Strain on the Interarticular Stress Distribution
Measurements Regarding the Development of Spondylolysis

K.-P. Schulitz¹ and F. U. Niethard²

¹Orthopädische Klinik und Poliklinik der Universität Düsseldorf (Direktor: Prof. Dr. K.-P. Schulitz), Moorstr. 5, D-4000 Düsseldorf 1, Federal Republic of Germany
²Orthopädische Klinik und Poliklinik der Universität Heidelberg (Direktor: Prof. Dr. H. Cotta)

Summary. In discussion the aetiology of spondylolysis, attention has been increasingly directed to the biomechanics of the lumbar vertebral column and the lumbo-sacral transition. The theory of a traumatic induction of spondylolysis was tested with stress distribution measurements on the vertebral column of cadavers. Using stretch measuring strips it was possible to investigate, the strain exerted upon the interarticular portion of the intact lumbar vertebral column preparation. A particular strain upon the pars interarticularis occurs through hyperextension, axial stress and torsion of the lumbar vertebral column. It is worth to be mentioned that force transmission within the vertebral arch structures is influenced by the positioning of the vertebral arch joints. Sagittally positioned vertebral arch joints lead to a greater strain exerted upon the interarticular portion. Our results have to be compared with those of others, who are of the opinion that spondylolysis is a condition resulting from a fatigue fracture.


For over 100 years spondylolysis has been the cause of many partly vehement discussions. The most interesting questions are about the causes and developmental mechanisms of this fissure in the vertebral arch, which occurs only in humans. Misunderstandings to be found in the literature on this subject are partly due to the failure of studies to clearly segregate spondylolysis from spondylolisthesis (Newman 1963). Newman was able to differentiate five different types of spondylolisthesis using causes as a criterion. Pathogenesis alone will be discussed in this paper as one of the causes of spondylolisthesis.

Along with the theory of an inborn cleavage in the vertebral arch (Neugebauer 1895; Turner and Tchirkin 1925), the mechanical aspects of the development of spondylolysis were given attention by Whitman as early as 1924, who supposed abnormal links in the lumbosacral area to be responsible for the evidence of excessive strain in the structure of the vertebral arch and the ensuing additional processes. Even today he emphasises in this context the very controversial term prespondylolisthesis. Meyer-Burgdorff (1931) saw spondylolysis as an acquired defect and mentioned...
associations with lordotically curved back and vertebral fractures in the thoracic-lumbar region. Müller (1931) explained spondylolysis as a Looser's transformation zone caused by mechanical strain. Recent clinical observations and experiments have been able to support the theory of the existence of a slow progressing fracture in spondylolysis. A number of spondylolyses were found above the stiffened region of the spinal column at unusual points in the lumbar region, after the occurrence of spondylolyses in the lumbo-sacral region (Rombold 1965). Repeated reports illustrate the high rate of spondylolysis in top athletes, who show extensive strain on the lumbo-sacral region as a common symptom (Rompe and Dreyer 1972; Rompe and Krahl 1975; Groher 1975; Jackson et al 1976).

In experiments Weis (1975) could produce a fracture in the interarticular portion through the exertion of shearing strain on the structures of the vertebral arch. Corresponding investigations have also been carried out by Lamy et al. (1975) and Cyron et al. (1976). However, the recent investigations did not take into account that, according to the statistics, the spondylolysis is an illness which attacks mostly young people and children. Spondylolysis is observed most frequently in the 10th year of life (Pfeil 1971a). Pfeil investigated extensively the development of spondylolysis in children, came to the conclusion that continual axial stress upon the vertebral body is capable of producing fatigue fractures of the interarticular portion (1971b). Krenz and Troup (1973) believe that the alternating pressure strain exerted upon the vertebral arch structures can lead to a slowly progressing fracture. There is disagreement as to whether strain or movement of the lumbo-sacral region is particularly detrimental (Wiltse et al., 1975; Mutton et al., 1977). In opposition to this, Troup (1976) points out that excessive mechanical strain through hyperflexion mainly causes the development of spondylolysis. In conclusion, Farfan et al. (1976) believe the flexion shearing forces occurring in the lumbo-sacral region and rotational movements to be equally harmful.

Differing results obtained experimentally can be partly explained by the fact that these studies were constantly carried out on individual and macerated vertebral bodies. The mechanical strain of the vertebral arch structures were rather provided by the experimental conditions than by actual conditions. Therefore, we planned the investigations in a way that would enable us to register the mechanical strain exerted upon the interarticular portion in an intact preparation of the lumbo-sacral region.

Materials and Methods

The stress distribution measurements on the interarticular portion were carried out on a total of six bone-ligament preparations. Four preparations consisted of lumbar vertebral column and sacrum without the respective part of the ilium. On these preparations strain exerted upon the interarticular portion was measured in flexion, extension, lateral bending and rotation. Two other vertebral column preparations were suspended in individually prepared metal frames and subjected to axial stress (Fig. 1). In such an experimental construction the entire vertebral column could be subjected to approximately 100 kp by a pneumatic system.

Measurements were performed using stretch gange strips (type 0.6/120LY 11, Hottinges-Baldwin Meßtechnik, Mannheim, FRG), which were attached with a special glue to the interarticular portions of L 4 and L 5, freed of soft tissue. The malformation occurring on the surface of the structures can be measured using these stretch gauge strips. However, this malformation is related proportionally to the total stress, in this case bending stress, exerted upon the interarticular portion. The change in length I was registered in relation to the initial length.