# A radiologic analysis: Relationships of the thoracic spine to aid palpation of the thoracic transverse processes

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## INTRODUCTION

In the field of osteopathic manipulative medicine, palpation is an important skill used by physicians to localize structures to diagnose and treat patients with somatic dysfunction throughout the musculoskeletal system. Specifically, in the thoracic spine, physicians can use the more superficial spinous process of each vertebra to assist in locating the deeper, more challenging to palpate, transverse process of the vertebra. Historically, the "Rule of Three's", proposed by Mitchell et al in 1979, describing the relationships between spinous processes and transverse processes of the thoracic spine has been taught in osteopathic medical schools. However, another model was more recently proposed by Geelhoed et al in 2006. To our knowledge, these models have never been analyzed radiologically using computed tomography in patients.

## OBJECTIVES

To evaluate the accuracy of several proposed models, including the "Rule of Three's" and Geelhoed's rule, which aid in palpation of the transverse processes of the thoracic spine based on their relation to the spinous processes. Furthermore, the study aims to analyze the intervertebral and intravertebral relationships of the transverse processes and spinous processes of the thoracic spine.

## DEFINITIONS

Rule of threes:

The rule of three states that the spinous process (SP) of,

- T1-T3 are located at the same level of their own transverse process (TP)
- T4-T6 are ½ a segment below their own TP
- T7-T9 are 1 segment below their own TP
- T10 follows the same rule as T7-T9
- T11 follows the same rule as T4-T6
- T12 follows same rule as T1-T3

Geelhoed's rule:

Geelhoed's rule states that the SP of each thoracic vertebrae are in plane with the TP of the vertebra below.

## METHODS

Retrospective analysis of high-resolution computed tomography (HRCT) of the chest was performed for this study. The HRCT chests were initially indicated to evaluate patients with interstitial lung disease. All HRCT chests were performed using the same protocol. Axial CT images of the chest were obtained with a slice thickness of 3.0 mm from the thoracic inlet to the diaphragm without IV contrast. Imaging was performed in the supine and prone position and during inspiration and expiration. Coronal and sagittal reformats were prepared. Exclusion criteria included spine or back conditions that significantly altered the normal anatomy or physiologic position of the spine of a patient resting in the prone position including hyperkyphosis, scoliosis, history of significant trauma to the spine, significant degenerative changes to the spine or spine surgery.

## METHODS CONT.

Measurements were taken using the digital measurement tool in Enterprise Imaging. 4 measurements were taken per vertebra/functional spinal unit to define the relationships among SP's and TP's (Figure 1 & 2).

Measurement #1: The vertical distance from the level of the TP's to the SP of the same vertebra.
Measurement #2 (left and right): Distance from the left TP to the left TP of the adjacent inferior vertebra. Repeated for the right side.
Measurement #3: The vertical distance from the SP to the level of the TP's of the adjacent inferior vertebra. Designated (+) if SP cephalad and (-) if SP is caudad to the TP.
Measurement #4: Distance from the left TP to the right TP of the same vertebra.

All measurements were taken on the prone imaging during the inspiratory phase in the coronal view. Each measurement was taken at the most posterior aspect of the respective SP's and TP's as the most posterior portion was assumed to be the most prominent during palpation. The most posterior portion was determined by identifying the SP or TP and progressing the CT slides posteriorly in the coronal view until the SP or TP was no longer in view. The previous slide, anterior to where the SP or TP was no longer visible, was then determined to be the most posterior portion. For measurements of the SP's, the visible posterior portion of the SP was bisected in the cephalocaudal direction to determine the center point from which measurements were taken. For measurements of the TP's, the visible posterior portion of the TP was often continuous with the lamina in the coronal plane of the same slice. This made it unfeasible to take measurements from a point bisecting the most posterior portion of the TP in the transverse plane. To keep measurements consistent, the lateral most point of the posterior portion of the TP was used for measurements. All measurements were performed twice by two investigators independently.

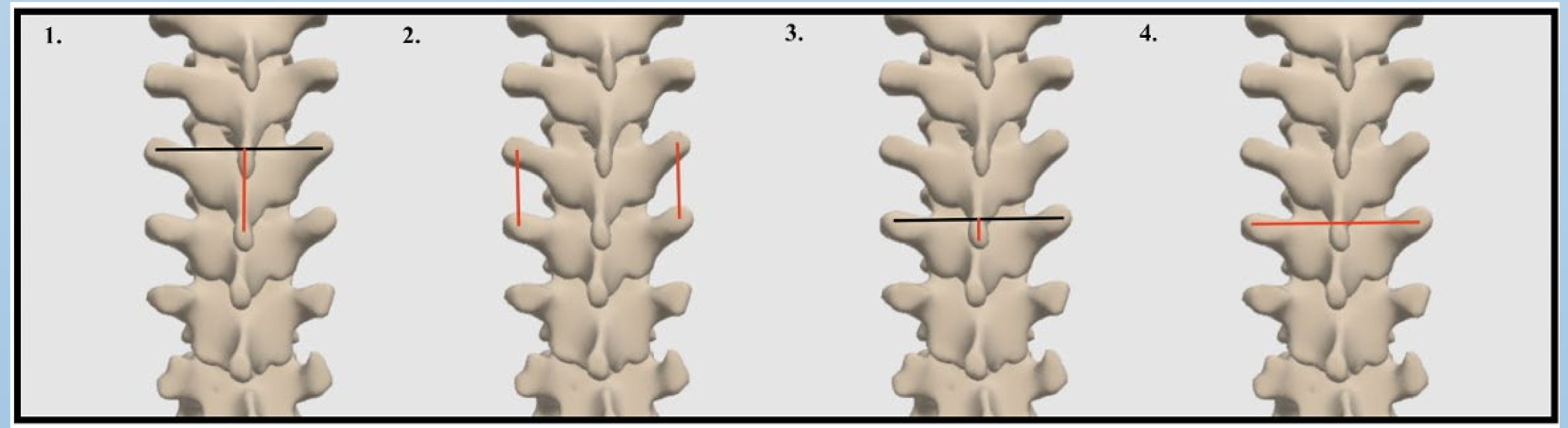


**Figure 1 – Illustrations of measurements #1 through #4 in the coronal view. The black lines represent the level of the TP's. The red lines represent the distance measured.** *(© Pharma Intelligence UK (trading as Primal Pictures), 2023. Primal Pictures, a Citeline business www.primalpictures.com www.anatomy.tv)*

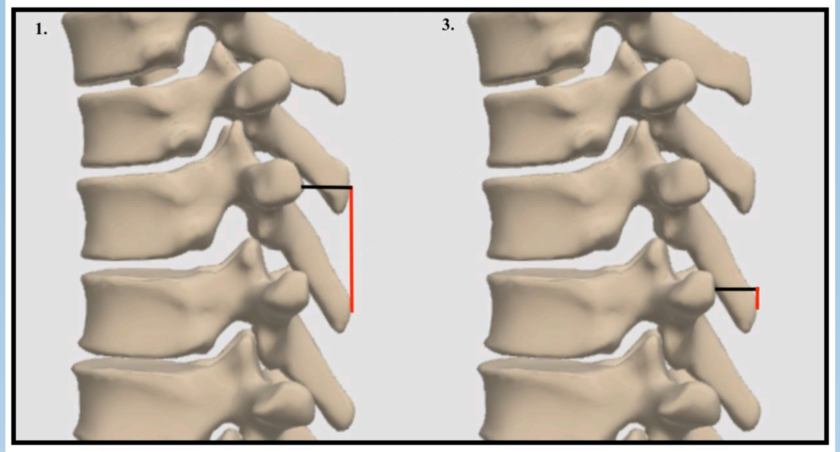


**Figure 2 - Illustrations of measurements #1 and #3 in the sagittal view. The black lines represent the level of the TP's. The red lines represent the distance measured.** *(© Pharma Intelligence UK (trading as Primal Pictures), 2023. Primal Pictures, a Citeline business www.primalpictures.com www.anatomy.tv)*

## STATISTICAL DESIGN

A chi squared test of independence will be used to test the accuracy of the "Rule of Three's" and Geelhoed's Rule. A chi squared goodness of fit test will be used to test the hypotheses that, (1) The majority of the most prominent points of the transverse processes of a thoracic vertebra will be on average 25.4 mm (1 in) from the sagittal plane of the spinous process of the same vertebra and (2) The majority of the most prominent points of the transverse processes of a thoracic vertebra on average will be 25.4 mm (1 in) from the adjacent caudal/cephalad thoracic transverse process. A MANOVA test will be used to compare the measurements based on gender.

A priori power analysis was performed for each statistical hypothesis test to estimate the required sample size needed for adequate power. For each chi squared test, we predict a moderate effect size with alpha set at 0.05, degrees of freedom at 1 and a minimum power of 0.80. The minimum sample size was estimated to be 88. For the MANOVA test, we predict a moderate effect size with alpha set at 0.05, a minimum power of 0.80 and two groups (Male and Female) compared across 4 dependent variables. The minimum sample size was estimated to be 196.

Inter-investigator reliability will be calculated using the two independent sets of measurements.

## DISCUSSION

This study has potential limitations that must be considered. Measurements were taken on prone imaging during the inspiratory phase. The HRCT protocol instructs the patient to take a breath and hold it while the imaging was performed. Patient compliance, the degree of inspiration and the subsequent motion of the spine during inspiration/expiration was not accounted for, however. This degree of variance in spinal motion during respirations would be expected in clinical practice while palpating the thoracic spine of a patient. When determining the most posterior point, researchers did not assess the relation of the most posterior point on the CT to the most prominent point that would be directly palpated. The measurements taken do not account for soft tissue surrounding the thoracic spine which could limit palpation of the most prominent point.

## RESULTS & CONCLUSION

We predict that the high-resolution computed tomography will reveal the intervertebral and intravertebral relationships as well as aid in evaluating the accuracy of the relationships between the SP's and TP's proposed in various models. We conclude that retrospective analysis of radiological studies provides the ability to confirm and/or expand our ability to utilize osteopathic principles and models in diagnosing and treating patients.

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