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Does sagittal spinopelvic configuration influence vertebral fracture type or localisation in trauma patients?: A retrospective radiological analysis

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Abstract: STUDY DESIGN:: Retrospective Data Analysis. OBJECTIVE:: To analyse correlations between spinopelvic configuration and fracture pattern or location in traumatic vertebral fractures. SUMMARY OF BACKGROUND DATA:: The spinopelvic configuration represented by the pelvic incidence (PI) angle showed to have a strong correlation with the occurrence of degenerative diseases of the thoracolumbar spine. No data is available, whether there is an influence of the PI angle on traumatic vertebral lesions as well. METHODS:: In a consecutive series of patients sustaining traumatic vertebral fractures, we retrospectively analysed spinopelvic CT data sets of 197 patients (121 male, 76 female, mean age 51). Measurements included the PI angle, level of fracture(s) and fracture type according to the AO classification. Statistical analysis was performed to calculate correlation between PI and fracture level and between PI and fracture type. RESULTS:: An average of 1.6 fractures per patient was found in the 197 individuals. PI angle showed a mean of 50.6 degrees for the left hip and a mean of 49.9 degrees for the right hip. There were no significant differences of the PI angle between male and female patients as well. Neither a significant effect of the PI angle on the vertebral fracture level (P=0.64) nor a significant relationship between the PI angle and the fracture type according to the AO classification (P=0.52) was found. CONCLUSION:: The spinopelvic configuration represented by PI angle seems to not influence neither the level nor the type of vertebral fractures in trauma patients.

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Does sagittal Spinopelvic Configuration influence Vertebral Fracture Type or Localisation in Trauma Patients? - A retrospective Radiological Analysis

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ABSTRACT

STUDY DESIGN: Retrospective Data Analysis

OBJECTIVE: To analyse correlations between spinopelvic configuration and fracture pattern or location in traumatic vertebral fractures.

SUMMARY OF BACKGROUND DATA: The spinopelvic configuration represented by the pelvic incidence (PI) angle showed to have a strong correlation with the occurrence of degenerative diseases of the thoraco-lumbar spine. No data is available, whether there is an influence of the PI angle on traumatic vertebral lesions as well.

METHODS: In a consecutive series of patients sustaining traumatic vertebral fractures, we retrospectively analysed spinopelvic CT data sets of 197 patients (121 male, 76 female, mean age 51). Measurements included the PI angle, level of fracture(s) and fracture type according to the AO classification. Statistical analysis was performed to calculate correlation between PI and fracture level and between PI and fracture type.

RESULTS: An average of 1.6 fractures per patient was found in the 197 individuals. PI angle showed a mean of 50.6 degrees for the left hip and a mean of 49.9 degrees for the right hip. There were no significant differences of the PI angle between male and female patients as well. Neither a significant effect of the PI angle on the vertebral fracture level (p=0.64) nor a significant relationship between the PI angle and the fracture type according to the AO classification (p=0.52) was found.

CONCLUSION: The spinopelvic configuration represented by PI angle seems to not influence neither the level nor the type of vertebral fractures in trauma patients.

Key words: vertebral fractures; pelvic incidence; spino-pelvic geometry

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INTRODUCTION

Sagittal balance of the spine is a precondition for upright standing and ambulatory competence in human beings. The shape of the sagittal spine with its more or less pronounced thoracic and lumbar curves is further determined by the spinopelvic constitution [1-3]. The spatial relation between the socket of the spine - the sacral endplate – on one hand and the acetabula (represented by the femoral heads) as consistent structures of the pelvis on the other hand, may be quantified with the pelvic incidence (PI) angle [1, 4-6]. This angle is a congenitally spinopelvic parameter which doesn't change with body position or increasing age [4, 5, 7]. It is known that the PI, and thus the sagittal spine configuration, correlates with some degenerative diseases of the spine such as spondylolisthesis, disc herniation or degenerative disc disease [3, 8, 9]. In a trauma setting however, several factors influence the spinal injury patterns and fracture localisations. Whereas, trauma mechanisms and bone quality have well known effects on the fracture type, no information about the influence of the sagittal spine geometry on vertebral fracture type or localisation is available. To clarify this issue we analysed the PI angle of a consecutive series of patients with traumatic thoracic or lumbar vertebral fractures in relation to their corresponding fracture type(s) and localisation(s).

MATERIAL AND METHODS

Patients

From our radiological database we retrospectively analysed a consecutive series of patients with traumatic thoracic and lumbar vertebral fractures. Between September 2006 and November 2010 a total of 617 patients sustaining vertebral fractures were treated either conservatively or operatively in our department. Of these patients, 197 (121 male and 76 female, mean age 51) were included in our study meeting the inclusion criteria of a pelvic and

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thoraco-lumbar CT scan obtained in the emergency department before treatment initiation. Patients with osteoporotic or pathological fractures were excluded.

Fracture classification and localisation

Vertebral fractures were classified according to the AO Classification of Magerl [10] using Type A for compression fractures, Type B for flexion-distraction injuries and Type C for fractures with rotational trauma mechanism. No further subgroup classification was discriminated to avoid weakening of the statistical evidence. For statistical reasons as well, the fractured vertebrae were numbered continuously from one to twenty-four starting with the fifth and most caudal lumbar vertebra continuing upwards to the axis as number 24. In patients with multiple vertebral fractures all levels were assessed for statistical analysis.

Pelvic incidence

Pelvic incidence was first described by Duval-Beaupere et al. in 1992 [4] . This position-independent spinopelvic angle usually is measured on lateral radiographs of the whole spine in an upright position including at least 10 cm of the femoral shaft caudal: A tangent line is drawn to the sacral endplate representing the basis of the lumbar spine. Then an orthogonal line (A), starting at the antero-posterior mid-distance of the sacral endplate is drawn down. A second line (B) starting from the same mid-sacral point then is drawn anteriorly through the center of the femoral head projection. If the femoral heads are not congruent, which is the case in the vast majority of lateral radiographs, a third line (C) connecting the two centres of heads is drawn and line (B) should cross the half-distance point of this femoral head connecting line (C). The angle between the line (A) and line (B) is the PI (Fig. 1).

Measurements on CT Scans

Fracture type classification and level assessments, as well as, PI measurement were based on our routine whole body CT scan imaging data sets for trauma patients. As PI measurement using CT scan was not described previously, we adapted the measurement technique educed from the original description[4] with a few mandatory specifications such as determination of

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the exact sagittal plane of the sacral endplate for the tangent line and mid-sacral point (see above) and identification of the femoral head centre using the plane with the maximum head diameter. Furthermore, we measured the PI angle for both the left hip and the right hip in all patients. Superposition of the sacral sagittal plane and the parasagittal femoral plane (either right or left side) images allowed simple computer assisted measurement of the pelvic incidence using a PACS system (Fig. 2). No other typical spinopelvic parameters, such as sacral slope or pelvic tilt were measured because of their dependency on body position.

Statistical Analysis

Continuous data are presented as mean with standard deviation. Pearson correlations between continuous variables are reported. IBM SPSS Statistics (SPSS Inc., Chicago, IL) was used for descriptive statistics and figures. To address clustering of fractures within patients, linear regressions with robust standard errors and patient ID as cluster was performed. Stata 11.2 (StataCorp, College Station, TX) was used for these analyses. Two-sided p-values less than 0.05 are considered statistically significant.

RESULTS

Of the 197 patients included in the study, an average of 1.6 fractures per patient was calculated, whereof the three most frequently affected levels were the transitional vertebra L1, B 12 and L2 (17.8%, 11.6%, 9.7%). Fracture type A was found in 254 (79%), type B in 28 (8%) and type C in 14 (4%) of all fractures. In twenty-four fractures no unequivocal classification was possible. PI angle showed a mean of 50.6 degrees for the left hip and a mean of 49.9 degrees for the right hip with a range of 25.8 to 82.7 degrees for all male and female. There were no significant differences of the PI angle between male and female (50.25° versus. 50.20°) patients as well. Neither a significant effect of the PI angle on the vertebral fracture level ($r=-0.35, p=0.59$) nor a significant relationship between the PI angle and the fracture type according to the AO classification (p=0.37) was found. Figures 3 and 4

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show the homogenous distribution of PI values among the 24 vertebrae. Figure 5 shows PI in relation to fracture type A, B and C.

DISCUSSION:

Of all vertebral fractures, the cervical spine is affected in about one third of all fractures and the thoraco-lumbal spine in about two thirds. Considering the thoraco-lumbar injuries, fractures around the thoraco-abdominal transition from T11-L2 are quite frequent (50-60%), while the thoracic spine (25-40%) and lower lumbar spine (10-14%) are less involved[11]. This typical pattern of fracture level distribution is principally assigned to the junction of the relatively inelastic chest with its thoracic kyphosis, ribs and sternum on one hand, and the "free" mobile lumbar segments on the other hand. Another explanation is the different orientation of the facet joints. While the joints in the thoracic spine show a more coronal and therefore rigid orientation, the facet joints of the lumbar vertebrae have a more sagittal alignment allowing superior flexion and extension excursion. Apart from stress-raising moments by indirect forces, sometimes direct impact to a certain vertebral level may cause osseous lesions as well. Whether other factors such as native spinal geometry or spinopelvic configuration play a role in the occurrence of fractures on a certain level is not established in the literature. Beyond the level of injury, there is common consensus about the relation of trauma mechanism and a distinct fracture type, reflected in several classification systems. The mostly used systems in Europe is the AO classification for thoraco-lumbar vertebral fractures by Magerl et al.[10] based on the "two-column-theory" described by Holdsworth[12] and Kelly and Whitesides[13] previously. The classification identifies the close relationship of characteristical incoming forces, such as axial compression, flexion/extension or rotation and typical fracture patterns. In contrast, intrinsic factors influencing occurrence and type of vertebral lesions are mainly the quality and quantity of the vertebral bone structure, typically affected in patients suffering from osteoporosis or congenitally diseases with altered collagen

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production. There is however, lack of knowledge about the potential influence of other intrinsic factors, such as the sagittal balance of the spine, in the pathogenesis of distinct vertebral fracture types as well.

With the present study we analysed a possible relationship between spinal injuries and the spinopelvic configuration represented by the PI angle based on the fact that the sagittal balance of the spine has a direct influence to non-traumatic, degenerative lesions of the thoraco-lumbar spine. Recently published articles showed that different sagittal spinopelvic configurations may lead to different degenerative diseases, especially of the lumbar spine[3, 8, 9]. Other investigations showed a significant influence of surgical restoration of the spinopelvic alignment on the outcome of spinal surgery[14-16].

Despite the strong influence of the spinal balance on degenerative conditions, our results did not support the hypothesis of a measurable influence of the spinopelvic alignment on neither the level of vertebral fracture nor its type. The weak correlation of the PI angle and the fracture level or type did not show any significant impact of this parameter. Therefore, we conclude that other known and probably unknown factors predominate the pathogenesis of traumatic spine injuries. Our data provide no answer whether there is potential influence of the spinopelvic configuration on the pathogenesis of osteoporotic fractures. Further investigations may disclose currently unknown effects of the sagittal balance on pathological conditions of the spine.

CONCLUSION

The spinopelvic configuration represented by the PI angle seems not to influence neither the level nor the type of vertebral fractures in trauma patients. Further investigations may illuminate whether there is a relation between the sagittal balance of the spine and osteoporotic fractures.

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LEGENDS TO FIGURES:

Figure 1

Measurement of pelvic incidence on lateral radiographs: The angle is formed by a perpendicular line to the sacral base plate (A) and a line connecting the mid-sacral point and the centre of the femoral heads (B).

Figure 2

Pelvic incidence on sagittal reconstructions of spinopelvic CT scans: According to measurements on conventional radiographs, vertebral mid-body planes and maxium femoral head diameter planes are used for angle measurements.

Figure 3

Distribution of pelvic incidence values among fracture level. Vertebrae Nr. 1 corresponds with 5th level L5.

Figure 4

Plot and linear regression show no correlation between pelvic incidence and fracture level.

Figure 5

Distribution of pelvic incidence values in relation to fracture types A, B and C.

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Figure 1

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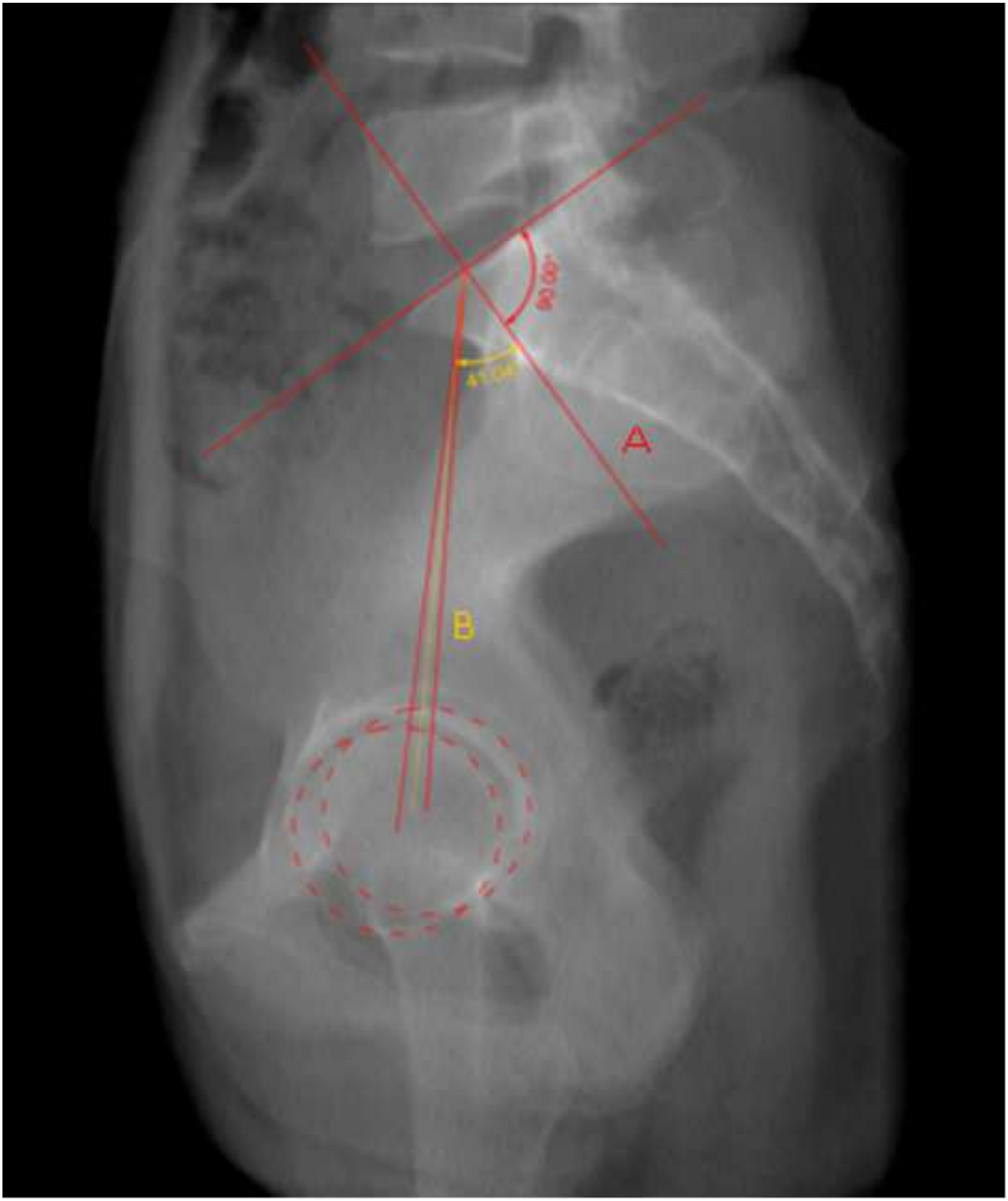

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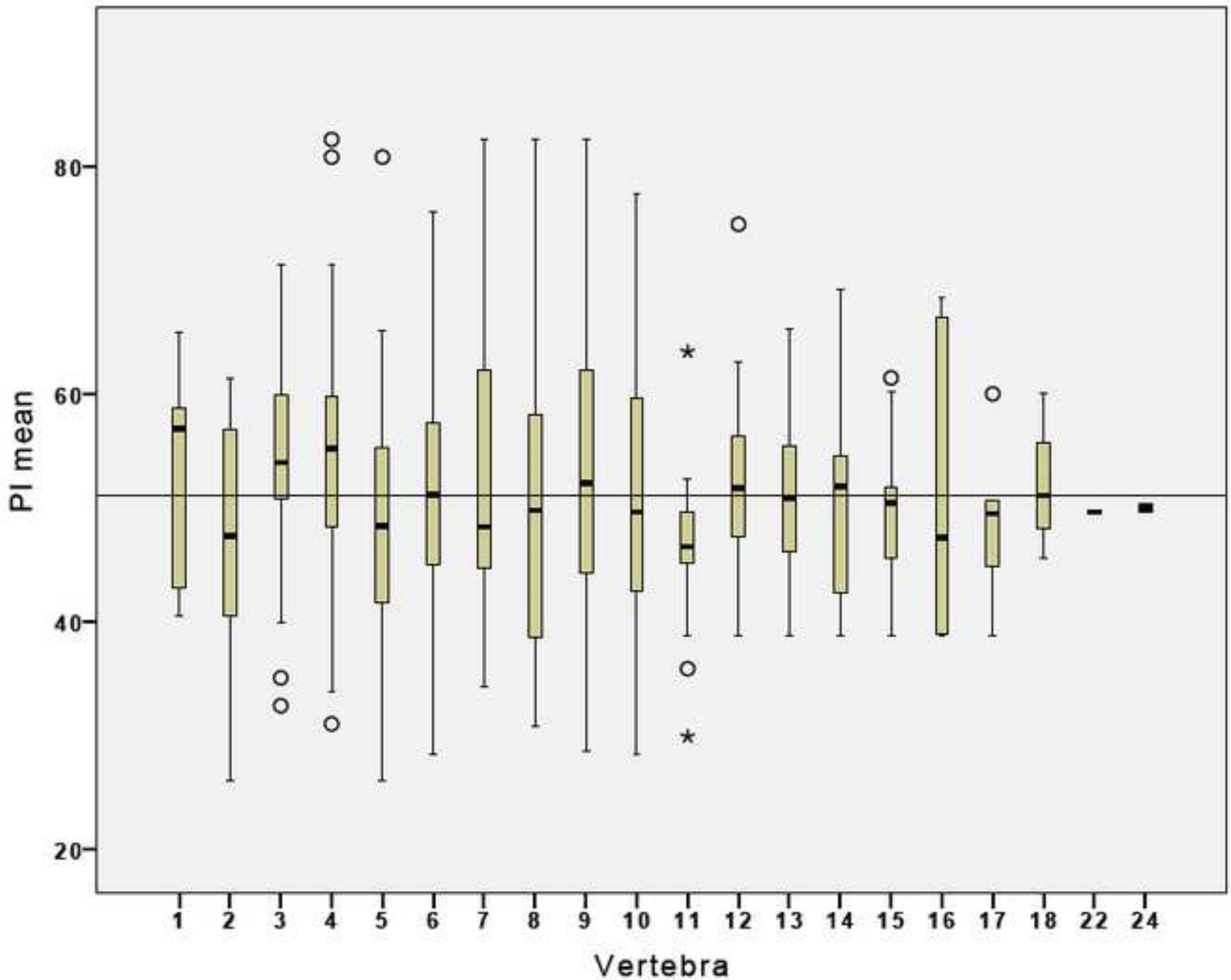

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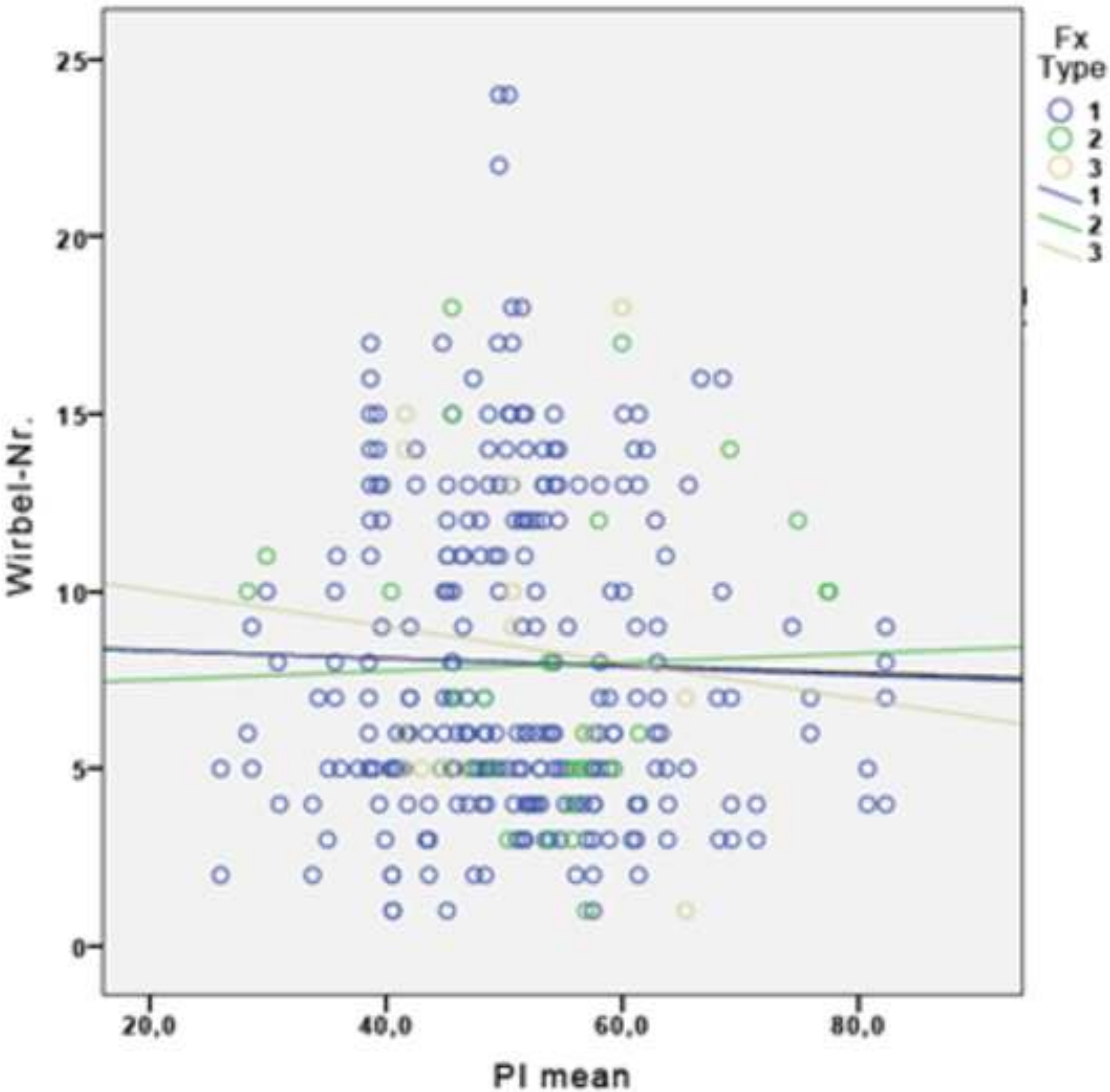

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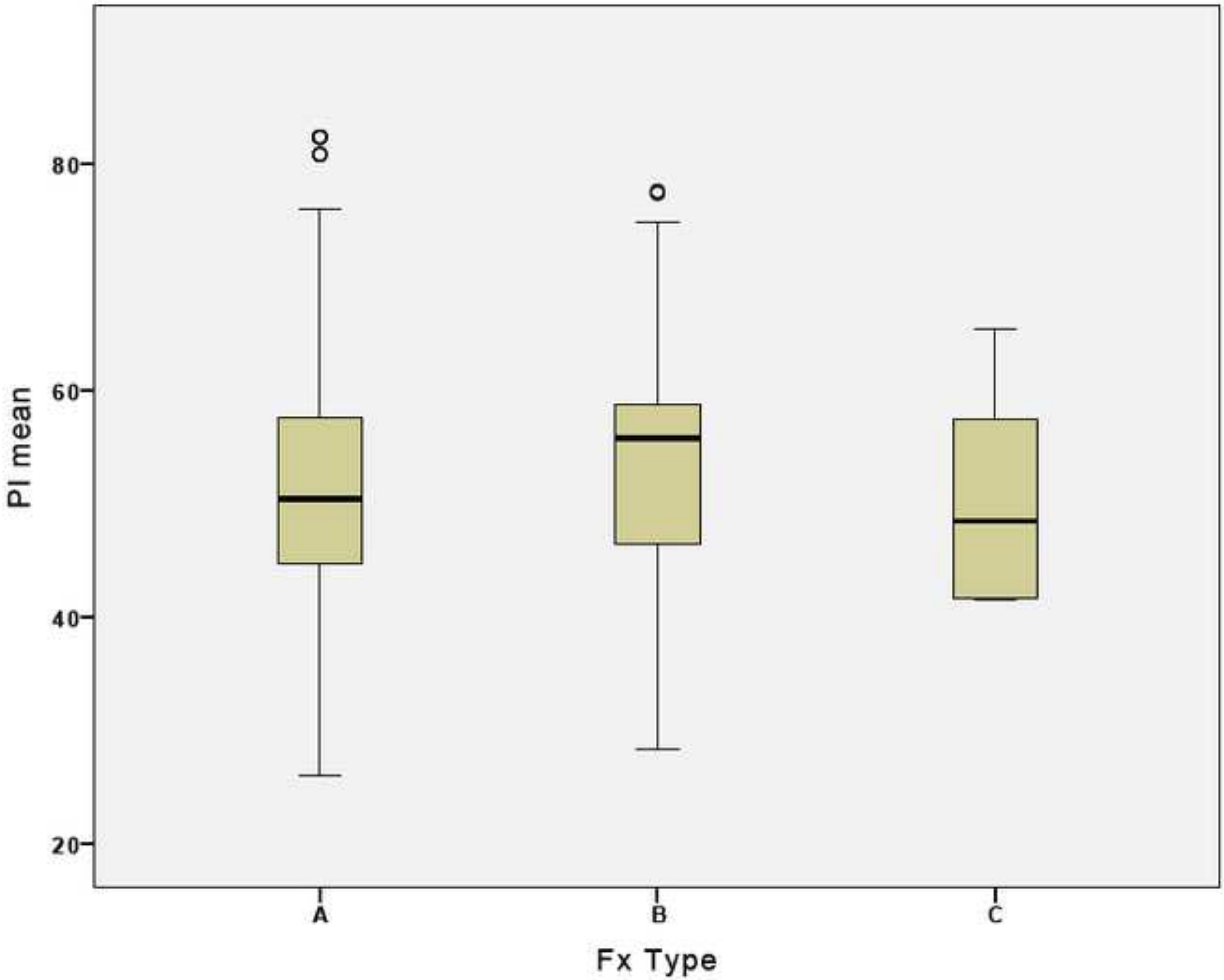

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