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Relationship between the spino-pelvic parameters and the slip grade in isthmic spondylolisthesis

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ABSTRACT

Purpose of the study: Analysis of changes in the spino-pelvic alignment, depending on the slip grade in patients with low and high-grade isthmic slip.

Materials and methods: A group of 60 patients who had lumbar spine radiograms adequate to measure the spino-pelvic parameters selected from a series of 195 cases of isthmic spondylolisthesis. We analyzed the following spino-pelvic parameters: pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT), lumbosacral angle by Dubousset (LSA) and lumbar lordosis (LL). The ANOVA statistical test was used to examine whether there is a significant correlation between (1) the slip grade and the value of PI, PT, and LL, and the Pearson correlation was used to examine a correlation between (2) the size of PI and the value of other spino-pelvic parameters, (3) the value of LL and SS, (4) value of the LSA and LL, PI and PT.

Results: The greater the slip grade, the greater the value of PI, PT, and LL and lower LSA. Positive correlations have been found between PI and SS, PT and LL. There was also a positive correlation between LL and SS. Negative correlations were noted between LSA and LL, PI and PT.

Conclusion: The spino-pelvic alignment changes with the grade of isthmic spondylolisthesis, and the individual spino-pelvic parameters correlate together to form a causal chain in the development of isthmic spondylolisthesis.

1. Introduction

Over the past two decades, it has been proven that various spinal pathologies may affect normal anatomical relationships between the lumbar spine, sacrum, and pelvis. These normal spino-pelvic alignment is known as the spino-pelvic balance. It is well known that its disturbances may finally result in loss of a normal body posture and global sagittal balance. Isthmic spondylolisthesis is among these spinal pathologies and it may affect normal spatial relationships between the spine and pelvis to a greater extent than the others. This is because isthmic spondylolisthesis is not only about a local slip and neurological consequences of the latter, but also about misalignment of the spine and pelvis which may develop in response to the slip. Loss of the spino-pelvic

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balance may in turn affect a normal body posture and whole body sagittal balance in the upright standing position. Therefore, an isthmic slip being a very local pathology may produce more global disturbances in the spino-pelvic area with the latter affecting the whole body posture and sagittal balance.

A topic of the spino-pelvic balance has rapidly aroused much interest among practising spine surgeons within the last two decades. This spread of interest is called 'the French revolution in spinal surgery' because French-speaking authors were the ones who popularized the issue of the spino-pelvic balance in late 90s. In 1998, Duval-Beaupere defined and introduced an essential anatomical parameter called ''Pelvic Incidence'' that is the PI [1]. It specifically describes pelvic anatomy in an adult mature individual. The PI does not change throughout an adult life and is independent of a position of the pelvis. The PI is a basic anatomical characteristic of each individual [2,3]. It describes an angle which can be found on a lateral view standing radiogram of the lumbar spine by drawing a perpendicular line from the middle of the sacral endplate and a line from that point to the centre of the line connecting two femoral heads. The PI ratio depends entirely on the inclination of the L5/S1 in the sagittal plane. The PI can only be changed in the growth period in adolescence and the acquisition of an upright posture. Then, the PI remains constant and can be changed only during resection of the cranial endplate of the sacrum during a surgery [4–7]. Soon after the introduction of the PI two other positional parameters of the spine and pelvis known as the Sacral Slope (SS) and Pelvic Tilt (PT), were introduced into radiological measurements. A correlation between the above mentioned parameters was recognized and defined according to the equation: PI = SS + PT. The PI is always a sum of the SS and PT. Contrary to the PI the SS and PT vary with a position of a subject and their pelvis. However, their sum, SS + PT, does not change with a position of a subject or the pelvis. For example, when the SS decreases by a given value, the PT increases by the same value while the value of the PI stays unchanged according to the equation: PI = SS + PT [2].

The PI affects the magnitude of lumbar lordosis and indirectly the remained sagittal spinal curves. A low value of the PI correlates with flat lordosis while a high value of the PI correlates with hyperlordosis. The basic spino-pelvic parameters also include the lumbosacral angle (LSA) and lumbar lordosis (LL). The LSA defines a grade of lumbosacral kyphosis in spondylolisthesis. According to some authors [8,9] the LSA is a factor determining the size of most lumbar hyperlordosis in spondylolisthesis. If the kyphosis angle decreases, the lordosis increases to maintain a balance in the sagittal plane [10]. In isthmic spondylolisthesis increased lordosis of the lumbar spine allows to maintain the sagittal balance. In other words, lordotisation of the spine is a compensatory mechanism which develops in response to an anterior slip. Lordotisation is the first of three compensatory mechanisms which may be engaged in patients with isthmic spondylolisthesis. When with increasing slip the lordosis reaches its maximum than pelvis retroversion, the second compensatory mechanism goes into action. Pelvis retroversion is a result of hip extension that is by backward rotation around the axis of the femoral heads. The range of retroversion is only 10–15° [11]. High PI provides a greater reserve for hip extension (pelvis retroversion). Pelvis retroversion results in an increase in the PT and a decrease in the SS according to the equation: PI = SS + PT. In a healthy subject retroversion of the pelvis produces an increase in LL, while anteroversion of the pelvis results in a decrease of the LL. If it was not for this a subject would not be able to maintain the sagittal balance. This is not a case in isthmic spondylolisthesis where the LL is not reduced in response to pelvis retroversion, as it is in healthy subjects. This is because in isthmic spondylolisthesis a correct interaction between the spine and the pelvis is disturbed due to loosening of solid ''attachment'' of the spine and the pelvis produced by a defect in the L5 isthmus.

When hip extension achieves its final range of motion, the third compensatory mechanism switches on. It is knee bending (Fig. 1). When all three compensatory mechanisms have been exhausted, a patient loses balance of the whole body in the sagittal plane.

Fig. 1 – A female patient with grade IV spondylolisthesis. Note adaptations of her body posture to abnormal anatomical relations between the spine and pelvis which developed due to grade IV isthmic spondylolisthesis: pelvis retroversion and knee bending which are compensatory mechanism allowing the patient to maintain body balance in a vertical standing position.

2. Materials and methods

2.1. *Patient population*

A group of 60 patients whose lumbar spine radiograms were adequate for an analysis was selected from a series of 195