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LUMBOSACRAL SYNOVIAL JOINTS IN FLEXION-EXTENSION

By

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INTRODUCTION

Subluxation of lumbar synovial joints in narrowed discs has been reported by several investigators (*Williams* 1932, *Johnson* 1934, *Lange* 1936, *Oppenheimer* 1937, *Hadley* 1935, 1936, 1951 and 1961, *Baumann* 1957 and others). It has mostly been claimed to occur in lumbo-sacral segments. *Harris & Macnab* (1954) defined subluxations as follows:

"A line was drawn on a lateral X-ray through the inferior border of the vertebral body. If the top of the facet from the underlying vertebra was found a few millimeters above that level a subluxation was recognized" (Figure 1).

Other authors (*Hadley* 1935 and 1961, *Keller* 1953, *Baumann* 1957) have identified subluxation as a contact between the upper edge of a S. 1 facet and the L. 5 pedicle in the intervertebral foramen (Figure 2). When these areas are forced against each other a dense contour is seen in lateral X-rays. This is called impingement. In autopsy specimens with osteoarthritis in synovial joints and marked disc degeneration impingement has also been verified as a wider shaped upper facet area causing a dense radiographic appearance (*Hadley* 1935 and 1961, *Baumann* 1957).

The normal anatomy of lumbosacral joints has recently been studied in autopsy material (*Lewin* 1967). The most distal parts of L. 5 pedicles are found in the intervertebral foramen lateral to the top of an S. 1 facet. This means that the S. 1 facet can move medially to the L. 5 pedicle. Therefore, in a lateral X-ray the upper section of a S. 1 facet will be projected upon the pedicle. High S. 1 facets can occur as a normal variable.

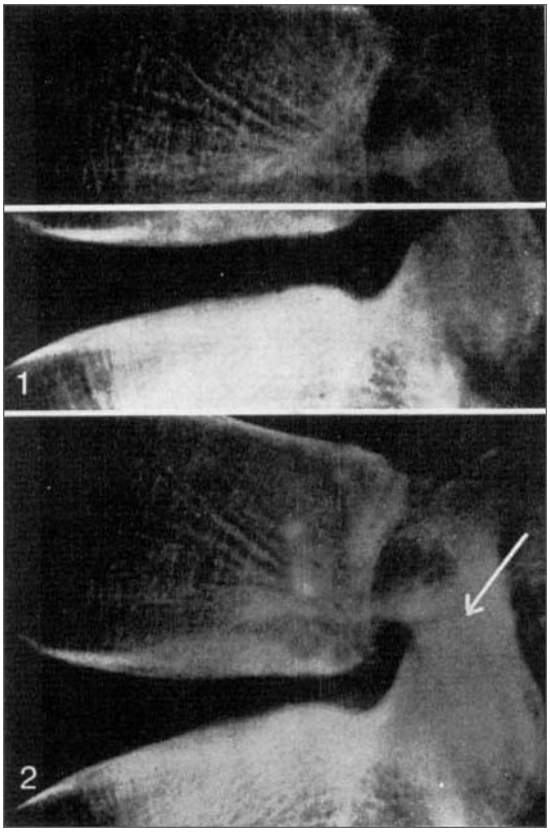

Figure 1. Lumbosacral interspace. The height of the disc is normal. Macroscopically the disc is graded as degenerate. The synovial joints had no evidence of osteoarthritis. The picture is taken in flexion. The distal border of the L. 5 vertebra is indicated. The top of the S. 1 facet reaches the borderline of L. 5.

Figure 2. The same specimen as in Figure 1, now in extension. The S. 1 facet has a high position. Its upper border points towards the medial deepening of the pedicle at the junction of the laminar isthmus.

Abnormal motion in the lumbar spine is often seen in synovial joints in extreme positions. It has been stated that it may indicate degenerative changes either in discs or joints. Impingement has been described as a possible cause of low back pain (*Keller* 1953 and 1962). Various manipulative procedures for correction of the positions of the facets have been discussed. It was therefore felt worth while to study the lumbosacral junction in flexion and extension in specimens with and without disc degeneration or osteoarthritis in synovial joints. With this in mind attempts were made to answer the following questions:

1. To what extent are the positions of S. 1 facets in flexion and extension affected by degenerative changes in discs or joints at the lumbosacral junction?

2. Is the range of motion in lumbosacral synovial joints altered by degenerative changes?

3. Do radiographic studies of synovial joints indicative of disturbances in the pattern of motion in lumbosacral junctions justify conclusions about the pathomorphology?

MATERIAL AND METHODS

This study is based on 42 lumbar spines from routine autopsies. The subjects ages ranged from 20 to 80 years. The age and sex distribution is seen in Table 1.

Table 1. Age and sex.

Age	20–45 years	45–80 years	
	16	9	25
	10	7	17
	26	16	42

The specimens were removed from the body of Th. XII to the sacrum and freed from musculature. The sacrum was fixed in a vice. Lateral roentgenograms were taken of the spines in flexion, extension and in normal resting position. The specimens were moved in a strict sagittal direction allowing the spines to assume an extreme position in either direction.

Disc degeneration was recorded and graded by gross anatomical evaluation after the discs had been cut horizontally (*Friberg, Hirsch* and *Schajowicz*). Discs with structural changes strictly confined to the nucleus pulposus, and not attended by loss of disc height were accepted as normal. Degeneration was classified as annulus ruptures with or without loss of original fibre elements.

In one subgroup the size of the interspace was unaffected; in the other it was narrowed. The synovial joints were studied microscopically. Osteoarthritis was said to exist if the cartilage of the facets had decreased in thickness and additional bony changes such as osteophytes or subchondral alterations were seen.

In flexion the upper border of the S. 1 facet was demonstrable in the lateral X-ray film. A line was drawn on L. 5 between the anterior and posterior distal edges of the vertebral body (Figure 1). In extension the projection of the upper point of the S. 1 facet relative to the distal border of the L. 5 pedicle was noted (Figure 2).

RESULTS

Flexion

In flexion (Table 2) the highest point of the S. 1 facet was found above the distal border of L. 5 in 17 cases, below in 13 and at the same level in 12. In two thirds of the spines where the level of the S. 1 facet

was high (10/17) no disc degeneration or osteoarthritis was present. More than one third of the specimens with low S. 1 facets had narrowed interspaces (5/13, Table 3). Osteoarthritis was found only in those synovial joints where the top of the S. 1 facets was higher than, or the level of, the line through the distal border of L. 5. However, of all cases recorded as high or at the same level, less than one fourth had osteoarthritis (8/29, Table 2).

Table 2. Position of S. 1 facets in flexion.

Facet position	Disc and joint pathology				Total
	OO	DO	OA	DA	
Low	8	5	0	0	13
Level	5	4	1	2	12
High	10	2	1	4	17
Total	23	11	2	6	42

OO = normal disc, no osteoarthritis.
DO = disc degeneration, no osteoarthritis.
OA = normal disc, osteoarthritis.
DA = disc degenartion and osteoarthritis.

Table 3. Position of S. 1 facets in flexion of unaffected and of narrowed lumbosacral disc interspaces.

Facet position	Disc interspace			
	Unaffected		Narrowed	
	O	D	D	Total
Low	8	0	5	13
Level	6	4	2	12
High	11	3	3	17
Total	25	7	10	42

O = normal disc. D = disc degeneration.

Extension

In 22 of the 42 specimens when tested in extension the upper point of the S. 1 facet was seen above the distal contour of the L. 5 pedicle (Table 4). The discs and joints were normal in all of the 22. The same incidence of high S. 1 facets was found when the disc space was nar-

rowed with or without synovial joint osteoarthritis (5/10, Table 5). In spines with normal lumbosacral discs and joints, high facets were noticed in about half of them (11/23, Table 4).

Table 4. Position of S. 1 facets in extension.

Facet position	Disc and joint pathology				
	OO	DO	OA	DA	Total
Low	12	5	0	3	20
High	11	6	2	3	22
Total	23	11	2	6	42

Table 5. Position of S. 1 facets in extension of unaffected and of narrowed lumbosacral disc interspaces.

Facet position	Disc interspace			
	Unaffected		Narrowed	
	O	D	D	Total
Low	12	3	5	20
High	13	4	5	22
Total	25	7	10	42

Range of Motion

It is evident that the *position* of the S. 1 facet varies both in normal and degenerate spines and does not indicate the morphology present. It was therefore felt that the *range* of movement of the synovial joint should be measured during maximum flexion and extension.

The figures presented in Table 6 were obtained by using the upper surface of the sacrum as a reference plane in the determination of the position of the L. 5 facet. For all measurements the mean values ± twice the standard deviation was between 4 and 8 mm.

When the estimated figures in a given case fell outside this range, the movement in a particular joint was considered increased or decreased.

Increased facet motion was noticed in 3 cases with no disc degeneration or osteoarthritis and in one case with only osteoarthritis.

Limitation of motion occurred only in the osteoarthritic group (4/8). According to the hypothesis of equal distribution between groups de-

creased motion in osteoarthritis was affected in only one of the cases.

Disc degeneration does not seem to affect the range of synovial joint motion. Osteoarthritis in intervertebral joints may decrease joint function.

Table 6. Facet motion.

Disc or joint pathology	Decreased	Normal	Increased	
1. OO	0	20	3	23
2. OO	0	11	0	11
3. AO or AD	4	3	1	8
	4	34	4	42

COMMENTS

Previous investigations of lateral radiographs have revealed subluxation in synovial joints and shown a close relationship between abnormal joint motion and degenerative changes in discs or joints. It is claimed to occur most often at the lumbosacral junction.

The present study is based on lateral X-rays of 42 fresh autopsy lumbar spines in full flexion and extension. The position of the S. 1 facets relative to the pedicles and distal border of L. 5 were identified. Degenerative changes in discs and synovial joints were recorded.

In the intervertebral foramen the inferior margin of the L. 5 pedicles are located lateral to the upper portions of the S. 1 facets. This is so because the pedicles at the junction of the laminar isthmus have a medial groove towards which the S. 1 facets point. The top of a S. 1 facet can normally reach this area. In extension this often happens at the lumbosacral level. It was found in 22 instances. In 11 of these both discs and synovial joints were normal.

25 discs were normal. In flexion S. 1 facets were high in 11 of these. In 17 specimens the fifth disc was degenerated. High positions were recorded in 6.

In flexion osteoarthritis was never present in low facets positions. Only approximately 1/4 of the high facets had osteoarthritis. In extension the ratio of high to low facets in joints with osteoarthritis was 5:3.

These studies on autopsy material show that the position of S. 1 facets varies both in flexion and extension regardless of the presence of degenerative changes in discs and joints. No significant differences

were found between normal and degenerative spines which could be used to predict pathomorphological changes in discs or synovial joints.

One may question the tenability of these findings and conclusions. Differences in deformation between normal and degenerated discs under static loads have been shown to be significant but small (*Hirsch* 1954, *Nachemson* 1963, *Rolander* 1966). This in itself would mean that although one would expect some changes in the pattern of synovial facet positions, they might not be measurable in lateral roentgenograms, especially since differences in facet positions are commonly found in normal spines.

The range of motion in the lumbosacral synovial joint was measured. Disc degeneration did not affect the excursion of the L. 5 facet relative to the sacrum. A decrease was noticed only in osteoarthritis which seems quite acceptable.

SUMMARY

Lateral X-rays were taken of 42 lumbar spines removed at routine autopsy. The roentgenograms were taken with the spine in full flexion and extension and in the normal resting position. From these X-rays the position of S. 1 facets was determined. The fifth lumbar discs were cut horizontally for macroscopical evaluation of degenerative changes and the synovial joints of the lumbosacral segment were studied microscopically for osteoarthritis. It was found that the position of S. 1 facets varied both in flexion and extension regardless of the presence of degenerative changes in discs and joints. The position of the facets did not justify any conclusion about pathomorphology in the lumbosacral segment. The range of joint motion was measured. Disc degeneration did not affect facet excursion. When the range of movement was decreased, the synovial joints showed evidence of osteoarthritis.

RESUME

Des radiographies latérales de 42 colonnes lombaires prélevées au cours d'autopsies routinières ont été prises en flexion et extension complète ainsi qu'en position normale de repos. Sur la base de ces radiographies, la position des facettes S-1 a été déterminée. Les disques de la cinquième vertèbre lombaire ont été coupés horizontalement afin de procéder à l'évaluation macroscopique des modifications dégénératives et les articulations synoviales de la région lombo-sacrée ont été étudiées au microscope pour déceler la présence d'ostéoarthrite. On a découvert que

la position des facettes S-1 varie en flexion et en extension sans rapports avec la présence de modifications dégénératives des disques et des articulations. La position des facettes ne justifie aucune conclusion concernant la pathomorphologie de la région lombo-sacrée. La mobilité de l'articulation a été mesurée et elle n'est nullement affectée par la dégénération du disque. En revanche en rapport avec une limitation du mouvement, on a constaté la présence d'une ostéoarthrite dans les articulations synoviales.

ZUSAMMENFASSUNG

Laterale Röntgenaufnahmen von 42 Lendenwirbelsäulen, die von Rutineautopsien erhalten worden, waren, wurden in voller Beugung und Sreckung sowie in normaler Ruhelage vorgenommen. Von diesen Röntgenbildern wurde die Lage der S-1 Facetten bestimmt. Die fünften Lendenwirbeln wurden zur makroskopischen Bewertung von degenerativen Veränderungen horizontal geschnitten und die Synovialgelenke des lumbosakralen Segmentes wurden zum Nachweis von von Osteoarthritis mikroskopisch studiert. Man fandt, dass sich die Position der S-1 Facetten bei Beugung und Streckung unabhängig von der Gegenwart degenerativer Veränderungen in Disken und Gelenken veränderte. Die Lage der Facetten erlaubte keinerlei Schlüsse hinsichtlich der Pathomorphologie im Lumbo-sakralsegment. Das Ausmass der Gelenkbewegung wurde gemessen. Diskusdegeneration beeinflusste den Bewegungsausschlag der Facetten nicht. Wenn eine Bewegungseinschränkung vorkam, dann zeigten die Synovialgelenke Zeichen von Osteoarthritis.

REFERENCES

Baumann, J. (1957) Beiträge zur Kenntnis der Altersveränderungen der Lendenwirbelsäule beim Menschen unter besonderer Berücksichtigung von Bandscheiben und kleinen Wirbelgelenken. *Helv. Acta Chir.* **24**, 9.

Friberg, S. & Hirsch, C (1950) Anatomical and clinical studies on lumbar disc degeneration. *Acta orthop. scand.* **19**, 222.

Hadley, L. A. (1935) Subluxation of the apophyseal arteculations with bony impingement as a cause of back pain. *Amer. J. Roentgenol.* **33**, 209.

Hadley, L. A. (1936) Apophyseal subluxation. *J. Bone Jt Surg.* **15**, 428.

Hadley, L. A. (1951) Intervertebral joint subluxation, bony impingement and foramen enchroachment with nerve root changes. *Amer. J. Roentgenol.* **65**, 377.

Hadley, L. A. (1961) Anatomico-roentgenographic studies of the posterior spinal articulation. *Amer. J. Roentgenol.* **86**, 270.

Harris, R. J. & Macnab, J. (1954) Structural changes in the lumbar intervertebral discs. *J. Bone Jt Surg.* **36** B, 304.

Hirsch, C. & Schajowicz, F. (1952) Studies on structural changes in the lumbar annulus fibrosus. *Acta orthop. scand.* **22**, 184.

Johnson, R. (1934) Posterior luxations of the lumbosacral joint. *J. Bone Jt Surg.* **16**, 867.

Keller, G. (1953) Die Bedeutung der Veränderungen an den kleinen Wirbelgelenken als Ursache des lokalen Rückenschmerzes. I. Auswertung der klinisch-röntgenologischen Befunde. *Z. Orthop.* **83**, 219.

Keller, G. (1953) II. Auswertung der histologischen Befunde. *Z. Orthop.* **83**, 517.

Keller, G. (1962) Wirbelgelenk und Rückenschmerz. Die Wirbelsäule in Forschung und Praxis. **25**, 27. Hippokrates Verl., Stuttgart.

Lange, M. (1936) Die Wirbelgelenke. Enke, Stuttgart.

Lewin, T. (1964) Osteoarthritis in lumbar synovial joints. A morphologic study. *Acta orthop. scand.* Suppl. 73.

Lewin, T.: Anatomical variations in lumbosacral synovial joints. To be published.

Nachemson, A. (1963) The influence of spinal movements on the lumbar intradiscal pressure and on the tensile stresses in the annulus fibrosus. *Acta orthop. scand.* **33**, 183.

Oppenheimer, A. (1937) Diseases affecting the intervertebral foramina. *Radiology* **28**, 582.

Rolander, S. D. (1966) Motion of the lumbar spine with special reference to the stabilizing effect of posterior fusion. *Dissert.*

Williams, P. C. (1932) Reduced lumbosacral joint space. Its relation to sciatic irritation. *J.A.M.A.* **99**, 1677.