

## The Ligamentum Flavum in Lumbar Spinal Canal Stenosis

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### SUMMARY

A series of 73 patients who had been surgically operated for lumbar diseases at Dept. of Orth. Surg. in Nagasaki Mitsubishi Hospital (mostly degenerative spinal stenosis, combined lumbar spinal stenosis and lumbar disc disease) has been reviewed to present clinical surgical and histological findings. It may be concluded that in spinal canal stenosis, the ligament flavum is shortened and projected into the spinal canal as the results of ossific change, the narrowing of intervertebral disc spaces, and the subluxation and the convolution of the post joint, thus the ligament gives physical and morphological aggravating changes. In addition to these, the ligament flavum itself shows qualitative changes such as degeneration, hypertrophy and fibrosis; and the dynamic factors such as spinal extension and a standing posture may also secondarily affect the ligament flavum.

### INTRODUCTION

As the causes and pathological features of lumbar spinal stenosis, morphological changes such as the vertical or innerward deformations of the lower articular process and the narrowing of the intervertebral arch space have been reported. We have also presented, in the 50th Annual Meeting of the Japanese Orthopaedic Association, the findings in degenerative spinal stenosis that the reduction of the anterior-posterior diameters of L<sub>4</sub> and L<sub>5</sub> of the bony spinal canal, the hypertrophy of the lamina, upper and lower articular processes, the spherical changes of the intervertebral joint and ossific prominence

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such as the bony change of vertebral body etc. In addition, we have suggested the possible hypertrophy of the ligament flavum on the basis of the result of peridurographic examination. In the present study, we examined the soft tissue, particularly the ligament flavum, in clinically treated cases.

## METHODS

### 1. Subjects

The patients who had been surgically operated for lumbar diseases (excepting tumors, inflammatory diseases and traumas) at the Department of Orthopaedic Surgery of the Nagasaki Mitsubishi Hospital for a period of about 2 years and a half since the time of the foundation of the Department in April, 1977, were subjected to this study. Clinical, surgical and histological findings from these patients were primarily presented in this communication.

The cases studied consisted of 13 patients with degenerative spinal stenosis, 3 cases with post-operative spinal stenosis, 14 patients having combined lumbar spinal stenosis (degenerative stenosis and disc lesion), 1 case with developmental spinal stenosis, 36 cases with lumbar disc diseases and 4 patients having the entrapment of the cauda equina or nerve root by other.

**Table I** Details of operation on lumbar spine in 73 patients

I	1. Degenerative spinal stenosis	13
	2. Postoperative spinal stenosis	3
	3. Combined lumbar spinal stenosis (deg and disc)	14
	4. Developmental spinal stenosis	1
II	Spondylolytic spondylolisthesis	2
III	Lumbar disc disease	36
IV	Entrapment of the cauda equina or nerve by other	4
total		73 (patients)

### 2. Age and sex of patients

Comparison of the age distributions in 3 major patient groups showed that lumbar disc disease was mostly seen in patients younger than 40 years of age, degenerative spinal stenosis was primarily in patients older than 50 years, and combined spinal stenosis occurred in patients of the age between 40 and 60 years. As regards the sex, the male was overwhelmingly predominant in all the groups studied.

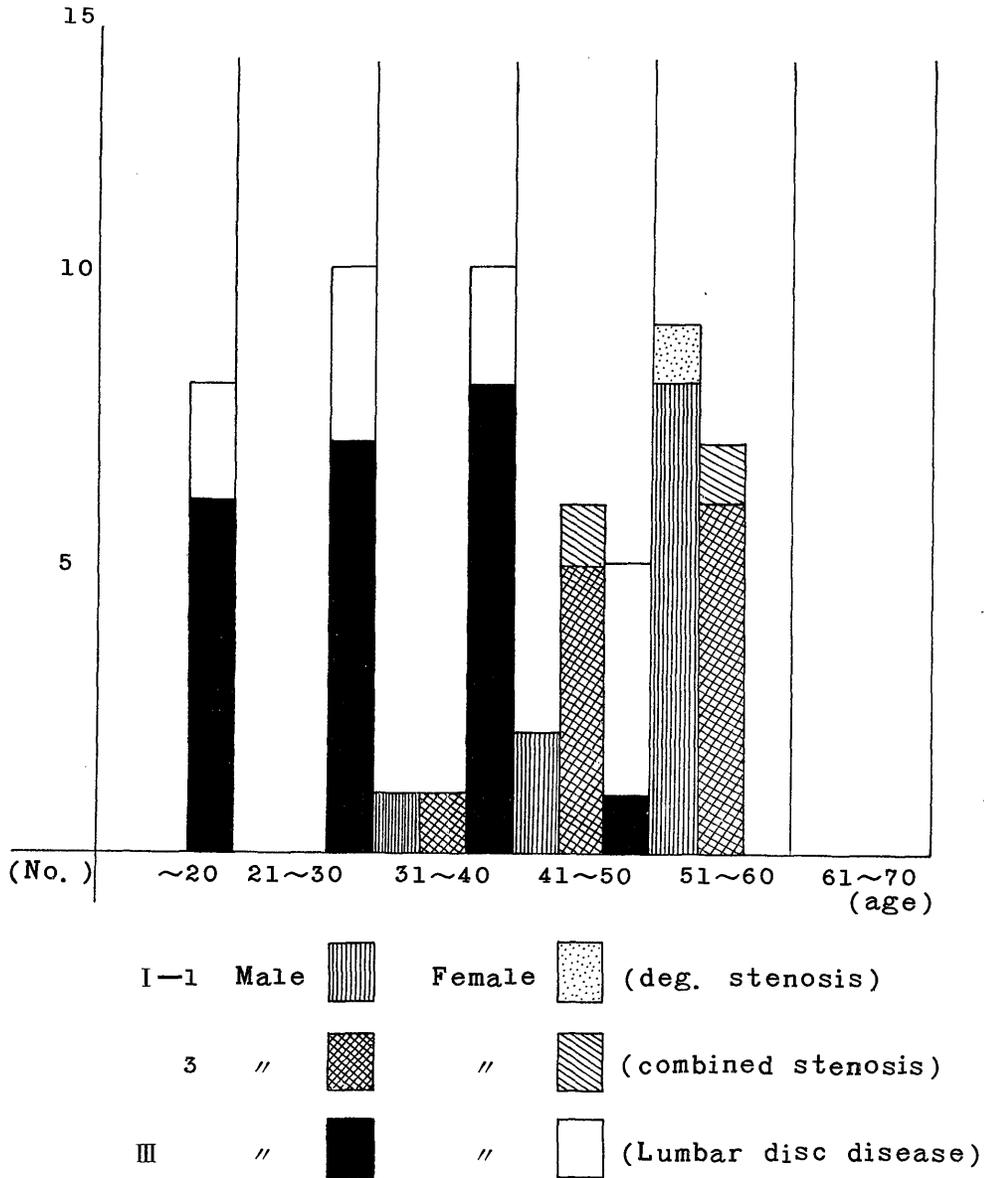
### 3. Clinical symptoms and findings

As regards low back pain, there was no difference between the group with degenerative spinal stenosis and that with combined spinal stenosis. Lower limb symptoms were observed, as expected, more frequently in the patient with combined spinal stenosis, and the degree of disorder (limitation), examined by the SLR test, was also greater in this patient group.

### 4. Radiographic findings

Simple radiographic pictures showed the presence of the subluxation and the

Table II Comparison of the age and sex in 3 major patients group



convolution of the post joint (facet) in more than a half of the cases with degenerative spinal stenosis and with combined spinal stenosis. Such findings were also seen in relatively many cases with lumbar disc disease. Therefore, it was considered that the regressive degeneration might secondarily affect the post joint via the narrowing of intervertebral disc. In many cases, spinal extension (backward bending) was an aggra-

**Table III** clinical symptoms and findings

group	I				II	III	IV
	1)	2)	3)	4)			
low back pain	13	2	11	1	2	29	4
leg pain	6	3	10			12	3
numbness in the leg (s)	6	2	7		1	19	2
Intermittent claudication	8	1	6	1			
SLR test							
{ -30°			2			10	2
{ 31° -60°	3	1	6		1	18	2
{ 61° -	9	2	6	1	1	8	
Motor weakness (legs)	4	2	11			11	2
Sensory changes (legs)	7	2	11	1	1	22	3
ASR ↓	5	2	2			6	
PSR	1	1	1		1	2	
Scoliosis deformity	1		4			7	
total	13	3	14	1	2	36	4

**Table IV** Radiographic findings

	I				II	III	IV
	1)	2)	3)	4)			
Post joint							
{ Subluxation	8	1	7			3	2
{ Convolution	5	2	8	1		8	
{ Sclerosis	3	1	4			7	1
Narrowing of disc space	6	3	3		1	8	
Dynamic factor							
{ Progression of the symptom by trunk flexion							
{ Progression of the symptom by trunk extension	6		6			10	
{ No diff.	4	1	4	1		21	3

vating factor. In some cases, movement of spinal extension caused the rise of the level of the passage disturbance according to myelographic examination, the change being in parallel with clinical symptoms.

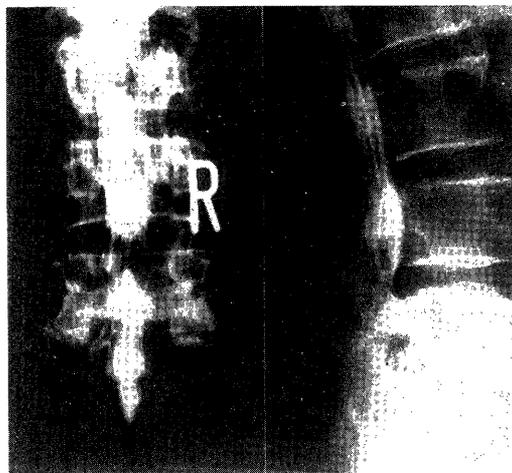
#### Illustrative Case Reports (1)

##### Case 1. (H. H., I-1)

A 56 years old male with low back pain and intermittent claudication. Myelographic passage disturbance at the level of L<sub>4</sub>/L<sub>5</sub> was noted. Total laminectomy was performed. The ligament flavum was found to be adhered to the dura which was strangulated fibrosis.

##### Case 2. (O. K., I-2)

A 46 years old male with low back pain and walking difficulty. Although the ant-post view in myelogram showed no passage disturbance, bilateral compressions were suspected. Total laminectomy was applied. The hypertrophy of the ligament flavum, and protrusion of the intervertebral disc were observed at the branching portion of nerve roots.



Case H. H. (I-1)

Fig. 1 Case 1. myelographic finding, complete block of L<sub>4/5</sub> level



Case O. K. (I-2)

Fig. 2 Case 2. myelographic finding, bilateral compression of L<sub>4/5</sub> level

Case 3. (T. K., I-3)

A 42 years old male patient having recently aggravating low back pain for 2 decades. Marked passage disturbance caused by a motion of spinal extension was observed by myelography. The total laminectomy at the level of L<sub>4/5</sub> was performed.

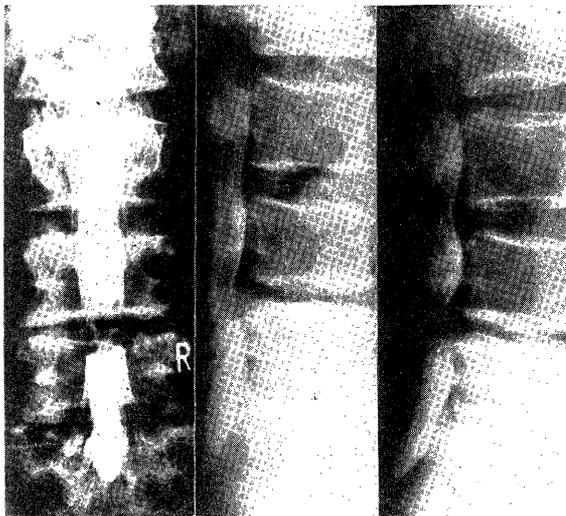
5. Sites and areas of stenosis

Dividing the picture in Fig. 4 into the spinal canal area and the root tunnel, the sites of stenosis were found to exist both in the spinal canal and the root tunnel areas in almost all the cases having degenerative spinal stenosis and combined spinal stenosis. Two-thirds of the cases with lumbar disc disease also had stenotic sites in these two areas, and the one-thirds of such cases had the sites only in the root tunnel. The entrapment of only the root tunnel was observed in four other cases.

As regards the stenotic area, 7 cases and 6 cases with degenerative spinal stenosis showed stenosis in 2 areas and 1 area respectively, and 6 and 9 cases with combined spinal stenosis had the stenotic sites in 2 areas and 1 area respectively. These 2 areas involved the L<sub>4/5</sub> and L<sub>5/S1</sub>, and the 1 area was mostly assigned to be the L<sub>4/5</sub> level.

6. Operative findings and results

For the patient group having spinal



Case T. K. (I-3)

Fig. 3 Case 3. myelographic finding ----- complete block of L<sub>4/5</sub> (narrowing of L<sub>4/5</sub> intervertebral disc space)

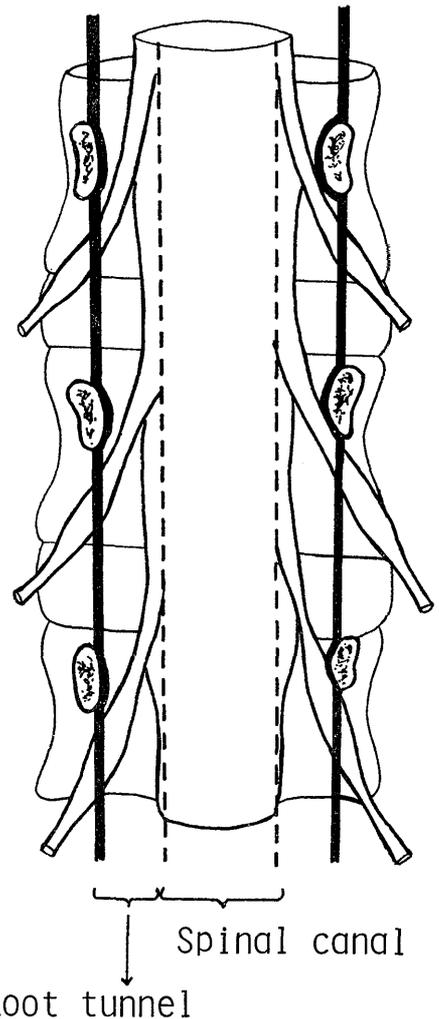


Fig. 4. Schema of stenosis

stenosis, the following operative findings were noted as ossific changes: the hypertrophy and the changes in handness of the spinous process and the vertebral arch, the narrowing of the intervertebral arch space, the hypertrophy of the ligament flavum between intervertebral arches, the hypertrophy and the innerward dislocation of the articular process. The decrease of the fat tissue in the peridural space was also noted. The ligament flavum, which clearly divided into the posterior portion forming the posterior wall of the vertebral canal and the lateral portion forming the lateral wall, was found to be in the state of hypertrophy at the posterior portion, and the lateral portion was seen to be involved in the compression of the nerve root in the so-called lat recess.

Surgical operation was performed by means of the vertebral arch resection, but the spinal fixation was also combinedly use for 7 cases. The vertebral arch resection was made as far as possible to the lateral portion, and the foramenectomy was also applied. Although the results of the long-term follow-up was not available yet, the presently available results may be summarized on the basis of the rule of judgement by Nakano, which is shown below. The results thus obtained were considered to be nearly satisfactory.

The judgement rule :

Good: Symptoms disappeared, and the patient is not restricted for his daily life and work.

Fair: Occasional low back pain, but no particular inconvenience in daily life.

Poor: Pre-operative symptoms not improved or rather slightly aggravated.

## 7. Histological examinations

Histological examinations were made on the ligament flavum specimens obtained on surgery from 15 spinal stenotic cases and 15 cases with lumbar disc disease (the specimens were collected primarily from the intermediate portion between the lat and med.)

Major findings were the disturbed arrangement of the collagen fiber and elastic fiber, and the hypertrophy of the blood vessel wall. The posterior and lateral portions of the ligament flavum showed no particular difference in the case of lumbar disc disease, while the granulation-like change and the calcification were observed in the lateral portion of the ligament flavum of some patients with spinal stenosis.

Table V Results

	I				II	III	All
	1)	2)	3)	4)			
Good	11	2	12	1	2	32	4
Fair	2	1	2			3	
Poor						1	

Operation method

Laminectomy (including, Foramenectomy)	11	3	6	1			3
{ Laminectomy + Spinal fusion	2		5		2		1
Love's method			3			36	
{ Love's method + Post fusion						1	

#### Case 4.

A 52 years old male, with intermittent claudication and walking difficulty. The total laminectomy was made at the levels of L<sub>4/5</sub> and L<sub>5</sub>/S<sub>1</sub>. The vertebral arch hypertrophy. Many fibrosis tissues were noted. Disturbed arrangement of elastic fibers was observed (weigert staining).

#### Case 5.

A 60 years old female, having low back pain and paralysed feeling at lower limbs for 10 years. Complete blockade in the myelogram was seen at the levels of L<sub>4/5</sub> and L<sub>5</sub>/S<sub>1</sub>. Operative findings showed that the dura was strongly strangulated, the lateral portion of the ligament flavum was hypertrophied in the area of the lat recess, which compressed the dura, and the posterior portion of the ligament flavum was disturbed for the fiber running and the lateral portion of the ligament had granulation and calcification (HE staining).

#### 8. Experimental investigation

Prototype models are prepared from human dried bones of the continuous lumbar vertebrae (L<sub>3-5</sub>). At first, negative models are produced from dried bones. Then, the positive models are molded from those negative using acrylic resins composed of vinyl ester resin 70% and soft polyester resin 30%. Intervertebral disc models are made of sponge rubber.

Vertical compression applied to the anterior portion of the intervertebral disc and

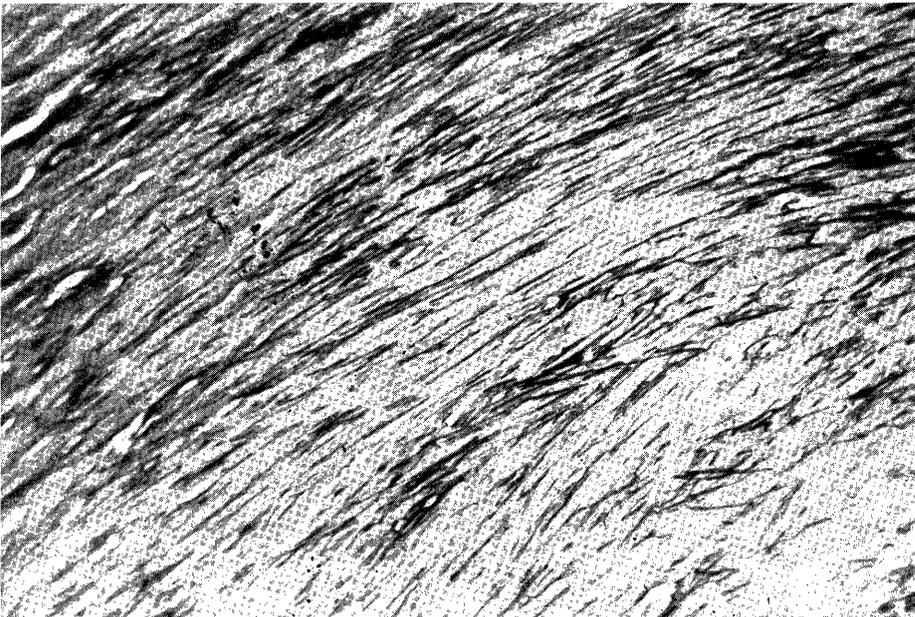


Fig. 5 Case 4. many fibrosis tissue, disturbed arrangement of fibers

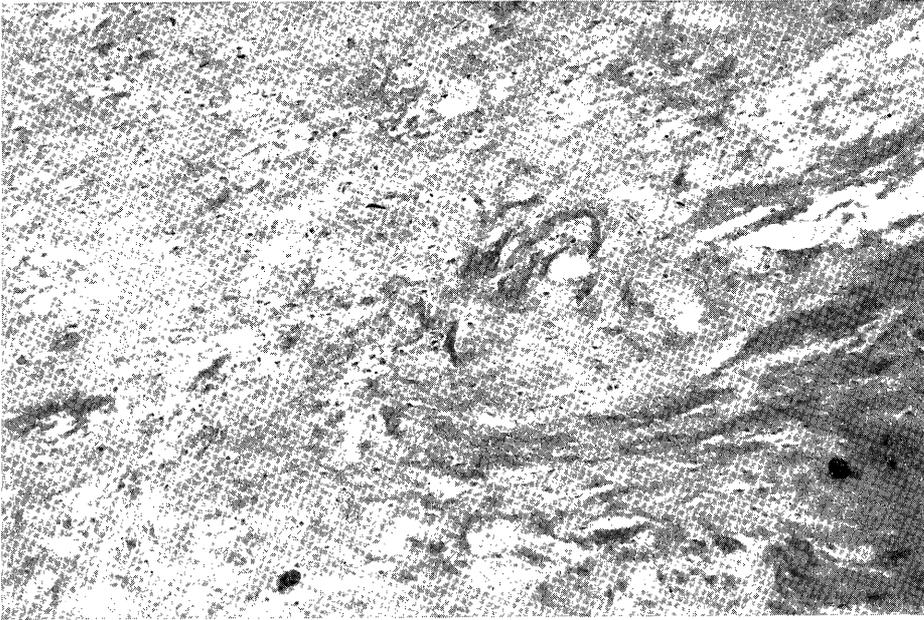


Fig. 6 Case 6. post portion of lig., disturbed of arrangement of fibers

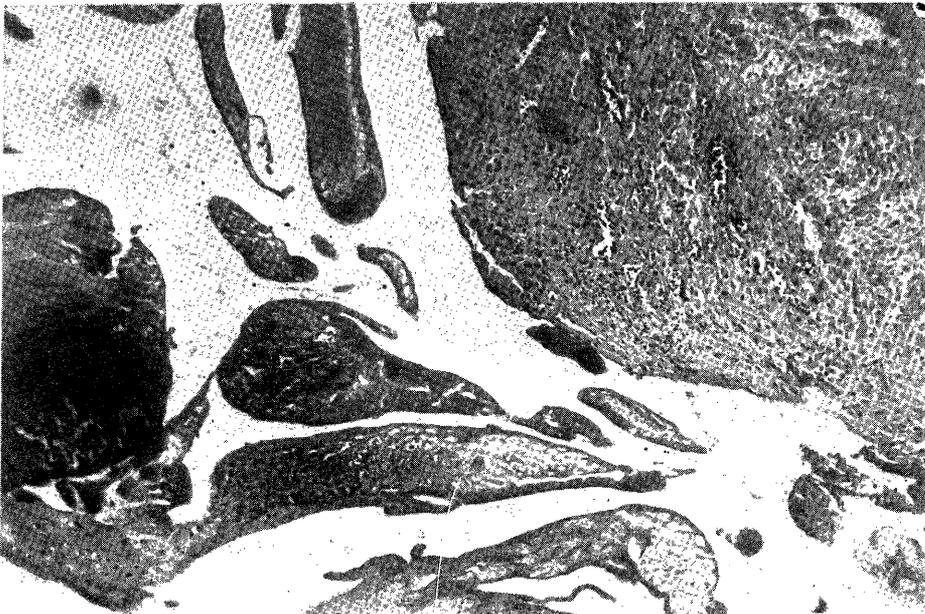


Fig. 7 Case 5. lat. portion of lig., granulation and calcification

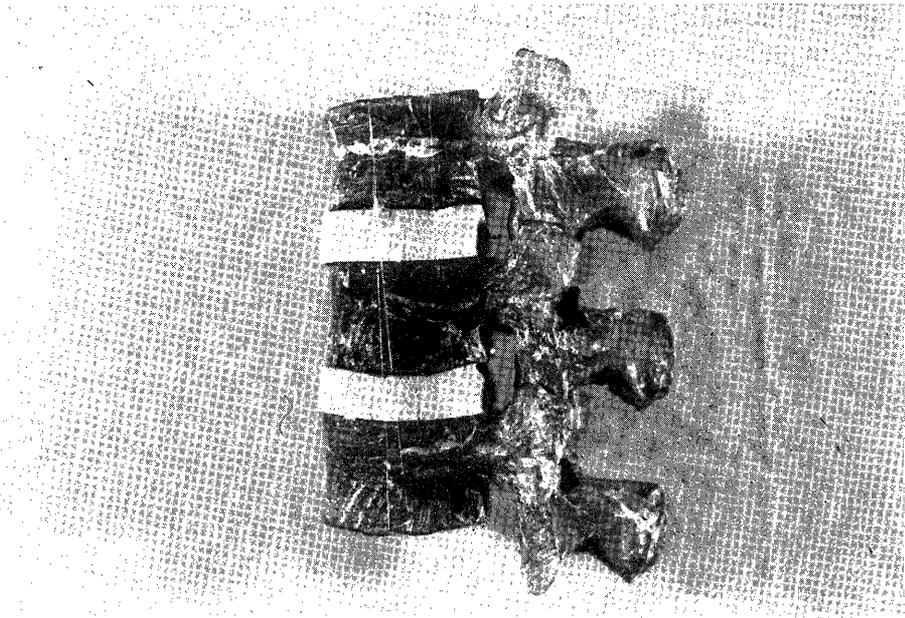


Fig. 8 prototype model (L<sub>3/5</sub>)

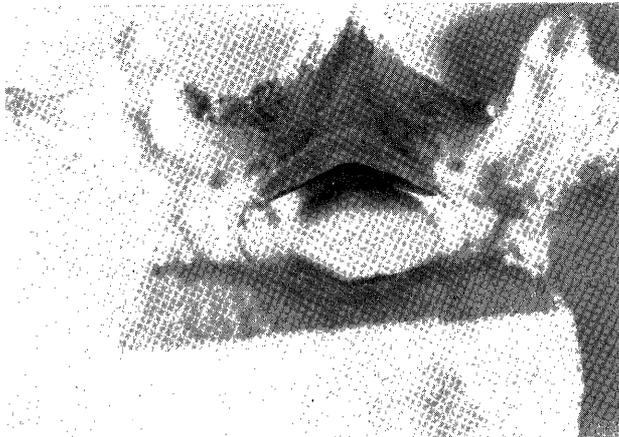


Fig. 9 cross section normal : 'lig flav'



vertical compression applied  
(post-joint dislocated)  
'lig flav' was projected to the  
inner side of the canal

the portion corresponding to the vertebral body did not largely change the length of the ligament flavum. However, when the intervertebral joint was incompletely dislocated or convoluted, the ligament flavum was shortened and was projected to the inner side of the vertebral canal. Similarly, the backward movement also shortened the length of the ligament flavum and resulted in the projection into the vertebral canal.

## DISCUSSION

The ligament flavum is that composing a part of the spinal canal wall, and connecting upper and lower laminae to form the three walls, namely bilateral and posterior walls of the spinal canal. The posterior portion of the ligament connects the upper margin of the inferior vertebral arch with the lower margin of the superior vertebral arch, while the lateral portion covers the anterior inner margin of the upper articular process of the inferior vertebral arch and the anterior inner region of the articular capsule, and attaches to the anterior inner portion of the inferior articulation, thus forming the lateral wall of the spinal canal. The lateral portion of the ligament flavum constructs the dorsal lateral wall of the intervertebral foramen

Yokoyama<sup>20)</sup> has stated, as to the hernia of intervertebral disc and the hypertrophy of the ligament flavum, that the ligament flavum itself shows a splitting and cicatricial hypertrophy, and that when intervertebral disc disorder is associated, the ligament flavum may reactively become hypertrophic in order to compensate the reduced locomotor and holding functions caused by weakened spinal strength. Towne et al<sup>13)</sup> have reported the case in which the cauda equina and root were compressed by hypertrophied ligament flavum, and stated that this was a histologically simple hypertrophy. Ramani<sup>8)</sup> has stated that there was no marked morphological change in the ligament flavum in the case of hernia (The relative content of the elastic tissue, 80% elastic and 20% collagen, did not change with age). Yong-Hing<sup>21)</sup> has reported as to the morphology and function of the ligament flavum that the ligament becomes double in its thickness by a shortening to a half of its original length, and also that the hypertrophy of the ligament passively contributes to the entrapment because of the enhanced fibrosis.

Also in the present cases, both degenerative spinal stenosis and combined spinal stenosis occurred in the patients of later than the 40 years which is the age easily be attacked by regressive degeneration. Radiographic examination showed the occurrence of subluxation or the convolution of the post joint in the majority of the present cases. Therefore, it is thought that physical shortening of the distance between the portions connected by a ligament flavum may naturally occur and it may serve as a passive compressing factor. In addition, the sites of stenosis were observed both in the spinal canal and the root tunnel in many cases, in particular the outer lateral portion of the ligament flavum, i. e., the lat recess area, was noted to show more marked changes in some of the present cases.

On the basis of the above findings, it may be concluded that in spinal canal

## Lig flavum in Spinal canal stenosis

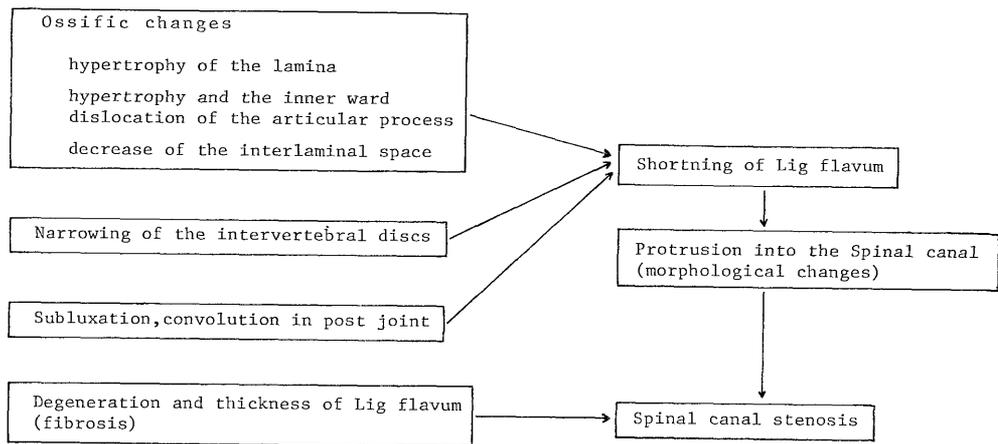


Fig. 10 Lig flavum in Spinal canal stenosis

stenosis, the ligament flavum is shortened and projected into the spinal canal as the results of ossific change, the narrowing of intervertebral disc spaces, and the subluxation and the convolution of the post joint, thus the ligament gives physical and morphological aggravating changes. In addition to these, the ligament flavum itself shows qualitative changes such as degeneration, hypertrophy and fibrosis; and the dynamic factors such as spinal extension and a standing posture may also secondarily affect the ligament flavum. These factors were all considered to act as aggravating causes of the development of spinal stenosis.

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