Morphometric analysis of the thoracolumbar and lumbar pedicles, anatomo-radiologic study

D Marchesi1,3, E Schneider1, P Glauser2 and M Aebi3
1 ME Müller, Institute for Biomechanics 2 Department of Pathology 3 Department of Orthopedic Surgery, University of Bern, Murtenstr 35, 3800 Bern, Switzerland

Summary. The geometric properties of 380 vertebral pedicles, ranging from T6 to L5, were analysed. Measurement were made directly from the specimens as well as from roentgenograms. The parameters considered were the horizontal and vertical pedicle diameters, pedicle angles in the transverse and sagittal planes, and the transverse and anteroposterior widths of the spinal canal and vertebral body. In addition, the length of the pedicle and the length of the pedicle including the vertebral body to the anterior cortex were measured along the pedicle axis and in a line parallel to the midline of the vertebral body. The smallest horizontal and vertical pedicle diameters were found at vertebral levels from T6 to T10. The correlation between pedicle widths and screw dimensions is obvious. In the transverse plane, the pedicle angle diverged from the vertebral body at all levels, except at T12. In the sagittal plane, the pedicles were angled cephalad from T6 to L3 and slightly caudally at L5. Knowledge of the length of the pedicle to the anterior vertebral body cortex is very important for safe screw purchase. At all levels, with the exception of T12, this length was found to be significantly greater along the pedicle axis than along a line parallel to the midline of the vertebral body.

Analyse morphométrique des pédicules thoracolombaires et lombaires

Résumé. Les caractéristiques géométriques de 380 pédicules vertébraux, compris entre T6 et L5, ont été analysées. Les différentes mesures ont été pratiquées directement sur les pièces anatomiques et sur leurs images radiographiques. Le diamètre horizontal et vertical du pédicule vertébral, son angle avec le plan transversal et sagittal, le diamètre transversal et ventrodorsal du canal rachidien et du corps vertébral ont été pris en considération. La longueur du pédicule seule, ainsi que sa longueur associée à celle du corps vertébral jusqu’au cortex ventral ont été mesurées le long de l’axe pédiculaire et sur une ligne parallèle à la ligne médiane. Les diamètres pédiculaires horizontaux et verticaux les plus étroits ont été mis en évidence aux niveaux compris entre T6 et T10. La corrélation entre la largeur pédiculaire et la dimension des vis utilisées en clinique est évidente. Sur le plan transversal, le pédicule forme un angle plus ou moins divergent à partir du corps vertébral, à l’exception de T12. Sur le plan sagittal le pédicule a une direction crâniale de T6 à L3 et légèrement caudale pour L5. La connaissance de la distance comprise entre la limite dorsale du pédicule et le cortex ventral du corps vertébral est très importante pour pouvoir insérer une vis avec sûreté. Cette distance est significativement plus grande le long de l’axe pédiculaire par rapport à une ligne parallèle à l’axe médian à tous les niveaux sauf pour T12.

Key words: Pedicle — Thoracolumbar — Spine — Morphology

The development of instrumentation techniques to stabilize and correct the injured or diseased thoracolumbar and lumbar spine has made enormous progress.
during recent years. This success is mainly due to the appreciation that the pedicle is the strongest vertebral structure for stable anchorage. The systems currently used, including plates, rods or external fixators, depend upon the ability of a screw or pin to obtain and maintain secure purchase in the vertebral body, extended from behind through the pedicle, until solid fusions occurs. The major advantages of these systems, in comparison to such techniques as the classical Harrington rods of segmental sublaminar wiring, are the fixation of fewer elements and greater stability (Louis 1986; Magerl 1984, 1985; Roy-Camille 1984, 1986).

Since the anatomic study of Saillant (1976) on dimensions and morphology of the vertebral pedicle, little has been published about this very important structure. Recently, however, Krag et al (1986) and Zindrick et al (1987) made an accurate analysis of the morphometric characteristics of the thoracic and lumbar pedicles using conventional roentgenograms and computerized tomographic (CT) scan data.

Our study was undertaken to gain a better knowledge of pedicle morphology and its relation to the geometry of the vertebral body and the spinal canal. It was our particular purpose to verify if recent results obtained from radiological examinations were confirmed by our measurements made simultaneously on specimens and their roentgenograms.

Materials and methods

A total of 190 vertebrae from 33 fresh, human thoracolumbar spine specimens obtained at autopsy were used in this analysis. Between 4 and 7 vertebrae per cadaver (ranging from T6 to L5) were available for study. Eighteen specimens were from males, with a mean age of 67.3 years (range: 29 to 84 years), an average height of 172 cm (range: 166 to 183 cm) and an average weight of 73 kg (range: 61 to 86 kg). Fifteen were from females, with a mean age of 72.5 years (range: 53 to 87 years), an average height of 165 cm (range: 152 to 176 cm) and an average weight of 65 kg (range: 49 to 76 kg).

The specimens were first disarticulated at individual levels and cleaned of all soft tissue. Individual vertebrae were radiographed in the transverse plane, with the X-ray source at a constant distance of 120 cm from the film plane. The specimens were so positioned that the longitudinal pedicle axis was 15 mm from the film. These conditions resulted in a magnification factor of 1.3%. The specimens were then sectioned sagittally in the midline and lateral roentgenograms made of the hemisected vertebra.

The horizontal (a) and vertical (b) pedicle diameters were measured at the narrowest point of the pedicle isthmus on both the specimens and their roentgenograms. Measurements of the transverse (c) and antero-posterior (d) spinal canal diameters were obtained in the same way. The transverse pedicle angle (T) was obtained by measuring the angle between a line parallel to the vertebral midline and a line perpendicular to the horizontal pedicle diameter in the transverse plane. The sagittal pedicle angle (S) was measured between a line perpendicular to the vertical pedicle diameter and the posterior vertebral body border in the sagittal plane. The length of the pedicle (e), defined as the distance from the most posterior aspect of the transverse process to the attachment of the pedicle to the vertebral body, and the total length of the pedicle with the vertebral body depth to the anterior cortex (f) were obtained in 2 ways. One