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# Finite Element Study: Locus of Axis of Rotation of $T_{11}$-$T_{12}$ and $T_{12}$-$L_1$ Segments under Flexion/Extension and Axial Rotation Configurations

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**Abstract**

In human, the thoracolumbar junction (TLJ) is a transitional region where the normal kyphotic thoracic region shifts to the normal lordotic lumbar region; the coronally oriented facet joints of the thoracic region transform to the sagitally oriented facet joints of the lumbar; and the relatively immobile thoracic region changes to the relatively mobile lumbar region. The different anatomical characteristics at the functional spinal units (FSUs) of T11- T12 and T12-L1 provide an opportunity to study the associations between pathoanatomical changes in these two levels. Hence, it is of interest to investigate the biomechanical responses of the spinal motion segments T11-T12 and T12-L1, which possess the transitional vertebra T12, to determine whether the biomechanical kinematic properties reflect these anatomical changes between these FSUs. The movement of a FSU is dependent upon several parameters, namely its complex geometry, facet articulations and material characteristics of the ligament us tissues, intervertebral discs, and upon the applied load vectors .

Accordingly, this study aimed to use a validated FE models of thoracolumbar junctional T11- T12 and T12-L1 functional spinal units (FSUs) validated under physiological loading modes: flexion, extension, lateral bending and axial rotation, and to compare the kinematics in terms of the locations and loci of instantaneous axes of rotation (IARs) .

**Keywords:** Thoracolumbar Junction; Finite Element; Axis of Rotation; Functional Spinal Unit

**Abbreviations:** TLJ: Thoraco Lumbar Junction; FSU: Functional Spinal Units; IAR: Instantaneous Axes of Rotation

## Results and Discussion

The locations and loci of T12-L1 differ greatly from those of T11-T12. In sagittal plane, the locations and loci of the IARs were located below the intervertebral disc for T11-T12, situated in the intervertebral disc for T12-L1. In transverse plane, they fell in the medio-anterior region of the movable vertebra T11 for the T11-T12, and located near the cortical shell of the upper vertebra T12 for T12-L1 [1], (Figures 1 & 2).

It is known that the anatomic geometrical structure of a FSU defines it motion and related biomechanical responses. Hence, some differences in anatomical features of these two FSUs may account for the variation in loci [2]. At level T11-T12, the facet articulation is essentially oriented in the coronal plane; while in the T12-L1 segment, the facet joint surfaces are sagitally aligned. For the intervertebral disc, at T11-T12, the anterior height is slightly larger than the posterior height; whereas, at T12-L1, the anterior height is greater than the posterior height, which results a lordotic angle. These different orientations of the facets and the geometry of interveterbral discs demonstrate the difference in loci at the two levels, (Figures 3 & 4).

## Significance

These findings offer an insight to better understanding the kinematics of the human thoracolumbar spine; provide clinically relevant information for the evaluation of spinal stability and implant devices functionality, and the biomechanical load effect on spinal deformity.

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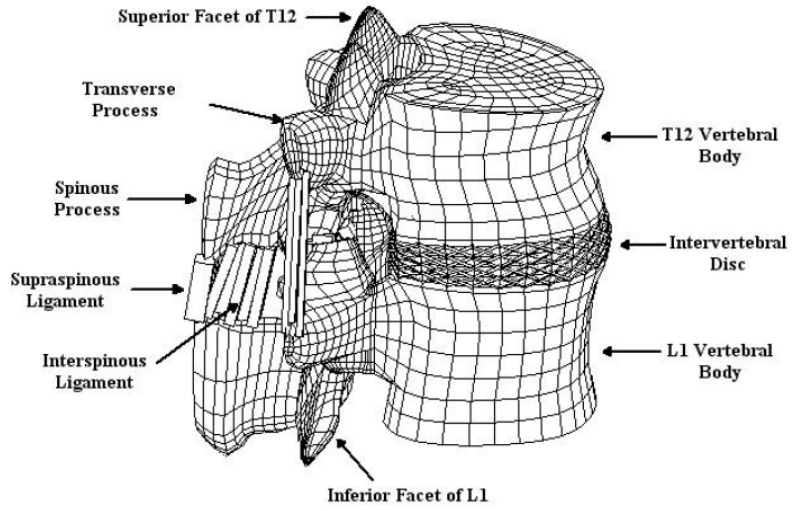


**Figure 1:** T12-L1 FE model.

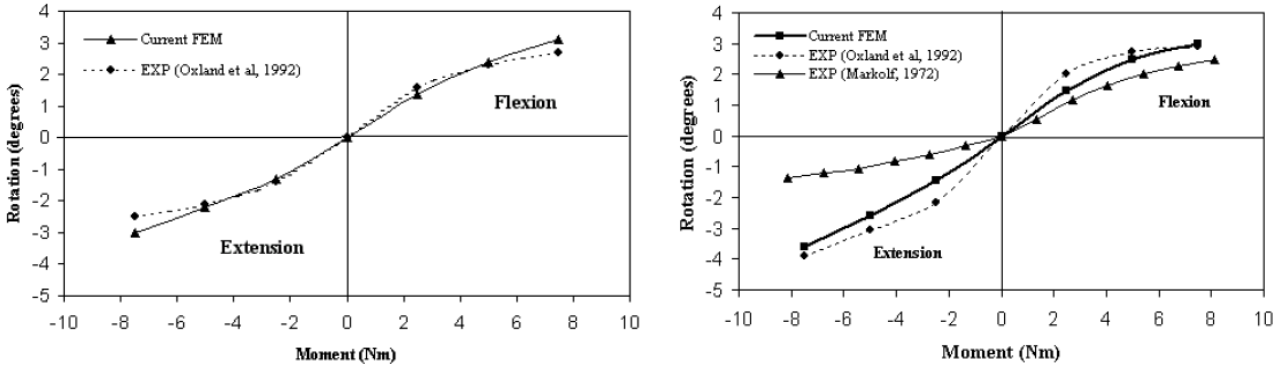


**Figure 2:** Angular motion of T11-T12 and T12-L1.

**Figures 1 & 2:** below show T12-L1 FE model and a validation study on the biomechanical responses of T11-T12 and T12-L1 under flexion/extensions, respectively.

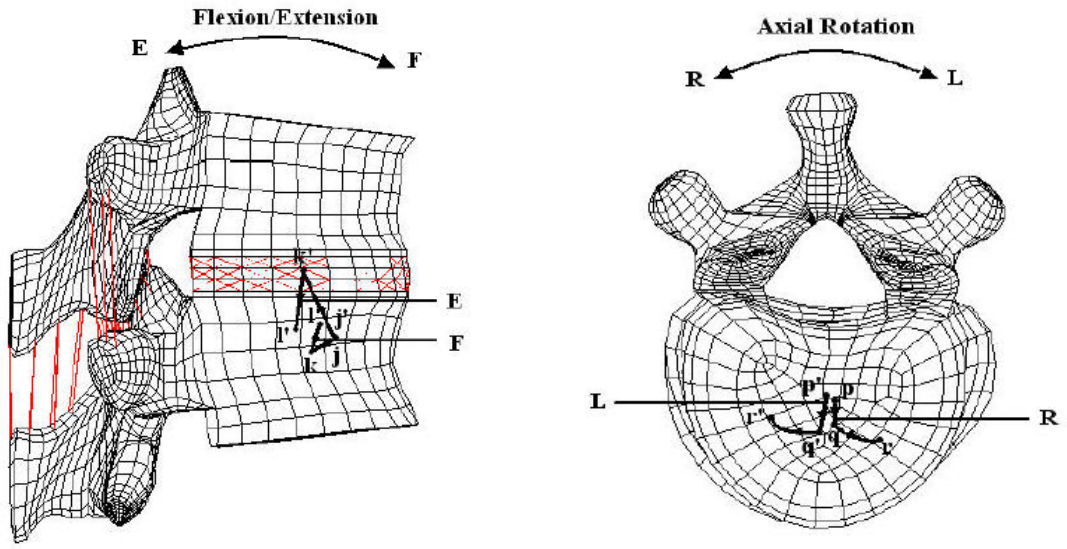


**Figure 3:** T11-T12 Locus of axis of rotation under F/E and A Rotation.

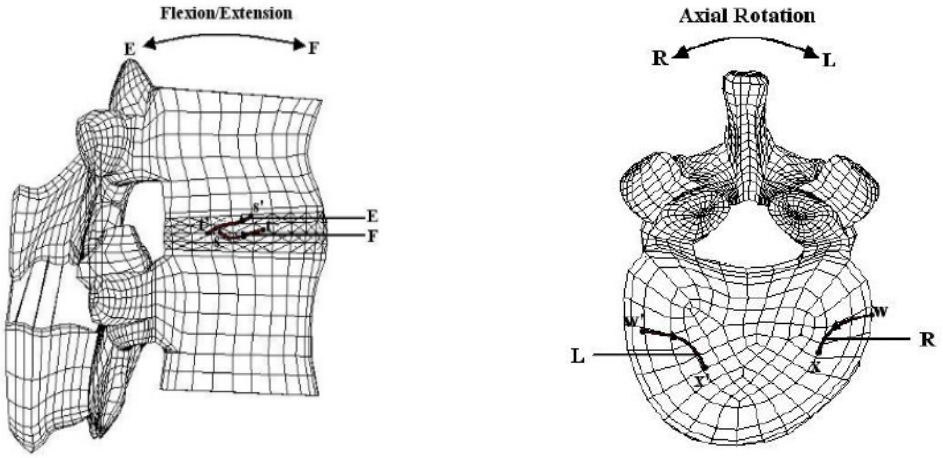


**Figure 4:** T12-L1 Locus of axis of rotation under F/E and A Rotation.

**Figures 3 & 4:** shows the locus of axis of rotation of T11-T12 and T12-L1 models under two loading configurations of flexion/extension and axial rotation, respectively.

## References

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