 degrees, L3 = 19 degrees, L4 = 23 degrees and L5 =29 degrees) and there was a significant differences between the lumbar pedicles of Asians and whites.

We analyzed sex related variations of pedicle dimensions by comparing the values between male and female as grouping variables and all the other parameters separately as test variables by using Independent Samples- T Test at 95% confidence interval. Significant difference in the horizontal diameter between male and female pedicle were found at all levels (p-value= <0.05) except at L5 levels (p-value=0.062). Similarly the difference in the vertical diameter between male and female was also found statistically significant at all levels (p-value=<0.05) except at L1 (p-value=0.136) and L5 (p–value= 0.062). The difference in the interpedicular distance was also found significant at all the level except at L1 (p= 0.22) and L3 (p=0.26). As in our study sex and age related variations was observed by several authors.[1,4,13,15,20,22]

Age groups related variation between different age groups was analyzed by using One-way ANOVA at 95% confidence interval but the variations were not compared between each age group separately. Significant age groups related variations were observed in all the pedicle dimensions at all vertebral level (p= <0.005) except the sagittal diameter at L5 level, where the different was not significant (p-value=0.108). In this study the findings suggested that there was continuous variations in the pedicle dimensions and the changes were characterized by increase of diameters in some age groups and decrease in others, but there was an overall increase in the dimensions as the age groups were followed from the youngest to the oldest.

AmonooKuofi et al[4] also found that there was a significant age related variations of pedicle dimensions at all segmental levels. Mitra SR et al[15] performed the Morphometric study of the pedicles in the Indian population and found the significant difference with white population but they didn't analyze the values between different ethnic groups within the Indian population. Liau KM et al[16]did the similar study in the Malaysian Malay population and found that female patients had the significantly smaller dimensions in most of the parameters measured as compared to male and the pedicles dimensions of the Malay populations differ significantly with white.

CONCLUSION

By this limited study, we can recommend that the pedicle dimensions of lumbar spine in Nepalese population, could be a guidelines for all the transpedicular procedures and research activities though we need to have further studies based on direct morphometric measurement and CT- Scan including all the vertebral levels (cervical, thoracic and lumbar). Pedicle dimensions of Nepalese are very similar to that of Indian population but differ significantly with white populations and most of these values were found smaller than those of white

populations. Pedicle screw sizes which are being used now a day may not be appropriate for all the vertebral levels in Nepalese population so that selecting an appropriate size pedicle screw and the

direction of insertion are very crucial while performing the transpedicular procedures.

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