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ORIGINAL RESEARCH

The morphometry of the neural arch in the lumbar vertebrae

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ABSTRACT
Background: The methods used in surgery on the spine rely on the use of specific bone structures and the detailed measurements of the different sections of vertebrae. It is crucial to have a precise understanding of the bone structures in treatment lower back pain which may occur due to nerve compression associated with lumbar vertebra. Key bone structures such as transverse process, superior and inferior articular facets play a significant role in the repair of the lumbar spine. The measurement of human vertebral geometry is very critical for performing precise surgical treatments. **Aim and objective:** To measure the morphometry of neural arch form in lumbar vertebrae. **Method and materials:** The study was performed on 100 dried adult human skeletal lumbar vertebrae. The transverse (TP) and spinous (SP) processes, vertebral canal (VC), isthmus, and laminae of dry L_1 to L_5 were measured with a Digital Vernier Caliper and evaluated. **Results:** The isthmus length decreases from L1 to L5 vertebrae and vertebral canal is in oval shape. The transverse process length on right side is greater than left side and increases from L1 (17.82 mm) to L3 (22.57 mm), then decreases till L5 (18.72 mm). **Conclusion:** The neural arch is dynamic in shape and systematically asymmetrical along the lumbar spine.

Keywords: Neural Arch, Lumbar Vertebrae, Transverse Process, Lamina, Spinous Process, Isthmus

INTRODUCTION

The measurement of the various parts of the vertebrae is essential in surgical procedures as it involves the utilization of bony anatomical landmarks. During spinal surgeries, dimensions of isthmus length and transverse process are important for better acceptance of spinal grafts. Preparation of spinal fixation by translaminar screws also involves the measurement of neural arch. Lumbar vertebrae are unique in their large size, wide body, absence of transverse foramina and costal facets. These consist of vertebral body and neural arch which are connected by pedicles. The four superior and inferior articular facets, spinous process and two right and left transverse process along with laminae form the neural arch.There are five lumbar vertebrae in human skeleton. The transverse process of L5 is very massive [1]. The vertebral body is wedge- shaped and is responsible for lumbosacral angle as it is markedly deeper anteriorly. The L3 vertebrae is jammed posteriorly between the L4 and L5 vertebrae [2]. From L4 to L5 the breadth of the vertebral bodies increases [3].

The anatomical studies proved to be very helpful to understand the detail complex morphometry of the vertebral column [4]. The majority of these studies have focused on pedicle size, vertebral form and facet orientation which are mostly used to make clinical diagnoses. The number of spinal surgeries like spinal grafts and spinal fixation are growing every year. For this reason, the neural arch dimensions become more significant.

MATERIALS AND METHODS

The present study was conducted on 100 dried adult human skeletal lumbar vertebrae. The study was carried out in Department of Anatomy, World Medical College in collaboration with Department of Anatomy, N.C Medical College. All vertebrae and other bones of skeleton were complete, had fully ossified with no deformity. The measurements were taken using a Digital Vernier caliper. Total seven variables were measured:

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Isthmus Length (IL): Isthmus length is distance between the most inferior point of the superior articular facet and the most superior point of the inferior articular facet. Both lengths i.e. Right Isthmus Length (RIL) and Left Isthmus Length (LIL) were measured by keeping the vertebrae in lateral position. (Fig.1)

Fig 1: Isthmus Length (IL)

Spinous Process Length (SPL): The length of the spinous process (SPL) in a superior view is measured from the most anterior to the most posterior locations on the superior margins of the vertebrae. (Figure 2)

Fig 2: Spinous Process Length (SPL)

Spinous Process Height (SPH): The distance, measured in lateral view, between the posterior-most point on the superior border and the posterior-most point on the inferior border of the spinous process of a vertebra is known as the spinous process height (SPH).

Fig 3: Spinous Process Height (SPH)

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Transverse Process Length (TPL): The distance between the transverse process's highest point on its external border and the point on its lateral border where the superior articular facets join it is measured. Measurements were made of the Left Transverse Process Length (LTPL) and the Right Transverse Process Length (RTPL). (Figure 4).

Fig 4: Transverse Process Length (TPL)

Vertebral canal superior width (VCSW): The maximum distance between the left and right superior margins of the vertebral canal is known as the vertebral canal superior width, or VCSW. (Figure 5)

Fig 5: Vertebral canal superior width (VCSW)

Vertebral canal superior length (VCSL): The maximum distance between the anterior most point on the superior margins of the spinous process and the vertebral canal is known as the vertebral canal superior length, or VCSL. (Figure 6)

Fig 6: Vertebral canal superior Length (VCSL)

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Laminar superior length (LSL): The distance between the anterior most point on the superior borders of the spinous process and the inferior most point on the inferior border of the superior facet is known as the laminar superior length, or LSL. Measurements were made of the Left laminar superior length (LSLL) and the Right laminar superior length (RSLL). (Figure 7)

Fig 7: Laminar superior length

DATA ANALYSIS

Statistical and descriptive analysis of all the parameters were performed using the Microsoft excel and SPSS version 20.0. Paired t-tests were applied to statistical analyze the data.

OBSERVATION AND RESULTS

Table 1: Isthmus Length measurements in Lumbar Vertebrae (Mean ± SD).

	L1	L2	L3	L4	L5
IL(R)	16.72±3.79	16.61 ±2.78	15.65 ±2.89	14.25 ±2.77	11.12± 2.26
IL(L)	16.77 ±2.81	16.33±2.64	15.83±2.51	14.19±2.82	10.7±2.25
P-value	0.92	0.65	0.858	0.92	0.596

Table 2: Spinous Process Length and Height measurements in Lumbar Vertebrae (Mean ± SD).

	L1	L2	L3	L4	L5
SPL	22.34±5.32	24.73±5.85	27.15 ±5.96	25.22±7.16	20.91±7.02
SPH	20.24±5.21	20.96±3.71	22.03± 4.17	21.67±3.83	16.67±2.70
P-value	0.127	0.003	0.01	0.024	0.005

Table 3: Transverse Process Length measurements in Lumbar Vertebrae (Mean ± SD)

	L1	L2	L3	L4	L5
TPL (R)	17.82±6.52	19.58±3.95	22.57±4.39	20.95±3.76	18.72±5.46
TPL (L)	17.02±5.87	19.07±3.86	22.02± 4.01	20.56±3.55	18.09±5.39
P-value	0.616	3.38	0.601	0.698	0.798

Table 4: Vertebral Superior Canal Width and Length measurements in Lumbar Vertebrae (Mean ± SD)

	L1	L2	L3	L4	L5
VSCW	26.88 ±3.01	26.53±3.12	27.82 ±2.94	28.95 ±3.40	30.54± 3.18
VSCL	21.23 ±2.17	20.71 ±1.87	20.17 ±2.03	20.41 ±2.66	21.26 ±3.11
P-value	0.001	3.49	0.00	1.55	2.22

Table 5: Laminar Superior Length measurements in Lumbar Vertebrae. (Mean ± SD)

	L1	L2	L3	L4	L5
LSL (R)	11.31± 2.20	11.47± 2.18	11.54± 1.37	11.64± 1.95	14.37± 3.28
LSL (L)	11.19± 2.25	11.25± 2.03	11.42± 1.69	11.58± 1.96	14.26± 3.60
P-value	0.822	0.77	0.368	0.388	0.59

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DISCUSSION

Tables 1 shows that the left isthmus is greater than right isthmus. In lumbar vertebrae, the isthmus length (IL) decreases from L1 to L5.

The Spinous Process Length (SPL) and Spinous Process Height (SPH) increases from L1 to L3 then decreases up to L5 vertebrae as shown in table 2.

In Tables 3, the transverse process length (TPL) first increases from L1 to L3 then decreases from L4 to L5. The right transverse process length is more than the left transverse process length.

Table 4 demonstrate that the width of Vertebral Superior Canal (VSCW) is more than the length of Vertebral Superior Canal (VSCW). From L1 to L5, the length and breadth disparity grows. therefore, the vertebral canal of lumbar vertebrae is oval in shape. The vertebral canal diameter is also influenced by the racial and ethnical differences along with the different geographical areas [6].

Table 5 shows that the Laminar Superior Length (LSL) of lumbar vertebrae gradually increases from L1 to L5. The length of right lamina was higher in comparison to the left lamina. This finding is similar to the study done by Ashish S et al [6].

The intersection of the two laminae is towards the left side of the median plane because there is difference in both right and left laminar lengths. The length of right lamina is greater than the length of left lamina. As a result, the spinous process is not considered in midline which makes the determination of structural defects, dislocations and fractures more difficult.

A radiographic study done by Van Schaik also states that the position of spinous process in an Anterio-Posterior radiograph is not satisfactory diagnostic guide in case of lumbar spine [7].

Masharawi et al found that the length of right transverse process was lesser than the length of left transverse process in their study [8]. But contrary to that, present study states that the length of right transverse process is greater than the length of left transverse process. This inequality in this parameter may be described because of difference in measuring methods used and bones from different population can also be responsible for it. A South African study confirms that in the osseous morphology of the dried lumbar vertebrae ethnic variation can be found [9]. This is the limitation of the study as ethnic variations were not studied.

CONCLUSION

The neural arch of lumbar vertebrae is systematically asymmetrical and extremely variable in shape. These parameters are influenced by ethnic, racial and environmental factors. The lengths of all the parameters i.e. transverse processes, lamina and isthmus are greater on the right side of the vertebrae. The length of transverse and spinous process increases from L1 to L3, then decreases till L5. The spinous process is deviated towards the left side from midline. so, it is not be used in determination of structural defects in lumbar region.

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Conflict of interest: Nil

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