Original Research Article

EXPLORING THE ANATOMICAL DIMENSIONS OF SPINOUS PROCESS OF HUMAN ADULT LUMBAR SPINE–AN OBSERVATIONAL INDIAN POPULATION BASED STUDY

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ABSTRACT

Background: Anatomical knowledge of pedicle and posterior elements of lumbar spine is crucial to assess its biomechanics and for surgical interventions aimed at the stabilization and correction of deformities. Many studies are available on Lumbar vertebral canal and its pedicles but the other posterior elements remain neglected. The Posterior elements includes transverse, spinous and articular processes which are important for stabilization during movements of lumbar spine. Congenital spinous process deformities are common in lumbosacral region. Interspinous implants are found be more advantageous to stabilize the lumbar spine as it is modest and minimum time-consuming procedure. However, its complications should not be unheeded. **Aims and Objectives:** 1) To measure the anatomical dimensions of spinous process of first to fifth lumbar vertebrae (L1 to L5) to design interspinous stabilization devices in context of Indian subjects. 2) To differentiate the L1 to L5 lumbar vertebrae by morphometric measurements of its spinous process.

Material and Method: An observational Indian population-based study on 53 dry human lumbar vertebral sets. Three dimensions of spinous process of each bone (L1 to L5) namely length, height and thickness were measured by 'Digital Vernier Calliper'. Data was analysed by SPSS (Version 12) software and statistically significant differences were evaluated by 'ANOVA' test.

Results: The length heightened from L1 to L3 and subsequently it reduced at L4 and L5. The fifth vertebra had shortest spinous process (SP). The height of spinous process showed an increase from L1 to L3 and decrease at L4 and L5. The thickness of SPs along its inferior border was uniform in all lumbar vertebrae. The length and the height of the spinous process was maximum at the third vertebra and minimum at the fifth vertebra respectively.

Conclusions: The study stated statistically significant differences in dimensions of spinous process of all lumbar vertebrae. This may be the guide for appropriate dimensions for implantation of interspinous stabilization device in Indian population and useful for anatomists, anthropologists and in forensic medicine to differentiate the individual lumbar vertebrae. However, large sample size is required for direct Morphometric measurement and gender specific studies for generalization of results.

Keywords: Dimensions; Interspinous implant; Lumbar Vertebrae; Spinous Process.

INTRODUCTION

Lumbar vertebra is developed from centrum and neural arch. Vertebral body is mainly formed by centrum and its posterolateral part has contribution of neural arch. Remaining neural arch forms vertebral arch which consist of pedicle, lamina, articular facets, transverse and spinous processes (SP). Body and vertebral arch encloses lumbar canal anterolateral part while spinous process contributes it in posterior midline. Adjacent spinous processes are connected by interspinous and supraspinous ligaments. Deformities in spinous process may be congenital as various types of spina bifida or due to injuries which affects the structures in the lumbar canal. Lumbar canal stenosis (LCS) leads to compression of the spinal canal structures, with neurological signs, symptoms and its complications. [1] 'Conservative treatment' is often indicated for patients with mild clinical symptoms of LCS. However, in case of severe LCS, 'decompression surgery' forms the mainstay of treatment. [2,3] 'Secondary instability' and 'rigid arthrodesis' etc. are known associated complications with surgery.[4]

'Non-fusion lumbar spine stabilization' is one of the accepted interventions which reinstates intersegmental motion to the magnitude of whole spine without any adverse impact on adjacent stabilized segments.[5] The research showed that it provides nonrigid fixation and normal flexible spine movements.[5] Use of interspinous implants is found be more beneficial to stabilize the spine as it is simple and less time-consuming procedure.[2,3,4] However, its complications should not be overlooked.[6] Such complications can be averted by setting clear indications and producing sophisticated implants.[7] It reiterates the need for meticulous assessment of anatomy of spinous process to develop appropriate fitting device.

There is a very limited published data on morphometric analysis of spinous process in Indian population. In current study, anatomical dimensions of spinous process of lumbar vertebrae (L1 to L5) were studied in order to design interspinous stabilization devices in context of Indian subjects. Moreover, the dimensions of lumbar spinous processes to determine site of lumbar puncture for cerebrospinal fluid collection are required. Defects of SP like various types of spina bifida are not uncommon in lumbosacral region. The generated results would create anatomical database for clinical applications.

MATERIALS AND METHODS

An observational study was carried out in which 53 adult human lumbar vertebral sets were examined. The bones with deformities, congenital defects or degenerative changes were excluded. Local institutional ethics committee approval was obtained for the study and all procedures were implemented as per ethical standards.

Spinous process dimensions

Three dimensions of spinous process of each bone (L1 to L5) namely length, height and thickness were measured by 'Digital Vernier Calliper'. The length (SPL) was considered from the junction of laminae to the tip of spinous process. The height (SPH) indicated maximum vertical distance of spinous process while thickness (SPTh) was denoted as maximum transverse measurement along the inferior border of spinous process.

Statistical Analysis

The data analysis was done using SPSS Version 12.0 (SPSS Inc. USA). Mean and Standard deviation (SD) of all observations were calculated. P value less than 0.05 was considered to be statistically significant. The significant differences were determined by 'ANOVA' test.

RESULTS

From the study, it was observed that spinous processes (SPs) of all lumbar vertebrae were directed dorsally. SPL enhanced from L1 to L3 (Table 1, Figure 1) and subsequently it reduced at L4 and L5. The fifth vertebra had shortest SPL. The height of spinous process showed an increase from L1 to L3 and decrease at L4 and L5.

Third lumbar vertebral spinous process had the maximum length and height (Table 1, Figure 1). The thickness of SPs along its inferior border was similar in all lumbar vertebrae. The length and the height of the spinous process was maximum at the third vertebra and minimum at the fifth vertebra respectively. (Table 1, Figure 1).

Table 1 depicts mean lengths, heights and thicknesses of spinous process of all lumbar vertebrae. Highly significant difference ($p<0.01$) was observed in all parameters of SPs of L1 to L5.

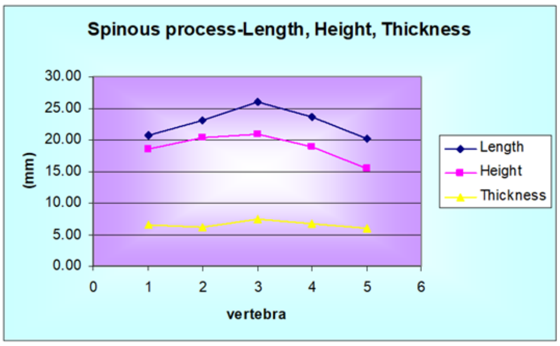

Figure 1: Dimensions of Lumbar Spinous Process (L1 to L5)

Table 1: Mean Dimensions of Spinous Processes and its Significances (L1 to L5)

Vertebra	Length (mm)	Height (mm)	Thickness(mm)
L1	20.8162	18.5487	6.6128
L2	23.1191	20.4372	6.2306
L3	26.0834	20.9951	7.3885
L4	23.7194	18.9615	6.6902

L5	20.2615	15.5272	5.9743
F Value	10.84	21.56	9.45
P value	<0.01	<0.01	<0.01
Significance	**HS**	**HS**	**HS**

HS = p < 0.01 was considered to be highly significant

DISCUSSION

Multiple interspinous implants have been utilized in the management of lumbar spinal diseases like canal stenosis, degenerative defects or lumbar instability etc.[8,9] None of the implants is found to be free from any complications. Hence, the dimensions of device need to be properly estimated to prevent undue complications. The current study examined spinous processes of 53 adult lumbar vertebral sets in Indian population.

In this study, there was significant rise in length of spinous processes of L1 to L3 and drop at L4 to L5. This was in agreement with the study finding of B Caietal.[1] who noted similar patterns in SPL from L1 to L5. Long spinous process may be useful guide to locate it during lumbar puncture procedure. Contrast findings of length were reported by Ihm et al. in their study,[10] where there was a gradual decrease in length from first to fifth lumbar vertebra. In present study, height of SP was more from L1 to L3 and less at L4 to L5 with maximum height at L3. B Caietal.[1] Also found largest height of SP at L3 in males but at L4 in females. In their study, there were variations in measurements of thickness of inferior margins of SPs. Gender differences were not revealed in the present study. However, the thickness of SPs along its inferior border was uniform from L1 to L5 in our study. SPs of females were found to be shorter, thinner and lower as compared to males in study findings of B. Caietal.[1] The sexwise differences may reflect the variations in average physical size among the genders.

This study revealed suitable anatomical dimensions of lumbar spinous processes to design interspinous stabilization device in Indian population. It is imperative to mention that ‘implant sinking’ seems to be natural process which is detected during aging as well as post spinal surgical interventions.[11] An implanted device may become unstable if it is loosely fitted.[7] Therefore, an aging impact and device sinking must be considered prudently during interspinous implantation procedures.

The study also recommends to conduct multiple studies withgender differences and larger sample size and for better generalization of results as there was limited sample size which may cause wider standard deviations. Furthermore, several morphometric studies with imaging techniques can be used to supplement the results of direct measurement studies.

CONCLUSION

The current study reported statistically significant differences in dimensions of spinous process of all lumbar vertebrae. These dimensions were observed to be appropriate for implantation of interspinous stabilization device in Indian population. However, there is need for more direct measurement morphometric studies for generalization of results.

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