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ON LOW-BACK PAIN

WITH SPECIAL REFERENCE TO THE VALUE OF OPERATIVE TREATMENT WITH FUSION

A CLINICAL
AND EXPERIMENTAL STUDY

BY

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PREFACE

Professor Henning Waldenström was the pioneer in Sweden for the investigation of diseases of the spinal column.

Professor Sten Friberg has expanded the field of research in this sphere by his own personal investigations and capable leadership. He gave me the idea of compiling this work which he has followed with interest and encouragement.

Professor Folke Knutsson has increased our knowledge of the roentgenological picture by his very comprehensive investigations. To his valuable teaching I owe much.

Docent Carl Hirsch has thrown light upon hitherto unclear details within this sphere by his patho-anatomical and experimental researches. Besides giving me most valuable advice, he very kindly placed his instruments at my disposal.

Owing to all these mentioned above conditions have been created for this work to come into being.

Mr. Tuve Leander assisted me to give shape to the work by editing the statistical part of it, whilst miss Karin Lundin took the photographs and made the diagrams.

Dr. Allan Rülcker and the administrative staff of the Stockholm Sick Benefit Society very kindly placed the necessary information from their records at my disposal.

Captain Jack O'Brien-Hitching, M. C. made the translation.

The Dean and members of the Board of Administrators of the Karolinska Institutet, granted me a Scholarship and very

kindly allowed me to use the Gustav V's Institute for Scientific Research. I also received a monetary grant from Gustav V's Eightieth Anniversary foundation.

I take this opportunity of tendering my heartfelt thanks to each and everyone mentioned above.

Stockholm, May, 1950.

Lars Unander-Scharin.

CONTENTS

INTRODUCTION

Lumbago and sciatica are very ordinary conditions. In the older literature these conditions were dealt with predominantly quite separately and it was thought that there was no definite connection between them. Throughout the times there has been much controversy as to the etiology of both.

Lomenico Cotugno (1764), a Neopolitan Doctor, gave a detailed description of the sympomatic picture of *sciatica* in his work "De ischiade nervosa commentarius". He was the originator of the term "sciatica". He differentiates between a sciatic condition arising from nervous causes and one arising from arthrogenous, and so drew a line of demarcation between the sciatic syndrome and hip diseases. Cotugno was of the opinion that the etiology was a distention of the neurilemma.

Laségue (1864) wondered why the sciatic nerve alone was exposed for this distention. To a large extent he shared Cotugno's theory about nerve changes but suggested, however, the hypothesis that the pain might myalgic.

Jansen (1930), *Helweg* (1934) and *Lindstedt* (1936) considered that the sciatic syndrome was myalgic. Helweg regarded sciatica as a functional myopathia. Lindstedt sought the cause of sciatica in vertebral fractures, deformities of the feet, anomalies of the pelvis and so on.

Many have been of the opinion that sciatica has some connection with gynecological, urological and other intra abdominal diseases.

Several authors consider that sciatica is a form of neuritis.

It is not the intention of the author to give a detailed ventilation of all the theories expounded as to the cause of sciatica. Instead he refers to *Friberg*'s collocation of 1941 wherein he referring the different theories about sciatica as being a myalgia or a neuritis, classifies the etiological factors into *toxico-infectious* and *mechanical.*

The *toxico-infectious* are angina, influensa, scarlatina, gout, malaria, pernicious anemia, syphilis, diabetes, arsenical, lead, bismuth and other poisoning.

The *mechanical factors,* comprising three groups in regard to the place for the pressure, are:

a) *The trunk or branches of the sciatic nerve:* coxitis, osteomyelitis, tumours, pressure of the musculus piriformis.

b) *The lumbo-sacral plexus:* fetal head during the last months of pregnancy, affections in the sacro-iliac joints (displacements, dislocations, subluxations).

c) *The roots:* anomalies in the lumbo-sacral region (sacralisation, lumbalisation, spondylosis, spondylolisthesis, spina bifida, narrow lumbo-sacral interspace).

Lumbago has long since been regarded as being a rheumatic complaint. Others are in favour of its being a genuine muscular disease. *Brocher* (1938) says: "Lumbago wird in den deutschsprachigen Lehrbüchern durchweg in Kapitel der Myalgi besprochen. Ein beweisendes anatomisches Substrat für diese Annahme fällt aber völlig, obwohl wiederholt danach gesucht wurde".

Jones (1948) has made the following collocation about the causes of lumbago:

I. Postural strain.
(Chronic drag of gravity).

II. Trauma.
1. Injury to vertebrae and joints.
2. Injury to soft tissues.
3. Injury to intervertebral disc.

III. Infection.
1. Spondylitis deformans.
2. Fibrositis and myositis.
3. Actinomycosis.
4. Blastomycosis.
5. Brucells abortus.
6. Osteomyelitis,
A) Pyogenic organisms,
B) Typhoid.
7. Epidural abscess.
8. Neisserian involvement.

IV. Catch all class.
(Growth disturbances, metabolic, endocrine senescent and neurotrophic).
1. Osteochondritis (Calvé).
2. Adolescent epiphysitis (Scheuermann).
3. Neuropathic joints of tabes and syringomyelia.
4. Parathyroid tumor.
5. Senile epiphysitis and osteoporosis.
6. Paget's disease.
7. Gout.

V. Congenital anomalies.
1. Defects of isthmus (most important).
A) Spondylolisthesis,
B) Sponlylosis.
2. Spina bifida (occulta).
3. Asymmetrical lumbosacral facets.
4. Sacralization transverse processes.
5. Lumbarization transverse processes.
6. Extra or deficient vertebrae.
7. Wedged vertebrae.

VI. Neoplastic.
1. Benign.
A) Osteoma and osteochondroma.
B) Giant cell tumour (may be malignant).
C) Hemangioma.
D) Eosinophilic granuloma.
2. Malignant.
A) Primary.
a) Sarcoma and osteogenic sarcoma.
b) Lymphoblastoma.
c) Ewing's tumour.
d) Multiple myeloma.
B) Secondary (metablastic).
a) Carcinoma of breast.
b) Hypernephroma.
c) Thyroid.
d) Prostatic carcinoma.
3. Tumours of the spinal cord, its meninges, roots and the filum terminalis.

VII. Vascular.
1. Aneurysm.

VIII. Psychogenic.
1. Hysteria.
2. Malingering.
3. Psychoneurosis.

During the latest decades the clinical and morphologic study of intervertebral discs have thrown more light on lumbago and sciatica. It may be regarded as being clear that changes within the intervertebral discs are, in many cases, the cause of both lumbago and sciatica, and that both of these conditions are thus symptoms of the same disease.

As early as in 1857 *Virchow* reported a case of a fractured disc in the caudal part of cervical vertebrae in a post mortem

and *Luscka* (1858) reported a case of nodular excrescence towards the vertebral canal in a lumbar disc but it was *Schmorl* and his school who, by means of very thorough patho-anatomic investigations, can take the credit for throwing light on the changes in the intervertebral discs. Nevertheless Schmorl placed no connection between the changes observed in the intervertebral disc and sciatica.

It is the Americans *Barr* and *Mixter* as well as the Frenchmen *Mauric* and *Alajouanine* who can take the honour of the fact that these important anatomic observations have been turned to good account in the clinics. They discovered that what had previously been regarded as chondromatas or enchondromatas compressing the nerve roots was in reality prolapsing disc substance.

Great interest was then shown in the anatomy of the intervertebral disc together with the one clinical component, *the sciatic syndrome*. The other component in disc degeneration, *low back pain*, has not roused such great interest as, perhaps, it does not manifest itself in the same dramatic degree. It is, however highly invalidating because of its often lengthy and severe course.

The search for prolapsing disc substance in conditions of lingering sciatica has become more and more a recognised method of treatment. One soon found that by extirpating disc herniation, freedom from sciatic pain was achieved, but, in many cases there remained a more or less severe state of low back pain instead. Many surgeons have, for this reason, decided, in addition to extirpation of the disc herniation, to perform a stabilising osteosynthesis within one or several interstices in the lumbar spine.

Osteosynthesis alone has been performed in cases of severe lumbago that have shown no improvement from conservative treatment. The reports given in the literature concerning osteosynthesis in lumbago that was placed in connection with malformations in the lumbo-sacral region, spondylolisthesis, spondylolysis, sacralization and so on, are rather many. There are, however, rather few reports about the results of lumbal osteo-

synthesis in lumbago where there were signs of disc degeneration.

The presumption that a lumbal osteosynthesis shall be successful is that it stabilizes the changed intervertebral disc in a satisfactory manner. This in its turn presupposes an effective diagnosis. The diagnosis of disc degeneration is, roentgenological except in cases where the disc herniation is extirpated, (a prolapsing disc substance naturally presupposes a degeneration of the disc). Sclerosis and osteophytes on the vertebral margins, lowered interspace and vacuum phenomena have all hitherto been regarded a sure signs of degeneration. *Knutsson*'s method for testing instability has enabled us to make an early diagnosis of disc degeneration. Comparative roentgenological and patho-anatomical investigations by *Knutsson, Friberg* and *Hirsch* have, in point of fact, shown that in cases where there was only instability of the vertebrae without other roentgenological signs, disc-degeneration existed patho-anatomically. A further advance in diagnosis of disc degeneration has recently been made by *Hirsch* and *Lindblom* by means of disc puncture and contrast filling of the disc.

The operation technique for lumbal osteosynthesis has varied. The original technique of only fixing the spinous process has been extended to include the fixation of the arches and intervertebral joints. Fixation of the vertebral bodies has also been undertaken. Osteosynthesis in disc degeneration presents difficulties, thanks to the often pronounced instability in the changed discs. It would be desirable to discover a method that would give good fixation in the shortest possible time. The results of different operation methods have been all to scantily reported to be able to give any sure guidance.

The idea of osteosynthesis is to prevent mobility between two or more vertebrae and so lessen or stop the pressure put on the discs when the back is loaded. By making instability tests and observing the structural alteration of the bone it is possible, roentgenologically, to get some idea about the effect of stabilisation. It is not possible, however, to find out what degree of veritable unloading of degenerated discs that is at-

tained through osteosynthesis. It is true that osteosynthesis carries with it a stoppage of mobility within a section of the back. The question then arises as to in which manner this limitation of mobility influences on the discs placed above the osteosynthesis. Elucidation of this question is of the greatest interest when it comes to forming an opinion about osteosynthesis. It seems that the question can only be answered by means of experimental studies.

Osteosynthesis is a major operation. A long stay in hospital is necessary whilst the period of working incapacity is especially long for manual labourers. The indication that this intervention should be resorted to is that conservative methods have been tried and found fruitless. It is therefore desirable that the value of conservative treatment of disc degeneration is investigated. It has been presumed that when the degenerative changes have progressed so that the discs have more or less cicatrized and fusion has taken place, a state of freedom from pain is entered into. That such is the case is by no means proved. On the whole there is no information as to whether, from the roentgenological changes, one can draw any conclusions in regard to presuppositions for subjective trouble. Nor is it clear as to the length of time needed for a disc to reach the final stage of stability. Another question is whether the degenerative changes manifest themselves haphazardly at different times during life or whether they arise almost simultaneously if the changes are multiple. A clinical study of patients with disc degeneration, untreated or conservatively treated, and having a lengthy period of observation should make it possible to throw some light on these problems.

It has been stated that low back pain is a very common condition and forms a great percentage of the diseases met with in sick benefit societies and large concerns. No investigation has been made during the latest years to find out how great is the frequency, as the conception lumbago and sciatica has, thanks to modern investigations, got another meaning than the old-fashioned "rheumatic".

The questions which the author has the intention to elucidate in this dissertation are therefore:

1) The frequency of low back and sciatic pain existing in a sick benefit society material as well as in a large concern.
2) What do we get from a post examination of patients who have been conservatively treated, or not treated for lumbal disc degeneration?
3) The result of lumbal osteosynthesis in lumbal disc degeneration?
4) What experiences can be gained from making experimental investigations of lumbal osteosynthesis?

CHAPTER I

THE ANATOMY OF THE INTERVERTEBRAL DISC

The anatomy of the intervertebral disc has been described by *Luschka* (1858), *Fick* (1910), *Braus* (1921), *Rauber* and *Kopsch* (1932), *Beadle* (1939), *Coventry, Chormley* and *Kernohan* (1945) and others. Normally there are 23 discs between the second cervical and the first sacral vertebra. The shape of the sagittal section of the disc corresponds exactly with that of the vertebra, bean-shaped in the cervical and lumbar regions, heart-shaped in the thoracic parts. In the cervical and lumbar vertebrae the discs are higher ventrally than dorsally, and this applies especially to the lumbosacral disc. In the middle of the thoracic vertebrae the discs are lowest whilst in the lumbar vertebrae they are highest. All the discs form a quarter of the movable part of the spinal column (*Rauber* and *Kopsch* 1932).

The disc is a fixed but movable connection between the vertebral bodies. The connection is strengthened by the ligamenta longitudinale anterior et posterior, which both proceed from the skull to the sacrum. The ligamentum posterior is intimately connected with the intervertebral disc. The ligamentum flavum connects the vertebral arch portions. Between the spinous processes there are strong ligaments. The disc consists of three parts: the cartilage plate, the nucleus pulposus and the annulus fibrosus. The parts of the vertebral bodies facing the disc are made up of compact bone. "These bony plates are, however, simply a reflexion of the spongy bone of the body of the vertebra, for they are perforated by many small holes corresponding to the marrow cavities" (*Coventry, Ghormley* and *Kernohan,* 1945).

They divide the end plates into three zones:

1) the central zone, with numerous small holes,
2) the peripheral zone, with larger, but less numerous holes, and
3) the epiphyseal ring which consists of dense bone.

Schmorl and *Junghanns* (1932) call the epiphyseal ring "Wirbelkörperrandleiste" and do not attribute any importance to this in respect of the growth of the vertebra. *Schmorl* and *Junghanns* (1932) and *Saunders* and *Inman* (1947) find it noteworthy that man and primates, having a vertical loading of the back, have only a ring-shaped reinforcement of the vertebral margins whereas other mammals have a whole plate.

The *cartilage plate* covers the ends of the vertebrae and functions as a line of demarcation for the disc upwards and downwards. The cartilage plate consists of hyaline cartilage which lies between the ends of the vertebral bodies and the fibrous part of the disc. The cartilage is found over the perforated part of the end plate but not over the extreme edge of it (*Coventry, Ghormley* and *Kernohan,* 1945). The cartilage plate becomes thinner towards the periphery and it encapsulates fibrous threads which go over to the annulus fibrosus. The cartilage plate is rather loosely cemented to the underlying bone by a very thin layer of calcium, which is absent corresponding to the perforation of the bony plate (*Calvé* and *Galland* 1930, and *Donohue* 1939).

Nucleus pulposus. This is the semigelatinous centre of the disc, which is encapsulated by the annulus. It is the peculiarly active or dynamic portion of the disc, by reason of its turgescence (*Fick* 1910, *Beadle* 1931, *Coventry, Ghormley* and *Kernohan* 1945 and others). The nucleus occupies approximatively the centre of the disc but is somewhat pushed backwards. The merging between the annulus and the nucleus is well marked in adolescence but becomes more diffuse in adults. The nucleus is soft and elastic and bends forward somewhat over the surface of the section showing that it is under a certain pressure.

Even in healthy discs one can find a cavity in the centre with villus-like processes, "rudimentary joint cavity" (*Luschka* 1858, *Schmorl* 1928). *Coventry, Ghormley* and *Kernohan* (1945) find no endothelium in this cavity. *Petit-Dutaillis* and *de Séze* (1945) see in these processes the reason for degenerative changes in the disc substance. *Bradford* and *Spurling* (1941, 1948) and *Inman* and *Saunders* (1940) see in this cavity a sign of dehydration of the disc.

Histologically, the nucleus consists of a loose network of fine fibres with a varying number of cell elements. Centrally the arrangement is irregular and the basic substance is more homogenous and structureless. Here the cells are large and occur in clumps, two or more well separable from the basic substance. The cytoplasm in these cells is profuse and vacuolized, the nucleus lies eccentrically and is surrounded by a clear zone near which the cystoplasm is often granulated. These cells are the so-called Virchow's physaliferous cells (*Inman* and *Saunders*, 1940) and *Petit-Dutaillis* (1947). These cells are thought to be of chordal origin. In the peripheral parts of the nucleus the layer of connective tissue is clearer, the cells less numerous and widespread and take a more fibroblastic character.

Coventry, Ghormley and *Kernohan* (1945) have not been successful in showing the presence of mucin in the nucleus by staining.

Püschel (1930) found 88 % water in the nucleus pulposus of a full term embryo. This water had decreased to 66 % at the age of 77. *Lindahl* (1949) found a water content of 86.3 % in the nucleus pulposus of 11 children and 79.7 % in adults (24 persons). *Keyes* and *Compere* (1932) have also made similar observations in regard to the water content of the nucleus pulposus. Daily variations in the water content in the disc have been suspected by *de Puky* (1935). When measuring 1200 persons varying from 5 to 90 years of age he found a variation in height during the day. The variations amounted to 1 % of the total height, on an average 1 cm for women and 2 cm for men. Younger persons showed a greater variation than

older. Experimental persons were taller in the morning. *de Puky* was of the opinion that these variations were connected with compression and loss of turgor in the intervertebral discs.

Annulus fibrosus: emanates from the cartilage plates, envelops the nucleus pulposus and attaches itself to the ligamenta longitudinalia anterior and posterior and the vertebral ends. "It gives the size and shape to the disc, and is the seat of most of its strength and tenacity" (*Beadle,* 1931). It is not entirely distinct from the nucleus, as the two tend to blend together (*Coventry, Ghormley* and *Kernohan* 1945). The annulus fibrosus constitutes the main part of the disc. It consists of fibrous and fibro-cartilaginous plates, 10—22 of them in the lumbar part (*Joplin* 1935). *Coventry, Ghormley* and *Kernohan* (1945) classify the the fibres into three groups:

1) those that "stream off" from the inner surface of the cartilaginous plates, where there is a gradual transition from hyalin cartilage to fibro-cartilage.
2) those that pass anteriorly and posteriorly to insert into the longitudinal spinal ligaments.
3) those fibres that pass over the edge of the vertebral body and sink into the bone of the vertebrae like Skarpey's fibres.

It has been thought that the annulus is much stronger anteriorly, where the contact with the ligamentum longitudinale is stronger, than posteriorly where the contact is weaker. The ligamentum longitudinale posterior is, in addition, weaker than the ligamentum longitudinale anterior. So say *Alajouanine* and *Petit-Dutaillis* (1941): "La partie postérieure du disque n'est donc renforcée qu'au niveau de la ligne mediane, alors que les parties laterales ne le sont pour ainsi dire pas. Cette disposition anatomique rend compte de la situation habituellement lateralisée des hernies discales postérieures." The outer plates are composed of more firm connective tissue than the inner. Fibroblasts with drawn out, compressed cores are found

between the collagenic fibres as well as cartilaginous cells singly or in clumps.

Ubermuth (1929) and *Böhmig* (1930) have studied the supply of vessels to the disc. They have shown that up to the age of 8 years the disc is supplied with small vessels through the cartilaginous plate which, according to Böhmig, are six. After the age of 8 they show signs of obliteration which is complete between the age of 20 and 30. *Coventry, Ghormley* and *Kernohan* (1945) found vessels with blood corpuscles during the first three decades but not after that.

At the beginning the actual disc substance was not thought to have any nerve supply but *Jung* and *Brunschwig* (1932) discovered nerve fibres in the ligamentum longitudinales anterior and posterior. *Roofe* (1940) found nerve fibres but no specialized end organ in the posterior portion of the annulus fibrosus and the ligamentum longitudinale posterior. These nerves were regarded as being capable of transmitting pain. Roofe was even able to prove recurrent nerves emanating distally to the ganglion and passing into the spinal canal through the intervertebral foramen. The nerve innervates the ligament and capsule apparatus as well as the periosteum of the nearest distally placed disc. This nerve was already discribed by *Luschka* in 1858 under the name of nervus sinuvertebralis, and by *Hovelacque* in 1925. No specialized end organs were found by *Coventry, Ghormley* and *Kernohan* (1945), but the type of terminal end organ indicated that they were probably pain fibres.

Wiberg (1949) found nerve fibres in the disc substance itself. He has dissected preparations of the lumbar and sacral spines and was able to confirm the existence of a nerve which arises distal to the ganglion, passes back through the intervertebral foramen into the spinal canal and there divides up. The presence of nerves in the intervertebral disc has been investigated microscopically, and fibres were found in the ligamentous coverings of the disc.

THE PHYSIOLOGY OF THE INTERVERTEBRAL DISC

It has long been known that the discs play an important role in the physiology of the back. Because of their powers of resistence they contribute to the maintainance of the shape of the vertebral column and, because of their elasticity, cause the balance to be regained after the completion of a movement. They also play an important role in transferring the weight of the body to the different parts of the back. This applies especially to loading the back or when the back receives a blow. *Petit-Dutaillis* and *de Séze* (1945) summarize the function of the nucleus puposus thus: "Ç'est au nucleus bien plus qu'á la constitution même de l'anneau fibreux, que le disque doit son elasticité. Ce nucleus, constitue par une substance molle, semiliquide, est sous-pression a l'interieur du disque. Du fait même de sa constitution riche en eau, il est incompressible et ne peut que transmettre toutes les directions en se déformant, toutes les pressions que lui transmettent les segments sus-jacents du rachis.

Le nucleus realise entre deux vertebres adjacents un veritable axe-rotule exactment placé pour favoriser les mouvements de flexion-extension du rachis.

Le nucleus tend á se déplacer au cours des mouvements de rachis: en avant dans l'extension, en arriére dans la flexion."

In different loadings of the back when the discs are exposed to various pressures they must increase or decrease their counter pressure according to the nature of the variation in loading. *Inman* and *Saunders* (1947) consider that this occurs because the nucleus, being osmotic, draws water to itself from the spongiosa of the vertebral body through the small holes in the cartilage plate. They say: "The retention of water within the nucleus and the development of pressures sufficient to withstand the forces applied to them can only be achieved through osmotic pressure. The substance of the nucleus should be looked upon as the impermeable solute which draws water through the cartilaginous plates from highly vascular spongiosa of the vertebral body.

Should the pressure tending to appropriate two vertebrae exceed the osmotic pressure developed within the nucleus pulposus, fluid would be driven from the disc through the cartilaginous plates into the spongiosa of the vertebra. Should the reverse hold true, the higher osmotic pressure would draw water from the spongiosa into the interior of the intervertebral disc."

Bradford and *Spurling* (1945) illustrate the function of the disc with the following picture (see Fig. 1).

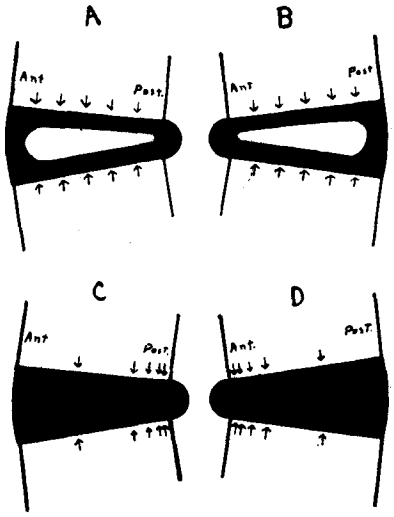

Fig. 1.

A and B show the alteration in the fluid nucleus pulposus during extension and flexion. The nucleus serves to keep the transmission of force, represented by the arrows, uniform over the intervertebral surfaces. C and D also represent extension and flexion, but without a fluid nucleus pulposus to distribute the transmitted force. In extension the maximum stress, represented by the concentration of arrows, is on the posterior intervertebral surfaces; in flexion, on the anterior intervertebral surfaces. The force is partially distributed over the whole intervertebral area because of the limited elasticity which is present even in the absence of a functioning nucleus pulposus. (After Bradford and Spurling).

It is of great interest to get to know the reaction of the disc for pressure.

In a post mortem material *Barr* (1937) has made the following experiment. Two spines with the intervening disc were removed and placed in a vice. Pressure was increased successively. This caused the disc to curve symetrically to the sides. When pressure was withdrawn the disc regained its shape. "This could be repeated ad libitum, demonstrating the usual elastic behaviour and function of the disc." If pressure was increased to a certain degree, rupture of the disc suddenly took place with prolapse of the nucleus mass. The disc then lost its elasticity and never regained its normal shape when pressure was removed. Rupture could take place anywhere in the annulus fibrosus.

In 1941 *Friberg* carried out similar experiments on material from dead bodies after having first roentgened the preparation so as to exclude roentgenologically manifested disc degeneration. In no case was Friberg able to bring about a rupture of the annulus fibrosus with prolapse of the discmass in a normal disc despite the fact that the pressure was so great that it caused damage to the bone. A gap in the annulus fibrosus was made with a troacar. In one case of a 62-year old man with a pronounced disc degeneration, two small pieces were forced out through the bored hole.

The author has also made similar experiments on healthy discs both with and without incising the annulus. In no case could a rupture be brought about. The pressure was so great that the surrounding vertebrae were fractured.

The load to which the lumbosacral disc is exposed in different positions has been calculated by *Waris* (1948). He says: "The same force resting on the lumbosacral disc would lift a 20 kg weight with the trunk inclined 90° would lift 180 kg in the erect posture, and the same force that would lift 20 kg with the trunk inclined 45° would lift 140 kg in the erect posture."

Bradford and *Spurling* (1945) have estimated that a grown man who lifts 45 kg with his arms stretched straight out from

the body puts a load of 720 kg on the lumbosacral disc. The weight of the body is not included.

In a post mortem material, *Petter* (1933) has measured the power of expansion evinced by the disc under compression. The measurement was taken partly before removing the preparation, partly after it had been removed and partly after dissecting the annulus fibrosus. In this way he was able to observe a difference of 0.7 mm in the height of the disc after removing the preparation and of 1.2 mm after dissecting the annulus fibrosus. The disc could be brought to its original height by submitting it to a pressure of 14.5 kg.

Measurement of the mobility of the vertebral column has been made partly on dead bodies by *Löhr* (1890), *Fick* (1911) and *Weber* (1927) and partly roentgenologically by *Bakke* (1931) and *Alvik* (1949).

Fick, whose measurements are most frequently quoted in the literature, says: "Wenn auch durch den komplizierten und festen Bandapparat die Beweglichkeit den einzelnen Wirbel gegeneinander sehr eingeschrenkt ist, so dass die einzelnen Wirbel keine grossen Verschiebungen gegen ihre Nachbarn erfahren können, wie es für die Festigkeit der Wirbelsäule als Schutzorgan des Rückenmarkes erforderlich ist, so kommt doch der Wirbelsäule als Ganzes durch die 24 malige Summierung der kleinen Bewegungen eine recht ansehnliche Beweglichkeit zu." *Fick* found the following mobility for the lumbar vertebrae: In the sagittal plane 110°, in the frontal plane 40° and when turning to one side 40°.

The following roentgenological measurement values were obtained by *Bakke:* In the sagittal plane (including the lumbosacral spatium, where the mobility was greatest, 23—24°) it was 70.6°. In the frontal plane 48.6°. In this plane the greatest mobility was between the 2nd and 5th lumbar vertebrae and the least was lumbosacral.

Alvik obtained 63.8° in the sagittal plane and mobility here was greatest between L4 and L5 and L5 and S1. In the frontal plane mobility was 51.1° with the greatest mobility in L3—L4 and the least in L5—S1.

THE PATHOLOGY OF THE INTERVERTEBRAL DISC

The pathological changes in the intervertebral disc have been described by: *Luschka* (1856), *Uebermuth* (1929), *Schmorl* (1926, 1927, 1929, 1930, 1932), *Junghanns* (1930), *Püschel* (1930), *R. Smith* (1931), *Andrae* (1929), *Böhmig* (1929), *Beadle* (1931), *Donohue* (1939), *Deucher* and *Love* (1939), *Coventry, Ghormley* and *Kernohan* (1945), *Inman* and *Saunders* (1947), *Bradford* and *Spurling* (1945), *Keyes* and *Compére* (1933), *Güntz* (1937), *Putti* (1930), *Friberg* and *Hirsch* (1949) and others.

During life the discs undergo continuous changes in structure and character in such a manner that it is difficult to decide what is normal and what is pathologic. Degenerative changes are so usual in backs that are considered healthy in middle age that the changes must for the most part be regarded as belonging to age in an organ that is subjected much destructive power. This has been especially illustrated by *Schmorl* and *Junghanns* (1932), *Junghanns* (1939), and *Coventry, Ghormley* and *Kernohan* (1945) who have made studies from enormous patho-anatomic materials.

Inman and *Saunders* (1940) say: "The causal factors in pathologic changes of the disc are often uncertain and whether they are in their initiation physiologic, degenerative, traumatic or inflammatory, they are for the most part not very dissimilar in nature, varying perhaps mostly in the degree of repair shown by such a relatively avascular structure."

The *cartilage plate* is the most resistent part of the disc. The power of resistence against any kind of trauma is great. It seems to be less damagable than the bone (*Beadle* 1931). This is also so in the case of inflammatory and neoplastic processes. The cartilage plate is of the greatest importance just because a disintegration of its continuity allows a disappearance of nuclear matter with accompanying loss of elasticity and degeneration of the disc. This has been proved experimentally on dogs, monkeys and rabbits by *Keyes* and *Compére* (1932), *Lob* (1933), *Tamman* (1934), *Filippi* (1935).

Changes in the cartilage plate can be primary or secondary to degeneration in the disc or to disease in the vertebral body. In advanced cases of cartilage plate destruction large parts of the nucleus can penetrate into the spongiosa like Schmorl's "Knorpelknötchen". The disc is thereby thinned, undergoes vascularization and at times ossification. These "Knorpelknötchen" were first described by *Luschka* (1858) and later by *Schmorl* (1932). According to Schmorl these interspongious disc herniations do not give any clinical symptoms. A general congenital weakening of the cartilage plate with multiple interspongious disc prolapses will according to Schmorl, be the cause of Scheuermann's adolescent kyphosis. This point of view is also supported by *Donohue* (1939).

Saunders and *Inman* (1940) describe a series of radiating fissures in the central part of the plate. These fissures are filled, on gross inspection, with a translucent material which histologically appears to be a relatively structureless cicatrix. According to *Uebermuth* (1929) and *Böhmig* (1930), these fissures were formerly the place for vessels that gave nutrition to the disc and which are obliterated and are now the basis for herniation of the nucleus in youth. But on the other hand, the high frequency of these fissures in the cartilage plate occurring in the older ages would indicate that they are of a degenerative nature (*Saunders* and *Inman*, 1940).

Rupture of the cartilage plate can occur secondary to a lessened firmness in the spongiosa of the vertebral body such as, for example, in osteoporosis where nucleus' turgor entails that it swells out and penetrates the vertebral body — fish vertebra. Similar ruptures are seen in inflammatory conditions and in tumours.

The cartilage plates do not disappear during the general degeneration process in the disc with rising years but changes in the form of cartilaginous degeneration, fissures calcification and fibrosis are often already far advanced between the ages of 30—40 (*Coventry, Ghormley* and *Kernohan*, 1945). The degree of changes in the cartilage plate in so-called pathologic

disc degeneration varies. In certain cases the changes in the disc are pronounced but the cartilage plate is intact whilst in other cases the cartilage plate is highly changed (*Junghanns*, 1939, *Inman* and *Saunders*, 1940).

The Nucleus Pulposus changes in structure from childhood to old age. In childhood the nucleus is well demarcated from the annulus. Histologically it consists of a fairly loose network with primitive cells and Virchow's physalipherous cells (*Coventry, Ghormley* and *Kernohan*, 1945, *Saunders* and *Inman*, 1940). During the second decade the transition between the annulus and nucleus is less distinct, the cells get fewer, the fibrous layers increase and the nucleus takes on a more homogenous character. In the third decade a number of cavities arise in the nucleus and cartilaginous cells also appear. Dehydration takes place successively. By degrees the nucleus assumes more and more the character of fibro-cartilaginous tissue and thereby loses more and more its elasticity (*Junghans*, 1939, *Coventry, Ghormley* and *Kernohan*, 1945).

Degeneration of the disc can occur already at the age of 20 years (*Inman* and *Saunders*, 1940). *Günz* (1937) describes the appearance of a disc degeneration in the following manner: fissures in the annulus fibrosus extending into the nucleus cavity cause the nucleus fluid to flow out, the tissue dries and villi from the nucleus cavity depart. This leads to a destruction of the function of the nucleus and the whole disc. The nucleus can become dehydrated so that the whole disc gets brittle, parts can be knocked off and remain lying like necrotic bodies in the other intervertebral disc. The disc diminishes in height and often gives an abnormal mobility between the surrounding vertebrae. Calcium is occasionally deposited in the necrotic disc. Now and then one can even see so-called brown degeneration in the neighbourhood of the cartilage plates. This brown degeneration is certainly not a residue from hemoglobin as it does not react to iron (*Schmorl*, 1932).

Different stages of repair can gradually take place consisting of an increase in the fibrous and cartilaginous tissue

for the purpose of replacing the degenerated nucleus. Even vessels grow in. At length one can even get an ossification of the degenerated disc.

In connection with these processes of repair a sclerosis of the covering plate can occur and this can reach a high degree.

Annulus Fibrosus. Coventry, Ghormley and *Kernohan* (1945) have described the normal aging of the annulus fibrosus. Right from the age of six the annulus fibrosus is fully developed and begins to grow in conjunction with the ligamenta longitudinalia anterior and posterior. During the second decade the annulus gets more and more strong, but at the end of the 2nd decade degenerative changes are noticed in the form of reduction of the nuclei and hyalinization. In the third decade one sees fissures, edema and more pronounced hyalinization. In the fourth decade one notices, besides fissures and hyalin degeneration, pigmentation and incipient vascularity especially in the posterior region of the annulus. "This invasion of the fibrocartilage of the annulus by blood vessels may be an attempt on the part of the body to strengthen and nourish a structure which has become weakened and degenerated". In continuation these degenerative changes increase and one also finds necrosis more or less ossified, hyaline degeneration and cicatricial tissue and the annulus fuses with the nucleus into a more or less homogenous mass.

The same changes that are seen in the physiological aging of the annulus is also seen in the disc degeneration occurring in younger years, but the course is more rapid whilst the most predominant feature in the picture are the fissures. *Saunders* and *Inman* have observed 2 types of fissures, the concentric which are more frequent forwards and occur most in senile kyphosis, and the radiating which appear for the most part dorsally and through which nucleus material can force a way out into the spinal canal.

PHYSIOPATHOLOGY

Barr (1947) says: "The syndrome of the ruptured disc, which pressing on one or more the nerve roots of the lumbo-

sacral plexus, causes intractable sciatic pain, has been so well demonstrated that it is accepted by practically every physician today" and further: — "a ruptured invertebral disc may cause no symptoms; it may produce a classical case with essentially all the usual signs and symptoms, or it may produce typical and variable symptoms and signs" and further: — "it is important to realise that patients with back pain, but no leg pain may be suffering from a ruptured intervertebral disc."

Love (1947) says: "Even the more frequently encountered lateral disc protrusions with low-back pain and unilateral sciatic pain produce recurring backache for a long time before the onset of true sciatic pain." He believes that this is due to stretching the posterior longitudinal ligament without compression of the roots of the sciatic nerve. When the fragmented disc subsequently breaks through the ligament and comes in contact with the root, pain arises in the same way as in pressure from a tumourous formation. But even without rupture of the ligament a root pressure can arise. Love says further that the ligamentum flavum can itself produce root compression through irritation.

Steindler (1947) discusses the pain mechanism in disc degeneration. In his opinion no pain can emanate from a healthy disc. He compares the disc with a joint where the cartilage is thought not to give pain but where the surrounding capsule, ligament and musculature do give pain. In the same manner the pain in disc degeneration originates from the ligament and the back musculature. If the disc degenerates and loses height, changed conditions arise not only between the spines but even between the arches and intervertebral joints. The ligament slackens, stability between the spines lessens and they can be pushed in various directions. It is this destruction of the balance in the back which produces the pain.

Inman and *Saunders* (1947) consider that pressure from the disc herniation on a nerve root alone cannot produce pain and they base their opinion upon experimental investigations. There must be other influences which are unknown. *Lindahl* and *Rexed* (1950) are of the same opinion. They give an in-

teresting complement to this question by means of histological investigations of biopsies carried out on the spinal nerve roots of 10 operated cases of sciatica. This material together with 23 cases described in the literature where the nerves in a sciatic condition were examined post mortem and showed, in 78 %, pathologic changes which led them to draw their conclusions that pathologic changes in the nerves and nerve roots in sciatica are a usual happening and that these changes, in some cases at least, should not be brought about by pressure from disc herniation. A similar investigation was made by *Lindblom* and *Rexed* in 1948. In 17 cases of section, where the nerve was exposed to compression from disc herniation, a serial sectioning of 44 nerves, nerve roots and root sheathes was made. Besides the purely mechanical deformation they found a slight increase of connective tissue substance in the perineurium and varying degenerative and regenerative phenomena in the nerve fibres. There was no cell infiltration in any case. If the spinal ganglion itself was compressed, a more pronounced formation of connective tissue arose than when the nerve was compressed. From this material, then, it was possible to estimate the reaction of the segmental nerve to compression.

Hirsch (1948) has made an interesting contribution to the question of the genesis of low back pain. In sixteen cases of relapsing low back pain a transdural puncture of one or both of the two lowest lumbar discs produced pain identical with the patient's spontaneous pain. Pain occurred either at the moment of puncture or when the intradiscal pressure was increased by introducing normal saline under pressure. It rapidly disappeared, and the Laségue sign was either markedly reduced or abolished, with the injected of ½ cc of 1 % solution novocaine into the disc.

Wiberg (1949) made examinations at disc operations and showed that pain could be caused by touching the surface of the disc but not by touching the surfaces of the vertebrae of the ligamentum flavum. He believes that it is conceivable that pain arises from the ligamentous covering of the disc.

Putti (1927), *Ghormley* (1933), *Hadley* (1935), *Lange*

(1936), *Badgley* (1941) and others are of the opinion that changes in the intervertebral joints, subluxations, arthrosis and arthritis are causes to low back diseases. Ghormley has coined the expression "facet syndrome" for pains in the lumbo-sacral region.

To sum up it may be said that despite the extensive investigations of the anatomy of the intervertebral disc as well as its physiology and pathology it is not possible to regard as being clear how or from where the pains in low back pain emanate. That the intervertebral discs, however, play an important part must be regarded as being evident because of the satisfactory results that have been obtained from disc surgery, extirpation of disc prolapses and spinal osteosyntheses.

CHAPTER II

PREVIOUS INVESTIGATIONS OF THE ROENTGENOLOGICAL PICTURE, THE CONNECTION WITH TRAUMA AND THE VALUE OF CONSERVATIVE TREATMENT IN LUMBAL DISC DEGENERATION

The literature dealing with the clinical picture of lumbal disc degeneration is comprehensive. It is not the intention of the author to give even anything like a complete list of the works that deal with this subject. A number of monographs have been published. The author will only mention the following authors who have actually contributed to the elucidation of clinical picture of lumbal disc degeneration: *Barr* and *Mixter* (1934), *Barr* (1937, 1938, 1947), *Love* (1936, 1939), *Love* and *Camp* (1937), *Barr, Hampton* and *Mixter* (1941), *Naffziger, Inman* and *Saunders* (1938), *Alajouanine* and *Petit Dutaillis* (1928, 1929, 1941), *Petit Dutaillis* and *De Séze* (1943, 1945, *Marble* and *Bishop* (1945), *Steindler* (1947), *Keegon* (1944), *Bradford* and *Spurling* (1945), *Norlén* (1944), *Friberg* (1941), *Friberg* and *Hirsch* (1949).

The author intends, in this historical survey, to throw light upon the following characteristics in the clinical aspect of lumbal disc degeneration i. e. the *roentgenological picture, the connection with trauma and the value of conservative treatment.*

A discussion about the *roentgenological picture* is, in point of fact, also a discussion about the clinical diagnosis since it is roentgenological in disc degeneration. This, however, does not apply to cases without roentgenological changes, where

disc herniations is extirpated. Disc prolapse is partly a phenomenon of degeneration of the disc.

Schmorl and *Junghanns* first described the roentgenological picture in degeneration of the disc (1927, 1928, 1932). They have made comparative roentgenological and anatomical investigations on a comprehensive patho-anatomical material. They found sclerosis and osteophytes on vertebral margins, lowered interspace and "Wirbelverschiebung nach hinten". Similar investigations and observations have also been made by *Hildebrandt* (1933).

Clinico-roentgenological observations of *lowered interspace, sclerosis and osteophytes on vertebral margins* in connection with low back and sciatic pain have been made by several authors. Thus *Ayers* (1929) found a thinning of the lumbosacral cartilage and arthritit involvement of the facets in thirty six cases of low back pain. In one case ankylosis had occurred between the 5th lumbal vertebra and sacrum. He says: "this thinning of the cartilage intimates that there is degenerative process going on". *Williams* (1937) found narrow lumbo-sacral discs in 71.25 % of 400 cases of low back and sciatic pain. *Badgely, Peck* and *Hodges* (1937) found 57 % narrow lumbo-sacral joint spaces in 447 patients suffering from low back and sciatic pain, whilst, in a control material of 528 persons, they only found 12.8 % with lowered lumbosacral disc. *Macey* (1940) observed a reduction in the interspaces of the 3rd, 4th and 5th discs in 28 cases out of 100 patients with disc herniation. *Willis* (1941) observed narrow lumbo-sacral discs in 25 % of 79 patients with low back pain.

By *retroposition* of its synonyms (posterior displacement, backward displacement, retrospondylolisthesis, posterior luxation, Wirbelverschiebung nach hinten) is meant that a vertebra is more or less displaced backwards in relation to the vertebra under it. This means a stabile displacement and not one that occurs in instability. This phenomenon has been described by *Schmorl* and *Junghanns (1926,* 1932), *A. de Forest Smith* (1920, 1934), *Hibbs* and *Swift* (1929), *Willis* (1935), *Williams* (1937), *Knutsson* (1940), *Friberg* (1941), *Severin* (1943),

Malemed and *Ansfield* (1947), *Fletcher* (1947), *Hagelstam* (1949) and others.

Knutsson (1940) who has introduced the term "retroposition" also found in isolated cases a forward gliding of a vertebra in relation to the one immediately under it, *anteposition*. In Knutsson's opinion this displacement of the vertebra was a sign of disc degeneration and that it might occur anywhere where there was a degenerated disc.

Hagelstam (1949), in a dissertation entitled "Retroposition of lumbar vertebrae" has thoroughly elucidated this phenomenon. He introduces a method for measuring the retroposition on roentgen plates. By means of this method he considers that he can measure a retroposition of under 2 mm, which is the limit of what one can see on mere inspection. In 79 % of 119 cases of low back pain and/or sciatica Hagelstam found retroposition of the 5th lumbar vertebra. He also found retroposition in twelve healthy people.

Instability of the lumbar vertebrae has been described by *Ferguson* (1934), *Brocher* (1938), *Knutsson* (1944) and *Hagelstam* (1949).

Ferguson (1934) gave the following definition of instability: "On hyperextension, the lumbo-sacral joint being hypermobile, the fifth lumbar glides backward on the first sacral vertebra, an exaggeration of the normal motion. Then on flexion, instead of gliding forward, the fifth lumbar tilts forward, being caught in the position of posterior displacement".

Brocher (1938) on post mortem preparations cut through the fifth lumbar disc, placed the back in lordosis and took roentgen pictures. He found a displacement of the fifth lumbar vertebra of 3 mm, and a narrowing of the intervertebral foramen.

Knutsson (1944) described a functional test of the instability of the disc junction and used the method as a routine in roentgen examinations of the lumbar vertebrae. He says: "when the disc is degenerated, there often appear signs of instability in the form of parallel displacement and abnormal

tilting movements between the vertebrae. In a large number of cases these signs of instability were the only manifestation of disc degeneration, the intervertebral space and surfaces of the vertebral bodies being intact. In this way, *Knutsson* has given a very valuable method of making an early diagnosis of disc degeneration. *Friberg* and *Hirsch* (1949), on a pathoanatomic material, have been able to verify the fact that the roentgenological instability, even in the total absence of other roentgenological changes, corresponds to widespread degenerative changes in the intervertebral discs. *Hagelstam* (1949), who has used the same method of measuring instability as used in retroposition, found, in 20 patients with low back pain and/or sciatica, the majority of lumbar vertebrae to be instabile. In twelve healthy young people who showed no roentgenological signs of disc degeneration he also found a slight instability of the majority of the lumbar vertebrae.

Mardersteig (1935), *Magnusson* (1937) and *Knutsson* (1940), have shown "*vacuum phenomenon*" roentgenologically with free air in the intervertebral discs. Knutsson points out that this phenomenon appears essentially when the lumbar vertebrae are in lordosis.

The method of puncturing of disc and filling it with an opaque contrast medium described by *Lindblom* (1948) is a step forward in the early diagnosis of disc degeneration. This enables disc ruptures and protrusions to be demonstrated besides indicating whether the patient's symptoms originate from the punctured disc.

Middleton and *Teacher* (1911) give a report of a man who suddenly got violent pains in the lower extremities accompanied by paraplegia after lifting a heavy burden. When a section was made some six weeks later, a rupture of the intervertebral disc was discovered between the 11th and 12th thoracic vertebrae. The mass was white and firm, and particularly resembled the central pulp of the intervertebral disc. This and similar cases previously gave the idea that *the intervertebral disc was easily damaged by trauma.* The ever increasing interest in the intervertebral disc during latter years

has caused the connection between trauma and disc degeneration to come into prominence especially from a technical point of view of insurance.

Beadle (1931), *Friberg* (1941) have both shown experimentally that in fractures of one or more vertebrae, caused by violent trauma, the discs often show a notable power of resistance.

Pease (1935), *Milward* and *Grout* (1936), *Gellman* (1940) and *Munro* and *Harding* (1942) report disc changes which they regard as having been caused by lumbar puncture. *Lindblom* (1948) and *Hirsch* (1948) have not noticed any complications when they have had to resort to puncture of the discs for the purpose of diagnosing low back pain. *Friberg* (1941) has found, when making experimental investigations on post mortem material, that puncturing of healthy, loaded discs does not produce disc herniation, not even if they are considerably loaded.

Günz (1936) reports that in one third of forty eight cases of disc degeneration (osteochondrosis) there was trauma. *Günz* thinks that repeated trauma produces ruptures in the posterior section of the annulus fibrosus. As a consequence of these changes, degeneration of the disc gradually appears. When at some later date, perhaps many years later, a trauma occurs, the patient will get trouble. Günz thinks that a trauma cannot directly cause a change in the disc that will give trouble.

Severin (1943) says: "Heavy work causes disposition toward disc degeneration or at least spinal symptoms in disc degeneration, but is not a decisive etiologic factor. A trauma not seldom incites symptoms from a previously latent disc degeneration, but is not the cause of degeneration except in exceptional cases".

Friberg (1941) found trauma given in 18.2 % of 44 cases of disc herniation.

Petit Dutaillis and *de Séze* (1945) give a description of 45 patients with disc herniation, eighteen of whom reported trauma.

Waris (1948) has described 374 patients that were operated

on for disc herniation and found that of the 84 cases that were "traumatic", there were only 26 where trauma could be regarded as being the cause of disc herniation.

Spurling and *Bradford* (1945), *Magnusson* (1945), *Love* (1947) and others report trauma to greater or lesser degrees in their materials.

Schmorl (1932) is of the opinion that repeated strain on the disc can cause disc degeneration sooner that one single trauma.

Summarily, then, it would seem that it is an accepted opinion that one single trauma could scarcely bring about degeneration of the intervertebral disc immediately, whilst that lesser, repeated traumas and strain in connection with heavy work can bring about disc degeneration and further, that a single trauma that happens later on only liberates the trouble in a disc that has previously undergone changes.

The conservative treatment which is given in low back pain consists of rest in special positions, corsets, medications and physical therapy. It is the general opinion that no surgical intervention shall be resorted to until the regular conservative treatment has been given and proved fruitless. Although conservative treatment is given to a very large extent, the information as to the results so attained are much more scanty than is the case in regard to those attained by surgical treatment.

De Forest Smith (1938) found conservative methods satisfactory in about 90 % of the patients treated for low back pain. Lumbo-sacral fusion was indicated in about 10 %.

Kuhns (1941) reports the results of treatment given to 1000 patients examined for sciatic pain and low back disability. Roentgenographic examination of these patients showed abnormalities of the lumbar spine and sacrum in 323 cases. The result as to relief in pain was that 771 were relieved, 72 were not relieved and 157 were unknown.

Brahme (1942) has examined 580 patients who have been conservatively treated: of these, 363 were free from symptoms, 133 were capable of working but not free from symptoms, and

62 were totally incapable of doing work because of their disease.

Severin (1943) found that only 4.7 % of the 144 patients with disc degeneration who have been given physical therapy or corset unimproved.

Boman (1944) has examined 186 severe cases of low back pain who were treated conservatively and, of these, 68 were cured, 52 were improved and 66 showed no improvement.

Kirstein (1945) made a post examination of 25 operated and 24 non-operated patients suffering from the sciatic syndrome with roentgenological symptoms of a space-restricting process in the spinal canal. 72 % of the operated cases and 37.5 % of the non-operated ones were free from radicular pains when post examined.

Durbin (1948) made a post examination of 147 patients with sciatic symptoms and neurological symptoms. 123 of these were treated by means of plaster jackets and 24 by other methods. One third were cured, one third were relieved and the remaining third got no relief at all.

The often very lengthy course of low back and sciatic pain has been pointed out. Thus *Brahme* (1942) says: "Lumbago-ischias may occur as a chronic illness which continues all through life, and which prevents the sick person from ever taking up his work again to full extent".

Malmros (1942) found lumbago trouble in 86 cases out of 90 patients with sciatic pain. The following table gives the course and duration of the trouble in these 90 patients.

TABLE 1 A

34 patients in whom the course was continous

Duration	Number
3 months—1 year	18
1—2 years	8
2—5 years	8
Minimum 3 months	
Maximum 5 years	

TABLE 1 B

56 patients in whom the course was intermittent

Duration	Number
1— 5 years	13
5—10 years	19
10—20 years	18
20—30 years	6
Minimum 1 year, 9 months	
Maximum 30 years	

Back trouble was the beginning of the complaint in fifty eight patients.

Waris (1948) found that the duration of the trouble in 374 patients who had been operated on for disc herniation was as follows:

TABLE 1 C

Less than 1 year	30 %
1— 2 years	21 %
2— 5 years	23 %
5—10 years	9 %
More than 10 years	11 %

Disc degeneration, low back and sciatic conditions have been spoken about in this chapter. An objection might be raised that it has not been proved that it is the degenerative changes in the discs that are always the cause of lumbago and/or sciatica and it is not right to draw a similarly between this condition and disc degeneration. The author would like to refer to the clinical and anatomical investigations made by *Friberg* and *Hirsch* (1949). A scrutiny of 9,419 patients examined and treated for back trouble and sciatica during the years 1936—1946 showed radiographic disc degeneration in 39 % and in 50 % of the material for the last two years, when Knutsson's instability test was carried out as a matter of routine in every case.

One hundred spines were removed from post mortem specimens and studied. All were radiographed in flexion and extension. They found that marked degeneration was present without any radiographic changes being manifest. In cases where there was instability, there were also pronounced changes in the disc. Where the radiogram showed reduced disc space, sclerosis or osteophytes, the corresponding disc was severely demaged.

It would seem that this investigation gives very strong support to the opinion that *lumbago and sciatica have their origin in degenerative changes in the intervertebral discs* and that one is not making any great mistake in placing low back pain on a par with disc degeneration.

CHAPTER III

THE FREQUENCY OF LUMBAGO AND SCIATICA AMONG THE MEMBERS OF THE STOCKHOLM SICK BENEFIT SOCIETY AND THE EMPLOYEES OF THE STOCKHOLM TRAMWAY COMPANY

The author has made an investigation of the frequency of lumbago and sciatica occurring amongst the registered members of the Stockholm sick benefit society during 1948. The material of the sick benefit society has been taken as a starting point because it is representative of the City of Stockholm as more than half of the population are registered members of this society. Nevertheless there must be a certain unavoidable selection since, because of the regulations applying to enrollment, the material of the Society must be more healthy than the people from whom they are taken. Therefore the figures which are given must be regarded as being minimum figures.

For this purpose the author has made use of the medical history cards which contain such particulars as diagnosis, the number of days of illness, time spent in hospital, any operative intervention, name, age and sex of the patient. Only such diagnoses have been accepted where it has been possible to know with certainty that the diseases under discussion have been manifest. The following diagnoses have been accepted:

Lumbago c. neuralgia ischiadica
Sciatica
Dorsal insufficiency
Acute dorsal insufficiency
Intervertebral disc herniation
Acute and chronic lumbago
Low back pains
Dorsal myalgia
Intervertebral disc degeneration
Traumatic lumbago.

The same investigations have been carried out in the Stockholm Tramway Company. This company was chosen partly because it has a large number of employees — 6.948 men and 533 women — and partly because of the supposition that persons who work on rolling stock show a higher frequency of this disease.

It must be pointed out that the diagnosis is supported by the medical history card i. e. the diagnosis made by the doctor. In some cases, exactly how many is not possible to say, this diagnosis has been confirmed by roentgenography although there are many who have never been roentgenographed.

Telefsen (1949) made a similar investigation of a sick benefit society material. He examined 1934 the material belonging to the Oslo Sick Benefit Society comprising 104.827 persons. His investigation concerned category of disease called "rheumatic diseases" which included lumbago and sciatica. The working incapacity for these diseases amounted to 119,106 days of sickness representing 13.02 % of the total number of sick days. It has not been possible to estimate the frequency of lumbago and sciatica because of the classification of the material.

Biörck and *Blomquist* (1949) studied infirmity and fatality in heart and vascular disease occurring within the Stockholm Sick Benefit Society in 1942. They found that the relative number of cases of illness was 2.1 % for men and 2 % for women for the whole of the sick benefit material for that year.

In connection with this it might be of interest to draw attention to the investigation made by *Friberg* and *Hirsch* (1949). They have gone through all the cases that have been examined for back trouble at the Orthopedic Clinic of the Karoline Institute during the years 1936—1946. During these 11 years, 15.150 cases have been examined and 9.419 of them were roentgenopraphed. Roentgenological signs of disc degeneration were observed in 3.673 cases (39 % of the 9.419 cases). See attached table and diagram taken from Friberg and Hirsch's work.

TABLE 2

Years of investigation	Number of cases examined	Number of cases roentgenographed		Number of cases with disc degeneration	Disc degeneration in % of number of cases roentgenographed
		%	Total		
1936	491	350	71	53	15
1937	663	480	73	78	16
1938	800	506	64	123	24
1939	794	467	67	153	33
1940	1140	625	55	194	31
1941	1374	700	51	230	33
1942	1678	907	54	285	31
1943	1958	1117	53	452	41
1944	1869	1217	64	586	49
1945	2033	1361	67	680	50
1946	2360	1689	76	838	50
Total	15160	9419		3672	39

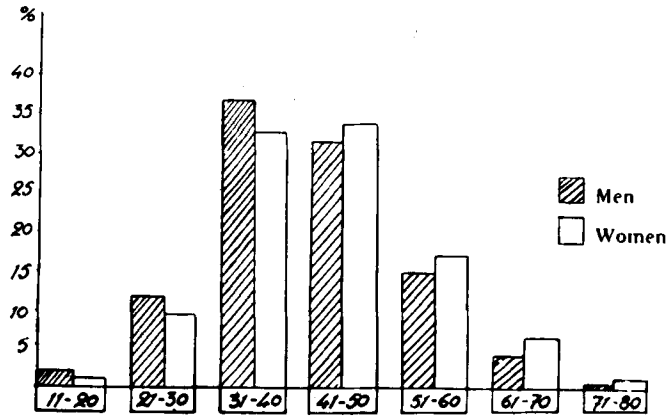

Diagram 1.

STATISTICAL INVESTIGATION OF CASES OF LUMBAGO AND SCIATICA (L. S.) REGISTERED WITH STOCKHOLM CENTRAL BENEFIT SOCIETY

The number of members in the sick benefit socities in Sweden has greatly increased since the beginning of the twenties. The figures for the numbers joining the societies

were, for men, in 1920, 486.433, in 1940, 749.945 and in 1947 they were 1.328.757. The corresponding figures for women were 231.374, 726.379 and 1.432.583. No exact comparative figures for 1948 can be given until May 1950. The total number of members for 1948 has been preliminarily estimated at 2.879.000 which estimation, in round figures, shows an increase of about 100.000 members. Se table below.

TABLE 3

Year	Men	Women	Total
1920	486.433	231.374	717.807
1940	749.945	726.379	1.476.324
1947	1.328.757	1.432.583	2.761.340
1948	—	—	2.879.000 (preliminary est.)

Of the adult population (from and including the age of 15), there were 50.8 % men and 53.5 % women registered in the recognised sick benefit societies.

The following figures for Stockholm City are now available and show the number of members enrolled at the end of 1947 and 1948.

TABLE 4

Year	Men	Women	Total
1947	106.684	180.649	287.333
1948	117.270	179.507	296.777

The above table shows that the male members have increased by about 10.500 whilst there has been a decrease in the women of a good 1.000 during 1948.

The statistical investigation of the actual members of the Central Sick Benefit Society, Stockholm, was carried out in order to show how often the disease low back and sciatic pains (L. S.) occurs during 1948. During that year there was a total of 116.767 notified cases of sickness — 71.588 women, 37.721

men and 7.458 children (persons under the age of 15 years).

The investigation was further limited to apply only to men and women between the ages of 15 and 64 years i. e. to the so-called productive ages. There seemed no justification in including children with a very poor frequency nor to let the investigation embrace a further 5-year group namely persons between the ages of 65 and 69, a group with a falling frequency. Pension begins at the end of the 65 year. In the statistical yearbook for 1948 the average length of life for the period 1936—1940 was for men and women 64/65 resp. 66/67.

From the masses comprising cases of sickness occurring in men and women from and including the ages of 15 and 64 years, 5.229 cases of L. S. were noted: of these 2.433 were men and 2.796 were women. This group represents 4.5 % of all cases of illness.

So as to be able to compare the frequencies obtained with one another, the notified cases of L. S. have been expressed in % to the average number of members in each group of ages. The following table has been arrived at:

TABLE 5

Age	Men			Women		
	Cases of L. S.	Average number of members	%	Cases of L. S.	Average number of members	%
15—19	17	7241	0.235	36	8153	0.442
20—24	70	9557	0.732	131	15928	0.822
25—29	195	15589	1.251	301	24522	1.227
30—34	300	15265	1.965	411	22942	1.791
35—39	440 1022	1624 63866	2.214	603 1482	25729 97274	2.344
40—44	422	14660	2.879	518	23888	2.168
45—49	378	11672	3.239	363	18662	1.945
50—54	283	8243	3.433	256	12677	2.019
55—59	181	5221	3.467	109	8033	1.349
60—64	147 1411	4748 44544	3.096	63 1314	6425 69735	1.058
Total	2433	108440		2796	167009	

The table shows that the relative frequency in regard to men begins with about 0.2 and rises rapidly to 2.2 (age 35—39). The corresponding development can be fixed for women — the small deviations which exist are quite insignificant.

From and including the 40th year the development for men, on the one hand, and for women, on the other, is quite different. The relative frequency for men rises continuously up to the 60th year after which a very pronounced decrease can be noticed: thus from 2.2 to between 3.5 and 3.1. The relative frequency in regard to women decreases after the 39th year from 2.2 to 1.1 for the age group 60—64.

In order to be able to follow the development more easily, the following diagram has been drawn up:

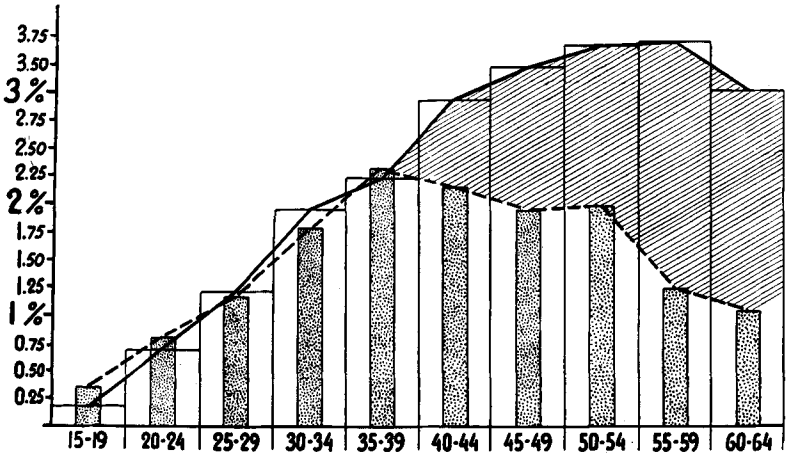

Diagram 2.
Relative distribution of the notified cases distributed in age groups.

The columns with straight lines represent the frequencies for men whilst those with dotted lines represent those of the women. The diagram shows the marked difference between men and women in ages from 40 to 64 inclusive. The development from and including the 15th year to the 40th year is the same for both sexes.

The above calculations give the following four-field table

(table 6). This is merely a classification of the previously drawn up table of notified cases of L. S., the average number of registered members and percentage.

TABLE 6

		Age 15 to 39 incl.	Age 40 to 64 incl.
Men.	Notified cases.	1022	1411
	Average number of registered members.	63866	44544
		$P_1 = 1022/63866$	$P_2 = 1411/44544$
		$Q_1 = 62844/63866$	$Q_2 = 43133/44544$
Women.	Notified cases.	1482	1314
	Average number of registered members.	97274	69735
		$P_3 = 95792/97274$	$P_4 = 1314/69735$
		$Q_3 = 95792/97274$	$Q_4 = 68421/69735$

From the above table will be seen the number of notified cases and the average number of registered members of the Central Sick Benefit Society, within two age groups, 15—39 and 40—64 years; the men and women are separated. The signs P and Q are the relative frequencies and therefore give the true relationship within each group of a certain mass of people belonging to a certain age group.

The method used to determine the statistic certainty is called "the average deviation in the difference between relative frequencies"[1]) (e. g. P_1—P_2 (the difference) $\pm$ the root of $(P_1 \times Q_1)\ n_1$ plus $(P_2 \times Q_2)\ n_2$ (the average deviation) where n is the number of members within each field. If an occurrence is statistically assured the average number "taken three times" is less than the difference between the different similarities, for example P_1 and P_2.

The above experiment in respect of the notified cases in the sick benefit society shows the following:

[1]) In this work, calculated only with 3 times the average deviation.

1) $P_2 - P_1 = 0.156742 \pm 3 \times 0.000967$, a statistically established difference
2) $P_2 - P_4 = 0.0128337 \pm 3 \times 0.0009767$ „ „ „
3) $P_1 - P_3 = 0.000767 \pm 3 \times 0.0006332$ not a statistically „ „
4) $P_4 - P_3 = 0.0036075 \pm 3 \times 0.0006473$ is a statistically „ „

From the above it will be seen that men between the ages of 40 and 64 are more prone to L. S. than men between the ages of 15 and 39. There is no difference as regards men and women in the latter age groups. With regard to men and women in the higher age group it will be seen that men are more prone to L. S. than women; despite the falling tendency for women over 39 years of age, a statistically assured difference is obtained in comparison with women between the ages of 15 and 39.

The investigation of the Central Sick Benefit Society also took into consideration the number of days of sickness for each sex. It it also noted the number of cases who were operated on and how many were admitted to hospital. The following table gives the result of this collation (table 7).

With regard to the days of sickness stated above, the numbers of the men in each field are on the left hand side whilst those of the women are on the right. The final total for each sick-day unit is given in the same manner.

The table shows that, in general, men have a lower average in respect of the number of sick days. The following four field table has been drawn up in order to investigate the statistical certainty (table 8):

TABLE 8

		Under 22 days [1]	More than 22 days	6 months
Men.	Notified cases	1381	1052	2433
	Expressed in %	56.79	43.21	
Women.	Notified cases	1092	1704	2796
	Expressed in %	39.07	60.93	
	Total number	2473	2756	5229

[1]) 22 days have been chosen because, as will be seen from the table 7, the frequency for men here begins to show a falling tendency.

TABLE 7

Age	Men	Women	Number of sick days																Totalt	Operative Intervention		Admitted to Hospital	
			4—7		8—14		15—21		22—28		29—42		43—70		71—120		4—6 months		> 6 months			Men	Women	Men	Women
15—19	17	36	2	3	6	11	3	7	1	4	2	4	2	7	1	—	—	—	—	—	53	—	—	2	1
20—24	70	131	16	13	17	33	11	23	7	18	4	14	7	13	6	12	1	3	1	2	20	2	—	5	7
25—29	195	301	38	25	57	48	27	49	11	27	22	48	13	44	18	32	6	14	3	14	496	1	2	14	28
30—34	300	411	31	23	88	70	50	61	29	44	39	77	33	58	17	39	5	28	4	11	707	2	1	24	33
35—39	440	603	54	48	120	92	90	80	41	66	50	94	41	89	25	68	9	38	5	28	998	3	8	34	61
40—44	422	518	54	30	107	92	75	67	35	51	61	68	40	95	34	59	11	31	5	25	940	9	4	44	48
45—49	378	363	45	25	98	52	75	48	36	38	36	69	37	55	35	45	12	18	4	13	746	1	2	28	34
50—54	283	256	33	13	77	50	50	31	20	22	41	45	36	46	17	32	4	13	5	4	537	—	1	18	15
55—59	181	109	17	2	38	11	22	13	21	9	34	21	27	20	14	16	2	6	6	5	290	3	—	12	12
60—64	147	68	16	4	33	8	22	13	12	6	24	21	13	20	13	3	12	3	2	5	194	—	—	4	2
Total	2433	2796	315	186	641	473	425	392	213	285	313	454	249	439	180	306	62	154	35	107	5229	21	18	185	241

The following expresses the average deviation in the differences between the relative frequencies:

$$60.93 - 43.21 \pm \sqrt{\frac{56.79 \times 43.21}{2433} + \frac{39.07 \times 60.93}{2796}} = \pm 1.361$$

$17.72 \pm 3 \times 1.361.$

3 × the average deviation gives no figure that goes up to 17.72, that is to say, the difference; the difference is therefore statistically established. As a rule men show a shorter period of illness than women.

Table 5 tells us the number of sick days per 100 members registered in the sick benefit society. In our case we have eliminated those persons whose period of illness exceeds 6 months: these cases can be regarded as being extreme. Such deviations as, for example, a case that fell sick at the end of 1947 but recovered some time during 1948 is regarded as corresponding to another similar case, but with this difference, however, that there is a prolongation of the time by one year. It is a levelling up, not 100 % of course, but good enough, at all events, as the difference that does arise is of little or no importance in the present circumstances: a large material from which a relatively large number have been selected and treated statistically.

We have found that the total of 73.429 sick days for men and 11.365 for women were caused by L. s. As the average number of members falling within the age groups under consideration were 108.440 and 167.009 respectively, the result is that the number of sick days per male member is 0.68 and for women 0.68 as well.

The figures for the sick days for the whole of the sick benefit society for 1948 have not yet been finally calculated so we are only able to give the figures that have been estimated preliminarily. These tell us that the number of days subject to sick benefit was 11.4 for men and 16.8 for women.

TABLE

Number of days

Age	4—7				8—14				15—21				22—28				29—42			
	1	2 3	4 5	6 7 8	1	2 3	4 5	6 7 8	1	2 3	4 5	6 7 8	1	2 3	4 5	6 7 8	1	2 3	4 5	6 7 8
20—24	—	4	—	—	1	2	1	—	—	—	3	—	—	—	—	—	—	—	—	—
25—29	1	4	4	—	—	13	6	2	—	9	3	2	—	3	3	—	—	2	1	—
30—34	—	4	1	2	—	16	8	6	—	5	4	—	—	4	—	2	—	7	2	2
35—39	—	6	—	4	2	5	3	6	—	1	4	4	—	1	2	—	—	3	2	2
40—44	1	4	3	7	—	5	3	1	—	1	1	3	1	1	—	—	—	1	1	1
45—49	—	1	—	3	—	3	2	2	4	4	—	—	—	—	—	2	—	4	—	2
50—54	1	7	2	2	1	10	—	6	3	6	—	2	—	7	—	1	1	—	1	2
55—59	1	5	—	—	—	4	—	1	—	4	—	1	1	—	—	2	1	3	—	1
60—64	—	—	—	—	—	3	—	—	—	—	—	1	1	2	—	1	—	2	—	1
	4	35	10	18	4	60	23	24	7	30	15	13	3	18	5	8	2	22	7	11

Men between the ages of 20—64 classified according to age, number

It will be seen from table 7 that, in all, 426 cases — 185 men and 241 women — were treated in hospital for low back pains. The table also shows us that 21 men and 18 women were operated on. Unfortunately it has not been possible to investigate the nature of the operative intervention.

INVESTIGATION OF THE NUMBER OF CASES OF LUMBAGO AND SCIATICA DURING 1948, IN THE MATERIAL OF THE STOCKHOLM TRAMWAY COMPANY[1])

In connection with the investigation carried out in the Central Sick Benefit Society in Stockholm, the following examination has been made.

[1]) All collectively enrolled in the Central Sick Benefit Society.

9
of sickness

43—70				71—120				4—6 months				>6 months				Totalt				
1	2 3	4 5	6 7 8	1	2 3	4 5	6 7 8	1	2 3	4 5	6 7 8	1	2 3	4 5	6 7 8	1	2 3	4 5	6 7 8	1—8
—	1	—	1	—	—	1	—	—	—	—	—	—	—	—	—	1	7	5	1	14
—	8	—	—	—	3	1	1	—	1	—	—	—	—	—	—	1	43	18	5	67
—	4	2	2	—	1	3	1	—	2	—	—	—	1	—	—	—	44	20	15	79
—	4	1	2	—	—	1	1	—	—	1	—	—	1	—	—	2	21	14	19	56
—	—	—	2	1	1	1	—	—	—	—	—	—	—	—	—	3	13	9	14	39
—	1	2	—	—	3	—	—	—	—	—	1	—	2	—	—	4	18	4	10	36
2	3	1	1	—	3	—	1	—	6	—	—	—	—	—	2	8	42	4	17	71
—	3	1	2	—	3	—	—	—	1	1	—	—	—	—	—	3	23	2	7	35
—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	2	6	—	3	11
2	24	7	10	2	14	7	4	—	10	2	1	—	4	—	2	24	217	76	91	408

of days of sickness and trade. Figures 1—8 refer to trade groups.

During 1948 it was discovered that there were 408 cases of L. S. amongst the male employees of the Tramway Company and 37 amongst the women. These figures have been compared with the average number employed by the company. In this instance, however, it has been necessary, from a working point of view, to place the figures against the number of employees for the period 1/1—1/10/1949. The reason for this is that the category in question, belonging to the tramway company, has been re-classified so that the average number of employees for each age group could only be given after a great amount of work. There are, of course, disadvantages attaching to this, but they have no importance in the statistical treatment.

The average number of men employed by the tramway company in 1949 was 6948 whereas in 1948 it was 6791 which makes a difference of 157 persons. The difference within the group which is of interest to us i. e. "the traffic staff" (male), was 302. This is quite a considerable difference, but as the

differences shown below have been obtained by comparison with figures that are too high, they will consequently be even greater.[1])

The investigation comprised the following categories grouped in accordance with the wage system.

1) The administrative staff including departmental managers and such like persons.

2) & 3) Traffic employees, i. e. drivers and conductors.

4) & 5) Persons employed in the waggon and mechanical workshops.

6), 7) & 8) Workmen employed on the permanent way and buildings.

The same classification into age groups as was used in the investigation of the Sick Benefit Society has been maintained. As the number of women employed by this company is so small — 533 — and has been classified into two groups, the Administrative and the Traffic, we have decided only to give a short report, at the end of this paper, about the occurrence of dorsal diseases amongst them. They are not sufficiently numerous to justify a special statistically established calculation.

The following table has been drawn up to give us a better survey (table 10).

Table 10 gives a complete picture of the classification of L. S. It will be noticed that two categories are prominent i. e. the traffic staff and those employed in the waggon department and the machine shops. Naturally the workers on the permanent way and buildings show a high percentage but this latter group must be regarded as being too small to be statistically dealt with. The administrative staff is also too small. On comparing with the material from the Central Sick Benefit Society it has been found that if one wishes to work with any

[1]) That is to say, the percentage obtained in this investigation should have been greater if the number of cases had been placed against the average number employed during 1948.

TABLE 10

Age	Administrative staff			Traffic staff			Employees in waggon and machine shops			Employees on permanent way and buildings			Total
	Average number employed	cases of l. s.	%	Avcrage number employed	cases of l. s.	%	Average number employcd	cases of l. s.	%	Average number employed	cases of l. s.	%	
20—24	17	1	5.882	338	7	2.071	48	5	10.417	1	1	100.00	404
25—29	52	1	1.923	1390	43	3.094	183	18	9.836	51	5	9.804	1676
30—34	51	—	—	884	44	4.977	379	20	5.277	65	15	23.177	1379
35—39	63 183	2 4	3.175	497 3109	21 115	4.225	284 894	14 57	4.930	58 175	19 40	32.757	902
40—44	81	3	3.704	231	13	5.628	99	9	9.091	36	14	38.889	447
45—49	211	4	1.896	259	18	6.950	78	4	5.128	32	10	31.250	580
50—54	119	8	6.723	563	42	7.460	79	4	5.063	34	17	50.00	795
55—59	83	3	3.614	373	23	6.166	75	2	2.667	36	7	19.444	567
60—64	46 540	2 20	4.348	124 1550	6 102	5.839	15 340	— 19	—	13 151	3 51	23.077	198
	723	24	—	4659	217	—	1240	76	—	326	96	—	6948

degree of certainty, that is to say M[1]) (Central Sick Benefit Society) $\pm$ 1, one sees that approximately 900 persons would be quite sufficient. This means about 0.8 % of 110.000 persons within the age group of 20—64 years. In the following diagram the percentages in Table 10 have been placed together with the corresponding curve for the Central Sick Benefit Society. One sees that the tendencies in the Central Sick Benefit Society and the Traffic Staff are similar. The three other categories of the Tramway Company are too extreme to present a clear picture, and must therefore be regarded as being statistically uncertain: this also applies to the groups, Waggon and Machine Shop employees even though these groups comprise 1.240 persons. The classification within the category is not even and only the age-period 30—39 is acceptable (see diagram 3).

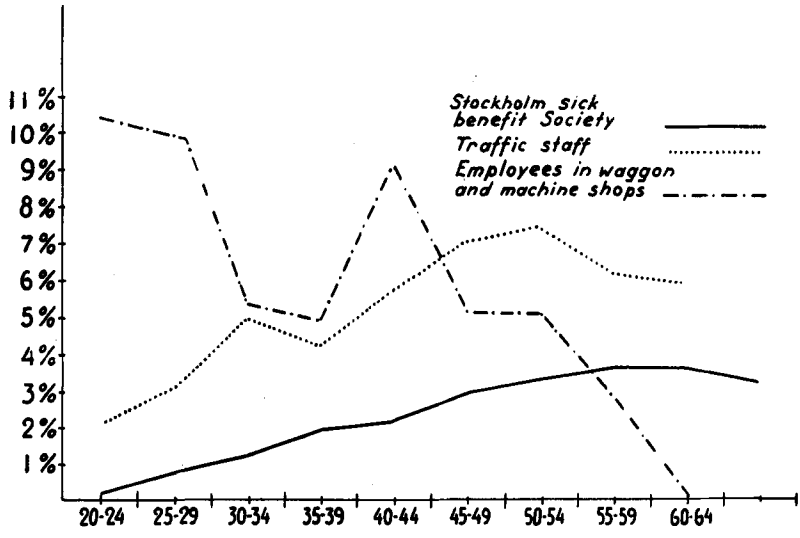

Diagram 3.

With regard to the Traffic Staff we have found the following:

[1]) The spreading round the average number, approximately 0.9: consequently in this case a relatively pronounced limitation of the material.

Age 20—39 years:

Of 3109 employed persons there was 115 cases of dorsal diseases which, in round figures, is 115/3109 — 0,03698 = P_1.

Thus we see that 2994/3109 is the relation between those who had no L. S. and the number employed within the group: the relation is called Q_1.

The quadrate for P_1 for the average deviation = P_1Q_1/n_1 = 0.00001143.

Age 40—64 years:

Of 1500 employees there were 102 cases of illness: therefore we get P_2 = 0.06582 and Q_2 = 1448/1550: the quadrate for the average deviation for P_2 will therefore be 0.00003967.

We should now examine whether there is any difference between the above groups:

The difference between P_2 and P_1 is 0.02884 and the average deviation of the difference is 0.07142. As the latter number, taken 3 times, does not reach 0.02884 (the difference), we conclude that the difference is symptomatic: here we have a statistically established difference.

In the material of the Central Sick Benefit Society we have the same conditions regarding men: from and including the 40th year they deviate quite considerably by showing a higher figure in respect to the occurrence of L. S.

If a comparison is made between the Central Sick Benefit material and the traffic staff of the Tramway Company, we find:

that the difference between P_{tramway} and $P_{\text{Sick Benefit Society}}$ is 0.03414 and that the average deviation of the difference is 0.006349. The difference is statistically established. Therefore we have concluded that there are special drawbacks in regard to the Tramway Company. It is possible that the factors which have influenced the material and caused the considerable difference can be ascribed to the nature of the work carried out by the traffic staff i. e. the continuous shaking of the rolling stock.

In connection with the foregoing comparison we can, for instance, make a comparison of both materials directly and without any classification of ages, that is to say, the occurrence expressed in %.

The %-figure which was found in the Sick Benefit Society for L. S. was 2.475 and the diffusion round this average was 0.9368 %.

The traffic Staff of the Tramway Company showed an average of 5.157 % with a diffusion round this average of 1.664 %.

The difference between both averages is 2.628 and the average deviation taken 3 times is 1.909. Thus a statistically established difference.

The waggon and machine-shop employees showed an average of 5.823 % with a diffusion of 2.582 %. The difference between this group and that of the Traffic Staff is 0.666 $\pm$ the average deviation which is greater than 2.0 % and so does not present any statistically established difference.

NUMBER OF DAYS OF SICKNESS FOR THE DIFFERENT GROUPS

In 1948 the number of sick days for members of the traffic staff of the Tramway Company between the ages of 20 and 64 amounted to 6817. The average number of employees in this group for that year was 4.659. If one works out the number of sick days for each employee in this group it comes to 1.46 sick days per person. If we compare this figure with that obtained from the Central Sick Benefit Society we get a relation of 1.46 to 0.68, that is to say, a relation of 2 to 1 which is a highly considerable difference. For the waggon and machine-shop workers, which amounts to 1.240 workmen, we get 2.316 sick days, which corresponds to 1.87 sick days per person employed and consequently more than twice as many as those belonging to the Sick Benefit Society.

In this connection it may be of interest to find out how

long each patient in general needs for recovery. As far as concerns the traffic staff of the Tramway Company, 58.69 % of the established cases have less than 22 days as is the case with the 63.69 % cases of the waggon and machine-shop workers and the 57.59 % belonging to the Central Sick Benefit Society.

Comparing the above mentioned groups with one another we get the following:

1) Traffic Staff — Central Sick Benefit Society: the difference is 1.1 with an average deviation larger than 1.0, thus no statistically established difference.
2) Waggon and Machine-shop workers — Central Sick Benefit Society: the difference is 5.57 with an average deviation larger than 3.0, thus no statistically established difference.

A report is also given about the occurrence of L. S. amongst the female workers in the Stockholm Tramway Company amounting to 533 persons. They are classified into two groups, the administrative staff and the traffic staff. As the number is so small it is not possible to compare it with the other categories of the male employees.

The result of the comparison will be seen from table 11.

TABLE 11

Year of Birth	Administrative Staff			Traffic Staff		
	Number of employes	Cases of L. S.	%	Number of employees	Cases of L. S.	%
1924—1928	40	1	2.500	18	3	16.667
1919—1923	50	2	4.000	68	1	1.471
1914—1918	57	4	7.018	54	4	7.407
1909—1913	59	7	11.864	53	3	5.660
1904—1908	31	1	3.226	26	1	3.846
1899—1903	19	1	5.263	16	—	—
1894—1898	15	2	13.333	4	—	—
1889—1893	22	3	13.636	—	—	—
1884—1888	1	—	—	—	—	—
Total	294	25		239	12	

SUMMARY

1) Of the 296.777 registered members in the Stockholm Sick Benefit Society, there were 116.767 cases of illness reported during 1948. Of these there were 5.229 cases of lumbago and/or sciatica representing 4.5 %. *Biörck* and *Blomquist* showed that the frequency of heart and vascular diseases in the same society during 1942 were 2.1 % for men and 2 % for women.

2) With regard to the notified cases of lumbago and/or sciatica, expressed in % of the average number of members, we see from table 2 that men belonging to the age group 40—64 show a higher frequency for this disease than men belonging to the age group 15 to 39. We find no difference between men and women belonging to the latter age group, but it would appear that in the higher age group men are more prone to this disease than women.

3) The number of sick days per male member that can be ascribed to lumbago and/or sciatica is 0.68 and for women it is also 0.68. The number of sick days in respect of all diseases for the entire sick benefit material is 11.4 for men and 16.8 for women.

4) Amongst the 6.948 male employees of the Stockholm Tramway Company there were 408 who were diagnosed lumbago and/or sciatica.

5) Amongst the different categories within the Administrative Staff, traffic staff, waggon and machine-shop workers and those employed on the permanent way and buildings, the Traffic Staff, which is the largest, having 4.659 on the pay list, shows the same tendencies as the members of the Sick Benefit Society but they have a higher frequency.

6) It must be thought probable that there is some connection between this high frequency of lumbago and/or sciatica occurring in the Traffic Staff and the nature of their work.

7) The number of sick days for the Traffic Staff was found to be 1.46 per person, for the waggon and machine-shop workers 1.87 and for the members of the Central Sick Benefit Society 0.68 per person.

8) 58.69 % of the Traffic Staff have been reported sick less than 22 days. The same figure applies to the machine-shop workers, 63.60 % and to the Central Sick Benefit Society, 57.59 %.

9) 185 men and 245 women belonging to the Sick Benefit Society have been treated in hospital for lumbago and/or sciatica. 21 men and 18 women were operated on.

CHAPTER IV

RESULTS OF CASES OF LUMBAGO AND/OR SCIATICA WITH ROENTGENOLOGICAL DISC DEGENERATION THAT HAVE BEEN TREATED CONSERVATIVELY OR LEFT UNTREATED

In order to be able to follow the clinical and roentgenological pictures of patients suffering from disc degeneration in the lumbar vertebrae, the author has carried out the following investigations.

The intention was to examine cases with roentgenological signs of degeneration in *one* disc within the lumbar vertebrae. If, in addition to this discdegeneration there have been other changes such as deformities, spondylosis deformans, scoliosis or suchlike, the case has not been included.

It has also been assumed that no surgical treatment of discdegeneration has been undertaken. The material has been chosen from those who have afforded the longest possible observation time and partly from cases on whom instability tests have been made. As a general rule the cases have not been examined earlier than 1936 when roentgen plates were first registered at the clinic. Instability tests were first carried out as part of the routine in November 1943 for which reason these cases that have been submitted to instability tests originate mainly from 1943—1944. The daybooks and roentgen plates have been examined in respect of 232 patients. Of these, 130 cases have been considered as corresponding to the as-

sumptions. These have been asked to present themselves for post examination. For various reasons only 75 have come.[1])

The examination carried out on cases by the author have been made with due regard to a thorough anamnesis and status together with roentgen examination of the lumbar vertebrae and stability tests. In this respect special attention has been given to the length of the anamnesis, the distribution of the lumbago and sciatic trouble, the result of conservative treatment and the degree of severity of the trouble. These examinations are not intended to throw light on the frequency of cases of disc degeneration examined at the clinic during different years. An examination of this nature has already been made by *Friberg* and *Hirsch* in 1949.

Right from the start it must be pointed out that all the persons examined sought relief for trouble in the lumbar region and/or for sciatic trouble[2]) and further that roentgenological signs of disc degeneration were manifested but that no connection between these factors has been proved even though it is highly probable that it does exist.

The investigation comprises 75 cases of which 34 are men and 41 are women.

The observation time has been from 3 to 18 years. By observation time is meant the time between the first examination, when a roentgenogram was taken, and the post examination. The observation time will be seen from table 12.

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[1]) Some have died, several had been operated on and therefore were unsuitable for post examination. Some would not come on account of having to make long journies whilst it was impossible to get in contact with some others.

[2]) On account of the great demand for orthopedic treatment on the one hand and the small number of orthopedic hospitals on the other, acute cases of low back pain have, as a rule, not been possible to treat but only the more chronic cases which have been difficult to treat.

TABLE 12

Observation time in years	Number of cases
18	2
17	1
15	2
14	1
12	7
11	1
10	9
9	3
7	3
6	2
4	4
3	40
	75

Localization of disc degeneration will be seen from the following table 13.

TABLE 13

Localization of disc degeneration[1])	Men	Women	Total
L_1	1	0	1
L_2	2	0	2
L_3	5	2	7
L_4	14	12	26
L_5	12	27	39
Total	34	41	75

[1]) The topografi of the disc takes its name from the vertebra immediately above it.

This table only gives the localization of the disc degeneration in the different cases but is not representative for the localization of the disc degeneration in a material of low back and sciatic pain. In this case one has primarily used the roentgenological changes as a basis.

The patient's *occupation* will be seen in the following table 14.

Table 14

Nature of work	Men	Women	Total
Heavy manual labour	16	27	43
Light manual labour	16	4	20
No manual labour	2	10	12
Total	34	41	75

Housewives with heavy housework to do have been in the group for heavy manual labour.

Trauma, stated by the patient as being the cause of the trouble, has occurred in 13 cases (17.3 %). It must be pointed out, however, that notice has only been taken in respect of cases where the trouble has occurred in close connection with the trauma. Table 15 gives a summary of the character of the trauma.

TABLE 15

Character of trauma	Men	Women
Lifting of loads	4	—
Lifting of loads and falling down with them	2	—
Got 200 kg suddenly against a shoulder	1	—
A fall from a train in motion	1	—
During a wrestling match	1	—
Fell and struck the gluteal region	—	4
Total	9	4

In three cases women patients have given pregnancy as a cause of the trouble.

Table 16 shows the localization of the disc degeneration in those patients who have given trauma as a cause of the trouble.

TABLE 16

Localization	Men	Women	Total
L_2	1	0	1
L_3	2	1	3
L_4	4	0	4
L_5	2	3	5
Total	9	4	13

The age when the trouble commenced will be seen from Table 17.

TABLE 17

Age	Men	Women	Total
15—19	2	1	3
20—24	11	9	20
25—29	9	14	23
30—34	5	9	14
35—39	3	0	3
40—44	1	1	2
45—49	2	5	7
50—54	1	2	3
Total	34	41	75
Highest age	50	54	
Lowest age	17	19	

It will be seen from this table that 43 patients (56 %) got the first signs of their trouble between the ages of 20—29 years.

Working capacity: 8 men and 4 women were never absent from work on account of their sickness. The other 64 patients were *totally incapable* of working during one or other period. Of these, 14 men and 26 women have been *partially* incapable of working as well. 10 men and 3 women were compelled to change their occupation from heavy work to light. Table 18 shows the time of total incapacity to work.

TABLE 18

Time in months	Men	Women	Total
1	3	6	9
2	3	3	6
3	1	4	5
4	3	1	4
5	2	0	2
6	4	7	11
8	1	1	2
10	1	1	2
12	3	3	6
14	2	0	2
15	0	1	1
20	1	0	1
22	0	1	1
24	3	3	6
30	0	2	2
48	1	2	3
72	0	1	1
Total	28	36	64

If one counts the total time of working incapacity we get 741 months or 61.8 years. This means that it averages out at approximately one year's working incapacity for the 64 patients and almost 10 months for each of the 75 patients.

Table 19 shows the *ages of the patients when they were post-examined.*

TABLE 19

Age	Men	Women	Total
25—29	2	1	3
30—34	5	4	9
35—39	3	5	8
40—44	10	8	18
45—49	6	6	12
50—54	5	7	12
55—59	1	8	9
60—64	2	2	4
Total	34	41	75

Table 20 shows the *character of the trouble.*

TABLE 20

Description of trouble		Men	Women	Total
Continuous nagging pain and feelings of tiredness in the low back		9	10	19
Repeated attacks of lumbago but *without* continuous pain		2	1	3
Repeated attacks of lumbago accompanied by continuous nagging pain		2	1	3
Back trouble also in the form of attacks of lumbago + sciatica	Right leg	5	9	14
	Left leg	14	15	29
Back trouble even in the form of attacks of lumbago + sciatica sometimes in the right leg and sometimes in the left leg		1	4	5
Sciatica only:	Right leg	0	0	0
	Left leg	0	1	1
Sciatica only; sometimes in the right leg and sometimes in the left leg		1	0	1
	Total ..	34	41	75

From Table 20 it will be seen that 25 patients had only back trouble. 48 patients have had low back and sciatic pain, and only 2 had sciatic pain only. Special attention was given to the character of the back trouble. 19/25 with back trouble have had continuous nagging pains and feelings of tiredness in the low back. In 6 cases there were attacks of acute lumbago. It is evident that in the great majority of cases the back trouble is of a nagging, lengthy character.

The table also shows that only two of the fifty cases of sciatic trouble had sciatica only. 30 had left-sided sciatica whilst only 14 had right-sided sciatica. In 6 cases the sciatic trouble was sometimes right-sided and sometimes left-sided.

In the above table, regard has only been taken to the most characteristic features of the back trouble. A more thorough

inspection of the back trouble shows the following variations:

1. Nagging pains of tiredness in the low back with radiating pains in one or both of the gluteal regions or in the coccygeal region.

2. Stiffness in the back in the morning accompanied by difficulty in getting out of bed. Sometimes the patient must roll himself from his bed.

3. Difficulty in lying in a soft bed or sitting in an easy chair. Lies best on a straight, hard mattress. Sits best on a chair that has its back almost at right angles to the seat.

4. Certain patients find it very difficult to lie. The best relief from pain is obtained from heavy manual work.

5. Very usual features are a feeling of instability and increased trouble when standing in a slightly forward position. The patient has a feeling that his back will break.

6. Sitting for a long time produces trouble.

7. Lancinating pains in the back on straining, coughing or sneezing.

Duration and type of *sciatic troubles* is seen from table 21.

TABLE 21

Type and duration of sciatic troubles	Number of cases
Moderate trouble for two months	1
» » » four months	1
» » » five months	3
» » » six months	1
» » » ten months	1
» » » four years	6
Severe » » two months	11
» » » one year	3
» » » four years	3
» » » six years	5
Short attacks of sciatica lasting many years	9
» » » » on two occasions only	6
Total ..	50

From the above table it will be seen that short-timed trouble, lasting 4 months or less as well as short recurring attacks have occurred in 28 cases out of 50. Continuous trouble lasting for a year or longer have occurred in 22 cases out of 50. Of the continuous types 13 have been classified as moderate and 22 as severe.

Summarily one sees that these patients have had partly back trouble, partly sciatic trouble and partly a combination of both. As a rule back trouble has had the character of being chronic for a long time, whilst the sciatic trouble has occurred more periodically.

Treatment: The patients have had conservative treatment which has been carried out on fairly uniform lines. 65 patients have been put into plaster of paris or have had to wear corsets made of cloth or leather. In addition to this corset treatment, 19 cases were given massage, 6 were treated in hospital and 5 were treated with roentgen. Some were put to bed.

The ten remaining patients were treated so that 5 of them got massage, 1 got roentgen treatment and 4 no treatment at all.

All throughout the patients have considered that corset treatment has had a good effect especially when it has been combined with massage. The corset has been warn continuously for longer or shorter periods. Many of the patients have been people from the countryside. For this reason it has been difficult for them to receive treatment in general hospitals, and to visit an orthopedic hospitals for conservative treatment has mostly not been possible as the number of orthopedic hospitals in Sweden is very low. Most of them have been treated polyclinically. Only such cases have been admitted to orthopedic hospitals where operational intervention has been planned on account of the unsatisfactory effect of the conservative treatment.

The results of treatment of the above mentioned 65 patients, who have all been treated by the corset method, will be seen from the following table 22:

TABLE 22

Result	Number
Completely well	15
Improved	43
No improvement	7
Total	65

Of the ten who were not treated with corsets, 5 (of which 3 had no treatment at all) are well whereas 5 have shown no improvement.

The results of the treatment in its entirety will be seen from table 23.

TABLE 23

Result	Number	%
Completely well	30	26.67
Improved	43	57.33
No improvement	12	16.00
Total	75	

Tables 22 and 23 show the results of the treatment which was given to the patients when they visited the clinic. In many cases the effect has been of short duration and the trouble has returned. In other cases the patient has been definitely well. Some of the patients have improved from the treatment and have then got worse again, but later on have improved without treatment.

The duration of the trouble will be seen from Table 24. This table gains more value if it is combined with Table 25 which shows how many patients still had trouble when they were post examined.

TABLE 24

Duration of trouble in years	Men	Women	Total
1	2	3	5
1—2	0	1	1
3—4	4	3	7
5—6	3	1	4
7—8	4	3	7
9—10	2	4	6
11—14	7	5	12
15—18	7	9	16
19—22	1	2	3
23—28	2	7	9
29—34	1	2	3
35—38	1	1	2
Total	34	41	75

From this table we see that the duration of the trouble has been rather long. From Table 21 we see the duration of sciatic trouble which has not been especially long. It must therefore be the back trouble that has given the most lengthy trouble.

Table 25 shows how the patients themselves judge their condition when post examined.

TABLE 25

Result	Number	%
Quite well	29	38.67
Improved	12	16.00
No improvement	34	45.33
Total	75	

If the figures in Tables 23 and 25 are placed together we get a difference. As previously mentioned, Table 23 only shows the immediate effect of the treatment but does not take the further development into consideration. Table 25 gives the condition at the time of the post examination. One notices that

the figures for the heading "quite well" increased from 20 to 29 which ought to signify that a number of patients under the heading "improved" and "no improvement" have gradually got well irrespective of the treatment. The "improved" in Table 23, numbering 43, have decreased to 12.

Working capacity at the time of post examination:

62 were capable of carrying on with their work,
13 were incapacitated for work.

The objective examination at the time of post examination:

Objective symptoms from the back	27
Objective symptoms from back + neurological symptoms from the lower extremities	18
Negative status	30
Total ..	75

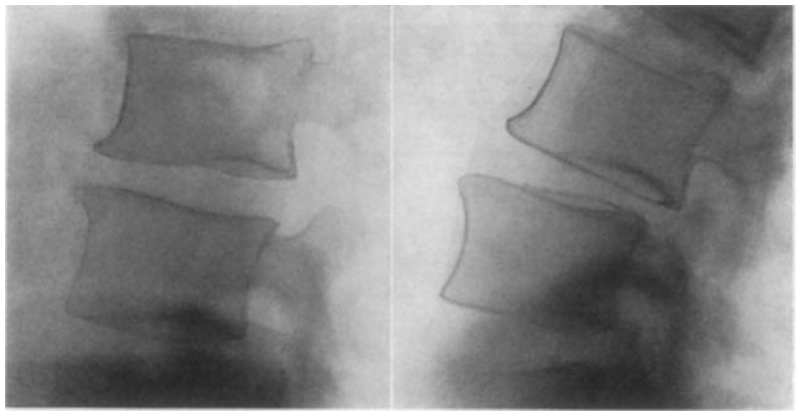
The roentgenological changes.

When discussing the roentgenelogical changes, the author has classified the cases into *lumbal* and *lumbo-sacral* discs. These are dealt with separately.

The lumbal discs.

One can count with the fact that, when the lumbal discs are normal they have a uniform height whereas the lumbo-sacral normally can vary in height. If one of the lumbal discs is lower than the others, even without any changes in the vertebral, it must be regarded as being a sign of degenerative change in the disc (Schmorl, 1932, Knutsson, 1937). This lowering of the disc becomes a still more certain manifestation of disc degeneration if, in addition, there is sclerosis on the edges of the vertebrae surrounding the disc and osteophytes on the margins of the vertebral bodies. Ante- and retroposition of the spine lying above the disc has been considered by Knutsson and others as being suspect for disc degeneration although there is no positive proof of this. *Friberg* and *Hirsch*

(1949), when making an anatomic-roentgenological examination of a postmorten material, showed that in the clinical instability of the discs, described by Knutsson, without other roentgenological signs of disc degeneration, the same changes are observed in principle as exist in discs with lowered interstice, sclerosis and osteophytes (Fig. 2). Therefore instability is to be regarded as being a sure sign of disc degeneration and presupposes rather advanced changes. The vacuum phenomenon in the disc (Fig. 3) goes to prove that there are positive degenerative changes (*Knutsson*, 1942).



forward bending. backward bending.

Fig. 2.

The following can be regarded as being positive signs of disc degeneration:

1. Diminished intervertebral space.
2. Sclerosis of the vertebral surfaces and osteophytes.
3. Instability.
4. Vacuum phenomenon.

As a probable but not proved sign of disc degeneration is retroposition. (The author means stabile retroposition and not that which is produced during an instability test) (Fig. 4).

Material — 35 cases.

It has been considered suitable to classify the cases into:

A) those without vertebral changes, and B) those with vertebral changes (sclerosis and osteophytes).

Cases with vertebral changes have, based on the reduction of the intervertebral distance, been classified in accordance with the following scheme:

1. *Slight changes,* where the intervertebral distance has not become less that half of its original height.

2. *Moderate changes,* where the disc has decreased to half or less than its original height.

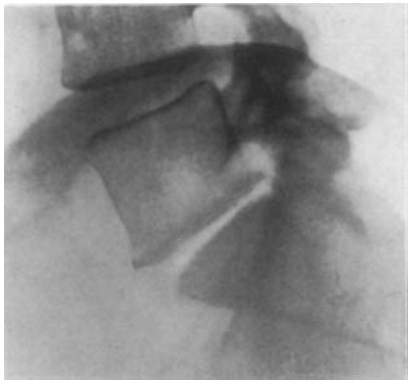


Fig. 3.

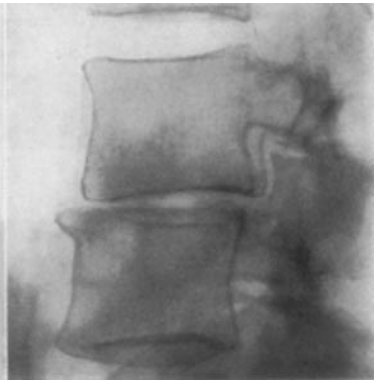


Fig. 4.

3. *Pronounced changes,* where the disc is merely a fissure-like space.

4. *Obliteration of the disc.* The vertebral bodies lie directly against each other with more or less overlapping bones (Fig. 5).

The author has been in some doubt as to how this classification of roentgenological changes should be done in order to be as exact as possible. The plan given above seems to be the best. It has further been shown that the degree or lowering of the disc and the degree of sclerosis and osteophytes run fairly parallel for which reason the gradation, to a certain extent, will be a measure for the gradation of sclerosis and osteophytes. In some cases, however, there has been a decrease in the intervertebral distance without any spinal changes.

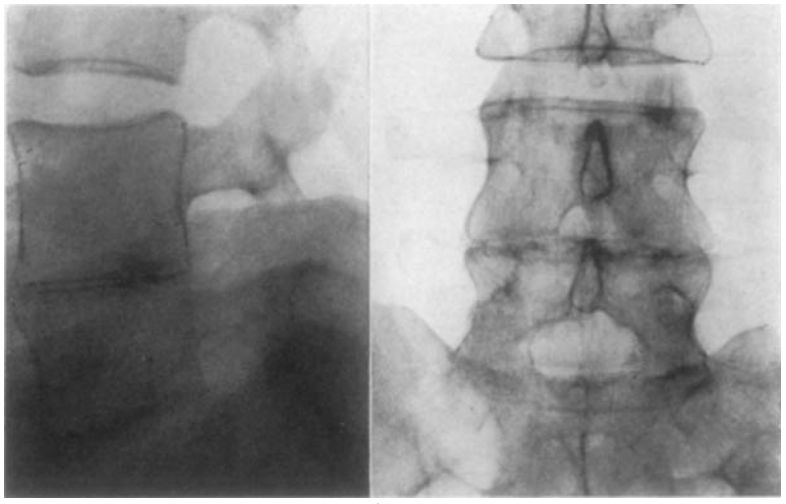


Fig. 5.

Roentgenological changes at the first examination.

A) *Cases without vertebral changes.* Ten in all and each one tested for instability. They appear as follows:

Retroposition + instability	4
Retroposition + instability + decreased intervertebral space	2
Anteposition + instability + decreased intervertebral space	1
Instability only	2
Decreased intervertebral space only	1
Total ..	10

B) *Cases with vertebral changes.* 25 in all.

In accordance with the proposed plan, 20 of these come under the heading *slight changes* whilst 5 come under the heading *moderate changes.* No pronounced disc degeneration or such with disc obliteration has been observed during the first examination. In 16 cases retroposition has existed. 10 of these were tested for instability, showing that 7 were instabile and 3 were stabile (6 were not tested for instability).

1 case shows anteposition and instability.

Vacuum phenomena have not been observed in any case during the first examination.

Roentgenological changes found during post examination.

(The figures in brackets after the cases give the observation time in years between the first examination and the post examination. If there is a figure after many cases it means that the observation time has been equally long.)

A) *Cases without vertebral changes.* Ten cases in all.

Progress with sclerosis and osteophytes as well as slight decrease in the intervertebral space has occurred in *three cases* (4). During the first examination all of these cases showed instability, 2 showed retroposition, of which 1 was accompanied by a slightly diminished intervertebral space. The 3rd case showed anteposition and a slightly diminished intervertebral space.

Two fresh disc degenerations have occurred in *one case.* A short account of this will be given.

(No. 15684. A. A.). In 1939 incipient disc degeneration in L. 3 with only retroposition. No instability test was carried out. In 1941 suspect disc degeneration also in L. 2 and L. 4 on account of retroposition without having had a test for instability. When post examined 7 years later the picture was the same as in 1941, but during the functional test the on account of retroposition suspected discs showed instability. This would seem to indicate that the *discs in this case were simultaneously affected.* This patient was free from trouble.

The *six remaining cases* were unchanged.

Four of the 10 patients had trouble when they were post examined. Of these there was only one where progress had taken place.

B) *Cases with vertebral changes.* 25 in all.

Progress had taken place within the group "slight changes", in ten cases out of twenty. Of these ten cases, nine had progressed to the group "moderate changes" (3, 3, 3, 4, 7, 10, 12 and 12) and one to group "pronounced changes" (12).

In five cases with "moderate changes" progress has

taken place in 4 cases. Of these, two showed an insignificant progress that cannot be counted among the pronounced changes (3 and 10), one where pronounced changes took place (9) and one where the disc was completely obliterated (12).

Of these twentyfive cases, progress has taken place in fourteen of which only three were pronounced changes. In ten cases the observation time was ten years or more. For comparison the observation time is given for those eleven cases where no progress of the disc degeneration has taken place (3, 3, 3, 4, 4, 4, 4, 4, 10, 12 and 14).

Retroposition has remained constant at both examinations as was the case with the one case of anteposition.

The state of *instability* found in eight cases during the first examination as well as the state of stability found at the same time in four cases has remained the same during the post examination (4, 4). Of the 13 remaining cases, 9 were stabile and 4 instabile. Thus there were 13 who were stabile and 12 who were instabile when post examined.

Vacuum phenomena during lordosis (stability test presupposed) were present in 2 cases where, in addition, progress of the changes had taken place. None of these cases was functionally tested at the first examination.

"Fresh disc degeneration" has occurred in 4 cases. These are described:

1) *Case No. 2020/36.*
First examination, degeneration of 2nd lumbal disc with slight changes. No stability test. Post examination 12 years later showed progress to moderate degeneration of this disc together with fresh *slight* changes in the 3rd disc. Instability in both disc.

2) *Case No. 15009.*
Slight changes in 4th disc. No instability test. Post examination 7 years later revealed vacuum phenomena in the lumbo-sacral disc during lordosis as the only sign of degeneration in this disc.

3) *Case No. 17956.*
The same as in case 2 but with an observation time of 9 years.

4) *Case No. 32120.*
Moderate changes in 4th disc. No instability test. Post examination 10 years later revealed slight changes in 1st lumbal disc with

instability. 4th disc stabile. A thorough examination of the disc L. 1 revealed a small intra-spongious disc herniation during the first examination indicating that the disc, on this occasion. was the seat of the changes.

As no instability test was carried out during the first examination and as the diagnosis disc degeneration was apparent in all four cases because of this instability test, one cannot be certain that these so-called fresh disc degeneration arose during the time between the two examinations. In the 4th case it was also possible to establish a small change to which no importance was attached. If one also looks at the case No. 15684 within the group "No vertebral changes" where 2 fresh disc degenerations were discovered shortly after the first, the tendency will appear to be that the degenerations in the discs in these cases have arisen rather simultaneously.

Of all the 35 cases of lumbal disc degeneration, *spondylosis deformans* was discovered in 3 cases during the post examination. This was very slight, practically physiological. The ages of these patients were 41,54 and 57 years.

In the whole material of lumbal disc degeneration (35 cases) 18 had trouble and 17 were free from trouble.

Of the 18 cases that had trouble, 12 were instabile and 6 were stabile. Post examination revealed that 20 were instabile and 15 stabile in the whole material. This meant that, of the cases that were free from trouble (17 in all), 8 were instabile and 9 were stabile.

Progress has taken place in 17 cases.

Fresh disc degenerations occurred in 5 cases.

Spondylosis deformans occurred in 3 cases.

LUMBO-SACRAL DISC DEGENERATION

Cases of lumbo-sacral disc degeneration have all been placed in one group for the reason that the lumbo-sacral disc has another topography than that of the lumbal discs. This disc forms a connection between the mobile lumbar column and the fixed sacrum. Anomalies in the form of sacrilization

of the 5th lumbal vertebra and lumbalization of the 1st sacral vertebra, the so-called transient vertebra, are common happenings and can be more or less pronounced. This even affects the lumbo-sacral disc so that, when the 5th lumbal vertebra is sacralized, without being the seat of pathological changes, it can be considerably narrower than the lumbal discs and more like the rudimentary sacral. *A low lumbo-sacral disc therefore need not be regarded as being pathologically changed* (Knutsson, 1942). First, if the limited vertebral surfaces show reactive sclerosis or osteophytes on the edges or the disc shows roentgenological signs of instability or signs of vacuum, one is intitled to presume degenerative changes. The retroposition pointed out by Knutsson also causes one to suspect degenerative changes here, but there is no proof of this yet.

The signs of disc degeneration that are emphasized in lumbal degenerations are also applicable in lumbo-sacral degenerations except the fact that the height of the disc cannot be accorded a greater significance. Naturally, this about the height of the disc does not apply in cases where, during the various observations one has been able to establish a diminishing of the intervertebral space nor in cases where the disc presents a fissure-like lumen in combination with considerable reactive changes and vacuum phenomena.

As was done in the case of the lumbal discs, the author has considered it suitable to make a classification of A) cases *without* and B) cases *with* vertebral changes. Cases with changes have also been sub-divided into *slight, moderate and pronounced* and those where the *disc has been totally obliterated* roentgenologically. When sub-dividing into slight and moderate changes the height of the disc has not been the deciding factor whereas the degree of reactive changes has.

The first examination.

A) *Without vertebral changes.* — 8 cases.

Retroposition + low disc in the posterior region (3 of these were stabile and 1 instabile)	4
Low disc in posterior region (These cases can almost be regarded as being incipient disc degeneration since, as was previously pointed out, a low lumbo-sacral disc without any other changes is no sign of disc degeneration. The author will revert to this later).	3
Vacuum in the normal posture of the back	1
Total ..	8

In these 8 cases, excepting the 2 with vacuum phenomena and instability respectively, the diagnosis has been considered as being for *suspect degenerative changes.*

B) *With vertebral changes.* — 32 cases.

The following classification has been made in conformity with the plan previously mentioned:

Slight changes	12
Moderate changes	12
Pronounced changes	8
Total ..	32

Vertebral changes only (sclerosis + osteophytes)	10
Vertebral changes + retroposition	13
Vertebral changes + retroposition + vacuum phenomena, in normal posture (1 stabile, 1 instabile, 1 not tested)	3
Vertebral changes + retroposition + vacuum phenomena in lordosis (all tested for instability)	6
Total	32

Tested for stability, 16: not tested for stability, 16.

Only in one case was instability established.

22 cases have shown retroposition.

Post examination (all cases tested for stability).

A) *Without vertebral changes.* — 8 cases.

The *four* cases with retroposition, of which one was instabile, show the following:

The case with instability still shows instability but otherwise no changes (3). One of the stabile cases has become instabile (3). In one case diminished intervertebral space with sclerosis (3). In one case there is a diminishing of the intervertebral space together with vacuum phenomena in lordosis. Thus in two cases progress could be registered.

The *three* cases which were suspected of degeneration only on account of the diminished posterior region of the disc have shown the following:

One shows substantial progress with retroposition, sclerosis and diminished intervertebral space (4).

One shows substantial vacuum phenomena in lordosis but otherwise no freshly occurred changes (10);

One shows considerable progress with retroposition and high degree reactive changes and vacuum phenomena in lordosis (6). In this case there was also an observation which was carried out 3 years after the 1st. On that occasion one found instability which vanished 3 years later.

The *last case* without spinal changes, where vacuum phenomena were present in the normal posture during the first examination, showed, when post examined, high degree reactive changes and substantial vacuum phenomena (11).

Therefor the *six* cases, classified under the heading of *incipient* disc degeneration, have shown definite signs of disc degeneration during the postexamination.

B) *Cases with vertebral changes* (32 in all).

The degree of the progress in the different groups is the following.

Of the *twelve* cases with "slight changes", two have pro-

gressed to moderate (3 and 4) and two to great changes (9 and 10). Thus there is progress in 4 cases.

Of the *twelve* cases with "moderate changes", seven cases have progressed to Pronounced changes (4, 6, 7, 8, 12, 12 and 17).

In the group "pronounced changes" (*8 in number*), 4 cases have lost the disc completely and the vertebral bodies lie directly against one another (6, 7, 10 and 10).

Therefore in 15 cases it has been possible to show progress.

For comparison the observation time is given for the cases where there has been no progress:

"slight changes" (6, 6, 6, 6, 6, 6, 7 and 12);

"moderate changes" (3, 3, 3, 4 and 4);

"pronounced changes" (3, 3, 4 and 4).

Retroposition has remained constant during the post examination, that is to say in 22 cases.

Instability was observed in 2 cases only; these were not previously tested for stability. These have been cases with slight changes of which the one showed moderate progress and the other vacuum in lordosis. The only case having instability during the first examination has now become stabile.

Of the cases observed during the first examination as having *vacuum phenomena in the normal posture,* (3 in number), the disc has been roentgenologically obliterated and the vacuum phenomena have disappeared in one case. In the two others the vacuum picture has remained unchanged. In 3 cases vacuum phenomena in the normal posture have occurred of which there are two in which this phenomenon was seen in lordosis during the first examination.

Vacuum phenomena in lordosis was manifest in six cases during the first examination of which, as mentioned above, two cases had vacuum phenomena in the normal posture during the post examination. In three cases (3, 3, 3) the vacuum phenomenon has remained unchanged whilst in one case it has disappeared. In 8 cases vacuum phenomena in lordosis have arisen; only three of these were tested for instability

during the first examination. Thus we have vacuum phenomena in lordosis in 14 cases.

"Fresh disc degeneration" has occurred in 7 cases which are briefly reported:

1) *Case No. 3233/36.*
When examined for the first time was diagnosed lumbosacral disc degeneration with slight changes; no stability test was made. When examined 7 years later instability was present in the 4th lumbal disc but there were otherwise no changes. When post examined 2 years later there were considerable reactive changes in both discs especially in the lumbosacral which also manifested vacuum phenomena.

2) *Case No. 2883/43.*
During the first examination, which did not include a stability test, lumbo-sacral disc degeneration with slight changes. Post examination 4 years later showed slight progress of the lumbosacral disc degeneration together with degeneration in the 4th disc accompanied by marked instability but without any vertebral changes.

3) *Case No. 4003/44.*
The same as Case No. 2.

4) *Case No. 1786/39.*
Moderate lumbo-sacral disc degeneration when examined for the first time and which did not embrace functional testing. 6 years later there was a highly pronounced lumbo-sacral disc degeneration as well as a moderate degeneration in the 4th disc. No instability.

5) *Case No. 31771.*
Moderate lumbo-sacral disc degeneration when first examined. No stability test made on this occasion. When under observation two years later, instability in the 3rd lumbar disc was the only sign of disc degeneration. Post examination 5 years later showed considerable progress of both disc degenerations together with continued instability in the 3rd disc.

6) *Case No. 1086/36.*
The first examination, which did not embrace tests for stability, showed moderate lumbo-sacral disc degeneration. Twelve years later there was a moderate degeneration in the 2nd lumbar disc and highly pronounced changes in the lumbo-sacral accompanied by vacuum phenomena in lordosis. Both discs stabile.

7) *Case No. 3444/36.*
The first examination, which did not include instability tests, showed moderate lumbo-sacral disc degeneration. 12 years later a moderate stabile degeneration in the 4th lumbar disc was manifest as well as highly pronounced changes within the lumbo-sacral.

When examining these 7 cases of so-called "fresh disc degeneration", it will be seen that, in no one of the cases, can it be said with certainty that there has really been any manifestation of fresh disc degeneration as no instability test were made during the first examination. Further, one sees that in 5 cases there were, in addition to the lumbal-sacral changes, also changes in the 4th disc, in one case in the 2nd disc and in one case in the 3rd disc.

Spondylosis deformans has arisen in 6 cases of the 40 lumbo-sacral disc degenerations. There have been very slight changes which can almost be regarded as being physiological. The ages of these patients was 42, 47, 47, 51, 55 and 63 years.

Only 11 of the 40 cases were *free from pains* when post examined. These 11 cases give the following picture:

three cases who were without any vertebral changes during the first examination show manifestations of instability in one case and progress in two cases during the post examination.

three cases with slight vertebral changes during both examinations. No progress.

five cases with moderate vertebral changes during the first examination. Three of these were unchanged when post examined, one showed progress and one showed progress together with fresh degeneration.

It is surprising that the four cases with highly pronounced changes, where progress has become a fusion of the vertebral bodies, were not free from trouble.

If one compares the lumbal with the lumbo-sacral disc degenerations, the following will be seen:

(The cases have been placed side by side in order to be surveyed more easily.)

Cases with lumbal disc degeneration.	*Cases with lumbo-sacral disc degeneration.*

PROGRESS

A. CASES WITHOUT VERTEBRAL CHANGES

10 cases of which progress to slight changes in 3 cases.

8 cases of which progress to moderate changes in 2, to highly pronounced changes in 3.

B. CASES WITH VERTEBRAL CHANGES

1. *Cases with slight changes.*

20 cases of which progress to moderate changes in 9 and to pronounced changes in 1.

12 cases of which progress to moderate changes in 2 and to highly pronounced changes in 2.

2. *Cases with moderate changes.*

5 cases of which progress is only insignificant (not to pronounced) in 2, to highly pronounced in 1 and to disc obliteration in 1.

12 cases of which progress to highly pronounced changes in 7.

3. *Cases with pronounced changes.*

0 cases.

8 cases of which there were 4 with obliteration of the disc.

SUMMARY

Progress to slight changes,	3	Progress to slight changes	0
Progress to moderate changes	9	Progress to moderate changes,	4
Insignificant changes,	2	Progress to pronounced changes,	12
Progress to pronounced changes,	2	Progress to obliteration of the disc,	4
Progress to obliteration of the disc,	1		
Total ...	17	Total ...	20

As previously pointed out these discussions about the degree of the changes have not proceeded from the same points of issue. Regarding the lumbal changes, the height of the disc has been the basis for estimating the degree whereas in regard to the lumbo-sacral it has been the degree of sclerosis that has been the deciding factor. A change in the height of the disc has also been registered in respect of the lumbo-sacral. It is therefore possible to establish from this material that the progress of disc degeneration has been far greater in the lumbo-sacral cases than in the lumbal. In the lumbal cases it would seem as if the disc sinks to a certain degree and then consolidates. In the case of the lumbo-sacral degenerations it seems that the progress has an obliteration of the disc as a final stage.

RETROPOSITION

Cases with lumbal disc degeneration.	*Cases with lumbo-sacral disc degeneration.*
FIRST EXAMINATION	
A. *Cases without vertebral changes.*	
10 cases of which 6 with retroposition.	8 cases of which 4 with retroposition.
B. *Cases with vertebral changes.*	
25 cases of which 16 with retroposition.	32 cases of which 22 with retroposition.
ANTEPOSITION	
2 cases out of 35.	0 cases.
SUMMARY	
22 cases of retroposition making 62.9 %. Retroposition and anteposition have remained constant during both examinations.	28 cases of retroposition making 70 %. In 2 cases retroposition has occurred during post-examination.

Retroposition, by which the author means a stabile overlapping of the overlying vertebra posteriorly in relation to the one lying immediately under, that is to say not the parallel displacement that occurs when bending the back forwards or backwards, has been guaged by inspection and not in accordance with the method given by *Hagelstam* (1949). Hagelstam has found "that by mere visual inspection of roentgenograms, a retroposition of less than 2 mm will escape discovery, and a retroposition of 2 mm is usually overlooked."

One finds an approximately similar frequency of retroposition in the lumbal and lumbo-sacral cases, i. e. 62.9 % and 70 % respectively. The degree of retroposition has not been estimated. Of especial interest are the 3 cases of lumbro-sacral disc degeneration, which because of retroposition were suspected as being disc degenerations and showed advanced changes during the post examination.

INSTABILITY

Cases with lumbal disc degeneration.

	Examination	
	1st	2nd
Instabile	17	21
Stabile	5	14
Not tested	13	0
Total	35	35

During the 2nd examination 60 %.

Cases with lumbo-sacral disc degeneration.

	Examination	
	1st	2nd
Instabile	2	4
Stabile	18	36
Not tested	20	0
Total	40	40

During the 2nd examination 10 %.

One finds that instability is considerably more usual in lumbal than in lumbo-sacral disc degenerations. Further one finds that in apparently roentgenological normal discs, degenerative changes can be exposed by means of instability tests.

FRESH DISC DEGENERATION

Cases with lumbal disc degeneration:	*Cases with lumbo-sacral disc degeneration:*
5 cases.	7 cases.

In none of these 12 cases (16.00 %) were there any definite points of appui that really fresh disc degenerations had become manifest. As a matter of fact no instability tests were made during the first examination for which reason it was not possible to expose a disc degeneration having only instability but no vertebral changes. One has found 4 instabile discs and 1 with vacuum phenomena that have arisen when bending backwards.

VACUUM PHENOMENA

Cases with lumbal disc degeneration.	*Cases with lumbo-sacral disc degeneration.*
During the *1st* examination no vacuum phenomena, during the *2nd* examination 2 vacuum phenomena which occurred when bending backwards, 5.71 %.	During the *1st* examination 4 vacuum phenomena in the normal posture and 6 in lordosis. During the *2nd* examination 6 in the normal posture and 14 in lordosis, 50 %.

It appears that vacuum phenomena are more common in lumbo-sacral than in lumbal disc degenerations. One has vacuum phenomena in the normal posture of the back which, to judge from this material, are less common than vacuum phenomena when the back is in lordosis. This vacuum phenomenon in lordosis has been manifested when making instability tests. By making instability tests it is possible to expose partly instability and partly vacuum phenomena. When bending for-

wards the vacuum phenomenon usually disappears. As will be evident from this material, vacuum phenomena appear as the only sign of degenerative changes in the disc.

SPONDYLOSIS DEFORMANS

Cases with lumbal disc degeneration.	*Cases with lumbo-sacral disc degeneration.*
3 cases.	6 cases.

There have been very slight spondylosis deformans changes as a rule in elderly persons, see page 77 and 83 and they have for the most part been regarded as being physiological.

In this connection something will be said about spondylosis deformans and the differential diagnosis regarding disc degeneration.

Benneke, 1897, *Hammerbeck,* 1931, *Schmorl* and *Junghanns,* 1932, and *Güntz,* 1936, have made special studies of this spinal change. Spondylosis deformans, in greater or lesser degrees, is manifest in all elderly persons. See diagram 4, taken from the work of Schmorl and Junghanns, showing the frequency of spondylosis deformans in different age groups.

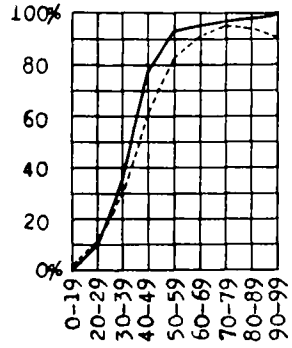


Diagram 4 (after Schmorl and Junghans).

The original name was spondylitis deformans but as there is nothing inflammatory about it, Schmorl suggested the term spondylosis which has been generally accepted. Naturally Schmorl considered that changes in the intervertebral discs

played a part in the occurrence of spondylosis deformans, but he often came across cases with highly pronounced degenerate intervertebral discs and greatly diminished intervertebral spaces that only showed insignificant changes due to spondylosis deformans. From this, Schmorl drew the conclusion that the outer region of the annulus fibrosus (Randleistenannulus), which does not send its fibres to the cartilage plate but to the bony margin, is the most important factor in causing spondylosis deformans. Deficiencies arise in the annulus fibrosus. If these enter the nucleus cavity, disc degeneration takes place. These deficiencies, however, can occur without causing the nucleus to be attacked. Especially common are deficiencies in the outer attachment of the annulus at the margin. The result is that the disc bends, and a stretching takes place in the ligament which leads to the occurrence of bony formations of the spondylosis deformans type at the place where they are attached to the vertebral body. Schmorl says: "ohne Schädigung des Randleistenannulus giebt es keine Spondylosis Deformans. Vor Bedingung zustande kommen des Vordringens ist allerdings, dass der Nucleus Pulposus noch genügend Turgor besitzt und die Zwischenwirbelscheibe noch elastisch ist."

SUBJECTIVE TROUBLE

Cases with lumbal disc degeneration.

Having a point of departure stability/instability, one gets the following.

Subjective	Stab.	Instab.	Total
free from pains	9	8	17
pains	6	12	18
Total	15	20	35

Cases with lumbo-sacral disc degeneration.

Subjective	Stab.	Instab.	Total
free from pains	10	1	11
pains	26	3	29
Total	36	4	40

It is quite evident from this material that more persons with lumbo-sacral disc degeneration during the post examination have pains than do those with lumbal disc degeneration, 72.5/51.4 %. As, however, the material is fairly small and the difference not too large, no great importance should be attached to this comparison. Instability has been suspected of being pain producing incident. It will appear from the above tables that there is a higher frequency of instability in the bad cases. The figures and differences are too small to allow of any definite conclusions to be drawn. One can sooner be of the opinion that it is not possible to draw any conclusions from the roentgenological picture as to whether the disc degenerations in question are pain producing or not.

The author has made mention about lumbo-sacral disc that have the *shape of an angle opening forwards, and with the posterior portion of the disc so low that the spines lie against one another but where there is no sure sign of disc degeneration in the form of sclerosis, osteophytes or instability.* In some cases there is retroposition. The author is of the opinion that this type of lumbo-sacral disc is strongly suspect as being degenerated. In the three cases in this material where this picture was the only reason for suspecting degenerative changes, decided manifestations of disc degeneration have later developed. The author does not mean a promontory angle or a lumbo-sacral angle which was previously considered as playing an important part in low back pain (*Braus*, 1921, *Robinson* and *Grimm*, 1925, *Wynen*, 1928, *Schmorl*, 1932). The measurement of the angles given by the author were found by Schmorl as being 10° and 27° (average 17°) in youthful persons and from 6° to 29° (average 16°) in adults. Wynen found 10° to 40°.

The author's opinion is that the number of degrees in that angle does not carry any importance but that the essential thing is the filamentous posterior part of the 5th disc. In many cases of lumbo-sacral disc degeneration one finds that sclerosis is essentially localized to the posterior part. It should therefore be a matter of a degeneration that first begins in

the posterior region of the disc. This coincides well with the observations made by *Friberg* and *Hirsch* (1949) in a large patho-anatomic material (1949). They say: "In the lower lumbar discs the ruptures in the annulus were mostly localised to the posterior part of the disc. From the centre they were directed either sagitally or laterally backwards to the intervertebral foramen. In the upper discs the ruptures were frequently also anterior."

Having regard to the age, the *disc degeneration has been manifest* during the first examination in accordance with the following table 26.

TABLE 26

Age of patient	Number of cases
20—30	12
30—40	33
40—50	23
50—60	7
	Total 75

SUMMARY

1) The material comprises 75 patients, 34 men and 41 women who have been treated conservatively or not treated at all. All of them have presented roentgenological signs of degeneration in *one* disc in the lumbo-sacral column at the 1st examination.
2) 57.3 % were employed in heavy manual labour, 26.7 % in light manual labour and 16 % did no manual work at all.
3) 17.3 % of the patients gave trauma as a cause of the trouble.
4) In 56 % the trouble began during the age period 20—29 years, and in 4 % the age period was from 15 to 19 years.
5) 85.33 % were totally in capacitated for work one month or more. The total period of incapacity for work amounted

to 61.8 years which means an average of nearly 10 months for each of the 75 patients.

6) 33.33 % had low back trouble only, 64 % have both low back and sciatic trouble and 2.6 % had sciatica only. Nagging, continuous pain in the back together with feeling of instability was predominant. Of the 50 cases with sciatica, 30 had left-sided trouble, 14 had right-sided trouble and 6 had trouble sometimes in the right and sometimes in the left leg. The back trouble has been of long duration whilst the sciatic trouble has usually been short.

7) For 30 of the patients the trouble has lasted from 1 to 10 years and for 45 patients it lasted more than ten years. These lengthy periods of trouble have been essentially predominated by back trouble.

8) 36 % had objective symptoms from the back in the form of muscular contractions, stiffness and throbbing pains. 24 % had objective symptoms from the back + neurological symptoms in the lower extremities. 40 % had no objective symptoms from either the back or leg.

9) The results of the conservative treatment which consisted mainly of the wearing of corsets and physical therapy have been as follows:

Quite well,	20 patients	(26.67 %)
Improved,	43 „	(57.33 %)
No improvement,	12 „	(16.00 %)

This means the immediate effect of the treatment.

10) The following subjective condition was registered during the post examination:

Quite well,	29 patients	(38.67 %)
Improved,	12 „	(16.00 %)
No improvement,	34 „	(45.33 %)

Capable of work, 82.67 % and incapable of work 17.33 %.

11) When discussing the *roentgenological changes,* the cases have been classified into lumbal and lumbo-sacral disc degenerations. As it is a question of the lumbal, the definite signs of disc degenerations have been considered as being:

1) diminished intervertebral space,
2) sclerosis of the spinal surfaces and osteophytes,
3) instability,
4) vacuum phenomena.

Retroposition has been considered as being a probable sign of disc degeneration.

The cases have been classified into those that have no vertebral changes and those that have. Cases that *have vertebral changes* have been sub-divided with the support of the *height of the disc* into:

Slight changes, where the intervertebral space has not diminished to the half of its original height.

Moderate changes, where the disc has diminished to the half or even more than half of its original height.

Pronounced changes, where all that remains of the disc is a fissure-like space.

Obliteration of the disc, where the vertebral bodies lie directly against eachother with more or less overlapping bone.

As far as the lumbo-sacral disc degeneration is concerned the same classification has been used but with the difference that no bearing is attached to the height of the disc but that one has taken the degree of sclerosis and osteophytes as a basis.

Progress of varying degrees has taken place in 17 cases out of 35 that had lumbal disc degenerations. 20 out of 40 cases of lumbo-sacral disc degenerations have shown progress.

Retroposition was manifested in 22 of the lumbal cases and in 28 of the lumbo-sacral.

Instability tests that were carried out on all cases during the post examination showed *instability* in 21 (60 %) of the lumbal and in 4 (10 %) of the lumbo-sacral.

Degeneration in other discs than the original could be registered in 5 of the lumbal cases and in 7 of the lumbo-sacral. It must be pointed out that there is nothing definite which would imply that these additional degenerations have become manifest at some later time than the original as no instability tests were made on any case during the first examination. This means that one might have overlooked cases with instability and vacuum phenomena in the lordosis posture of the back.

Vacuum phenomena were registered during the post examination in 2 cases only of the lumbal cases (5.71 %) both of them in lordosis posture. Among the lumbo-sacral cases there were 6 vacuum phenomena in the normal posture and 14 in lordosis (50 %).

Spondylosis deformans of a slight degree was registered in 3 of the lumbal cases and in 6 of the lumbo-sacral cases. Differential diagnosis between disc degeneration and spondylosis deformans is discussed.

It is pointed out that lumbo-sacral discs that have a very low posterior part are strongly suspected as being degenerated. This is illustrated by 3 cases with such changes only during the first examination and that, during the post examination, sure signs of disc degeneration were present.

A comparison between the presence of instability and the subjective trouble gives nothing definite which would point to the fact that the instabile cases should have more trouble. On the whole it would seem that it is not possible to draw any conclusions from the roentgenological findings in regard to the patient's trouble.

12) During the first examination definite manifestations of disc degeneration were evident in respect of the age of the patient in accordance with the table 26, page 91.

CHAPTER V

SURGICAL TREATMENT OF DISC DEGENERATION IN THE LUMBO-SACRAL SPINE

The surgical treatment of lumbago and sciatica which are considered to have their origin in degenerative changes in the intervertebral discs was, in reality, disc herniation. The authors of disc prolapses and stabilizing operations.

Mixter and *Barr* (1934) found that disc herniation was by no means a rare cause of low back and sciatic pains and that what was before regarded as neoplasm emanating from the intervertebral discs was, in reality disc herniation. The authors describe in their report 19 cases of disc herniation of which 11 were lumbal.

After this report the problem of the ruptured disc has been taken up with ever increasing interest. Many surgeons have published results of extirpation of the disc herniation, *Mixter* and *Ayers* (1935), *Love* (1936), *Camp* (1937), *Love* and *Walsh* (1938), *Love, Adson* and *Craig* (1938), *Love* (1939), *Dandy* (1941, 1942, 1943, 1945, 1947), *Barr* (1941, 1947), *Petit-Dutaillis* and *de Séze* (1945), *Alajouanine* and *Petit-Dutaillis* (1941), *Lenhard* (1947), *Willis* (1948) and others.

In Scandinavia *Malmros* (1942), *Norlén* (1944), *Kirstein* (1945), *Friberg* (1941), *Friberg* and *Hirsch* (1946), *Lindgren* (1945, 1949), *Senning* and *Sjöquist* (1947), *Waris* (1948) and *Rövig* (1949).

It was soon seen that the patients were usually free from sciatic trouble after being operated on for disc herniation although there often remained a more or less invalidity from

low back pains which many times were more pronounced after the operation than before it. *Waris* (1948), for instance, says: "the sciatic pain which dominates before operation is often left on the operating table and the patient is discharged from the hospital very satisfied with his condition. But on returning to his daily occupation — especially if it is heavy physical work — lumbar pain on exertion gradually begins to appear and may dominate now when the pain in the extremities has receded." In a follow up examination of 374 operated cases, Waris found an increase of brack trouble postoperatively. He had 67 % dorsal insufficiency in his material and of these 10 % were severe.

Senning and *Sjöquist* (1947) had 34.3 % low back pain, of which 21.1 % were severe when they post-examined 403 operated cases. *Love* (1947) has post-examined 987 out of 1.217 patients that had been operated on for intervertebral disc protrusion (81 %); 38.5 % of these stated that they have back trouble. *Barr* (1947) found 55 % low back pain in 132 patients of which 10 % were severe. *Friberg* and *Hirsch* (1946) after a post-operative observation time of 5 years, found, when post-examining 44 operated cases (37 prolapses and 7 explorations but no prolapse) that 30 % had dorsal insufficiency. *Lindgren* (1945) found 43 dorsal insufficiencies among 200 patients that had been operated on for disc herniation: of these 4 were severe. Prior to the operation 72 patients had back trouble for which reason a decrease could be established post-operatively. *Malmros* (1942) found that out of 66 operated patients there were 44 % who had low back pains of a lighter or more severe degree. Many others authors have reported dorsal insufficiencies. Table 27 gives the frequencies of low back pain from different operation materials.

Because of these frequently pronounced post-operative dorsal insufficiencies, many surgeons have performed stabilizing operations either primary in connection with extirpation of disc herniation or as a secondary step, when it appears that an invalidating back pain remains or arises post-operatively.

TABLE 27

Name of author	Year	% of low back pain	Out of total number of cases
Malmros	1942	43.9	66
Poppen	1945	50.0	400
Friberg-Hirsch	1946	30.0	100
Lindgren	1946	40.0	200
Senning-Sjöquist	1946	34.3	403
Kirstein	1945	40.0	25
Love	1947	61.5	987
Barr	1947	55.0	132
Lenhard (Dandy's material)	1947	6.8	147
Waris	1948	67.0	347
Rövig	1949	95.7	46

Barr and *Mixter* (1941) have performed osteosynthesis on 33 out of 94 laminectomies. The indications for fusion were if the patient had to do heavy work, if there was any existing instability, if a major laminectomy had been performed or if the facettes had been injured. 73 % of the fusioned cases and 52 % of the nonfusioned cases were free from back trouble. *Barr* (1947) presents a rather large material of 234 cases of which 102 had osteosynthesis and 132 had not. The fusion material had 40 % low back pain whilst the nonfusion material had 55 %. *Røvig* (1949) gives a report on the status of 100 patients of whom 46 were operated on by removing the protruding disc only, and 54 on whom, in addition to the removal of the protruding disc, spinal fusion was performed. Fifty of the fusion cases were free from low back trouble whereas only 3 of the non-fusion cases were free. *Aitken* and *Bradford* (1947) have investigated a large insurance material with extirpation of disc herniation per se or in combination with primary or secondary fusion. They say: "We are of the opinion both as a result of this series and of our own private practice that primary fusion should be performed more frequently," *Arthur Davis* (1947) says in his

introduction to *"Symposium of the Intervertebral Disc"*: "Experience with the frequency of recurrence in cases in which fusion was not done, the fact that protrusions occur largely in the two lowest intervertebral spaces, and the high frequency of unstable lumbo-sacral junctions have convinced the writer that in most cases, if not all, operation should include posterior fusion from the fourth lumbal vertebra to the sacrum." He supports his opinion on a material of 250 operated cases of protruded intervertebral disc. *Poppen* (1945) says: "The relief of sciatica was satisfactory in most cases (400 of verified herniated intervertebral discs). Residual back discomfort occurred in almost half the patients. This percentage was materially altered in those who had also had fusions, and who comprised 9 percent of the series."

Shinners and *Wallace* (1944) performed primary or secondary fusion in 18 cases out of 140 laminectomies. They consider that they gained nothing by this intervention. *Owens, Williams* (1945), *Briggs* and *Milligan* (1944) combine laminectomy with an osteosynthesis done in such a manner that a bit of the processus spinosus is placed into the cavity from which the degenerated disc has been removed (intervertebral spine fusion). In addition an external fusion is usually done. In this way they thought that relapse of disc herniation can be prevented.

Dandy (1942), *Love* and *Walsh* (1940), *Key* (1945), *Spurling* and *Grantham* (1940), *Friberg* and *Hirsch* (1946) advised against primary fusion. Dandy considers that by a radical removal of the degenerated disc he can gradually bring about an intracorporal fusion.

Farrel and *MacCracken* (1941) made only fusion in 27 cases of low back and sciatic pain. They compare this material with 21 cases operated with osteosynthesis and laminectomy and think that osteosynthesis only is sufficient in disc herniations. *Williams* and *Yglesias* (1933) have also made a primary fusion without laminectomy in low back and sciatic pain. If the sciatic trouble should remain, a facetectomy is performed at a second stage.

Osteosynthesis in a conditions of low back pain without sciatic symptoms has been described by *Hibbs* and *Swift* (1929), *Chandler* (1929), *Lee* (1936), *Mitchell* (1938), *Breck* and *Basom* (1945), *King* (1948) and others. It has generally been conditions of insufficiency that has been regarded as being a sequence to spondylolisthesis, sacralisation, lumbalisation, spina bifida, narrow lumbo-sacral space. Nevertheless *Ayres* (1929) states, that of 36 cases with only thinning of the lumbo-sacral certilage, he has obtained good results in 35 cases with spinal osteosynthesis.

The method employed in osteosynthesis has varied greatly. *Wilkins* (1886) in one case of fracture of a vertebra made an osteosynthesis by means of a metal wire through the foramina intervertebralia. This is the first case of spinal osteosynthesis to be published. *Hadra* (1891) fixed the spinous processes in vertebral fractures with silver wires. *Lange* (1902) placed steel rods at an angle between the processus spinosi and the arches in spondylitis.

Hibbs and *Albee* began to use spinal osteosynthesis as a matter of routine on a large clinical material and were also the pioneers in the technique of spinal osteosynthesis. In 1911 they each described their methods. *Hibbs* fractured spinous processes and allowed them to overlay one another. *Albee* placed autogenous bone grafts from the tibia into the spinous processes. In 1912 *Hibbs* completed his method by effecting a connection between the arches and in 1917 by arthrodesis in the intervertebral joints. In the beginning Hibbs and Albee operated on cases of spondylitis and scoliosis.

De Quervain and *Hoessly* (1911) used spina scapulae as a graft. *Radulesco* (1921), *Bisguard* (1933), *Withman* (1929), and *Kleinberg* (1933) used ox bone. *Orell* (1934 & 1942) effected osteosynthesis by transplanting os novum with or without bone-chips on the spinous processes and arches. Os novum is produced by placing os purum, — necrosed bone, free from fat, connective tissue and albumin — subperiostally on the tibia. He has thereby used autoplastic, homoplastic and heteroplastic transplants with good results. *Orell* states that

an essential advantage with this method is that the transplant is soft and therefore can be easily adapted. *Laine and Moore* (1948) have also used heteroplastic transplant (from an ox)

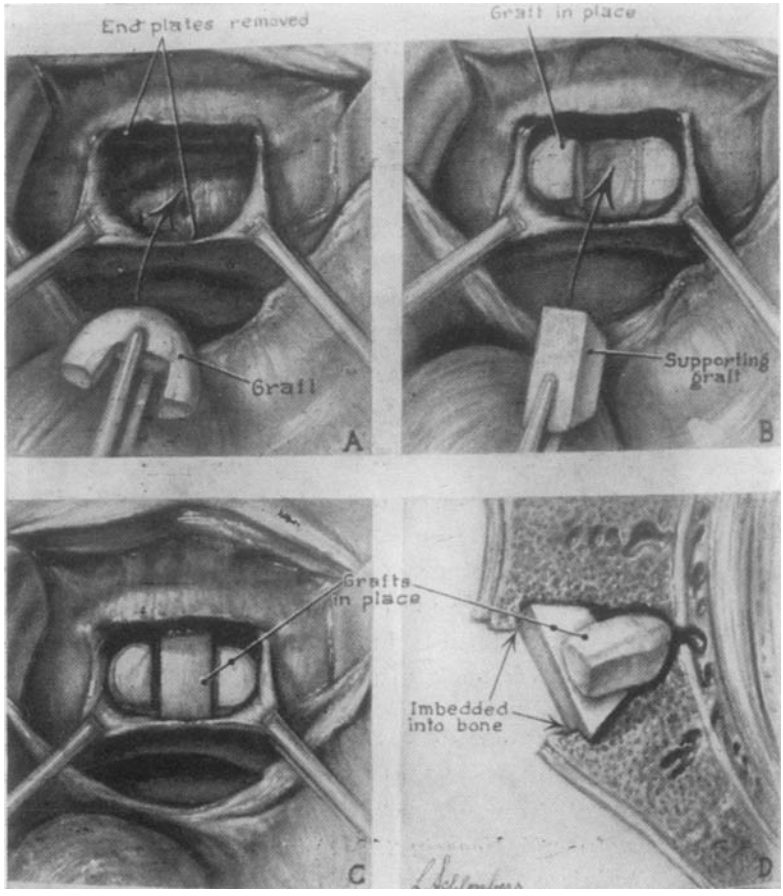


Fig. 6.
Method of inserting ox bone crescent and peg in disc space. (After Lane and Moore).

for intra-corporal fusion with transperitoneal positioning (see Fig. 6).

Lance and *Aurrousseau, Mathieu* and *Demirleau* (1936) fixed in spondylosisthesis the vertebral bodies by posterior

transplantation. *Burns* (1933), *Mercer* (1936), *Jenkins* (1936), *Kellog Speed* (1938), *Friberg* (1939) have fixed the vertebral bodies transperitoneally in spondylosisthesis. *Ito, Tsuchiya* and *Asami* (1934) made a fusion in the vertebral bodies in tuberculous spondylitis after having removed transperitoneally the tuberculous nests.

The technique of osteosynthesis in disc degeneration has, to a very large extent, been based on four principles.

1) fixation of the spinous processes;
2) fixation of the spinous processes and arches;
3) fixation of the spinous processes and arches combined with arthrodesis in the intervertebral joints;
4) fixation of the vertebral bodies by means of intercorporal fusion.

As a rule one has used autogenous transplant from the tibia or the crista iliaca. Every surgeon has then developed his method by means of some of these principles as a background. The transplant has usually been placed loosely on the arches or spinous processes. The assumption for consolidation has been that the patient has been fixed in bed and plaster for some length of time.

An improvement in technique as far as osteosynthesis is concerned was made by *Breck* and *Basom* (1943), and *Bosworth* (1945) who launched the method of locking graft or clothes-pin graft, an H-shaped graft which was pressed in between the spinous processes of the vertebrae surrounding the degenerated discs whilst the patient was in kyphosis (see Fig. 7). The graft was firmly fixed when the patient was in lordosis. In this way it was possible to obtain a better fixation and to allow the patient to get up earlier. The technique described by *Lane* and *Moore* (1948) of placing in and locking the transplant with a transperitoneal entry also aims at the same thing.

Very detailed descriptions of the technique used in spinal

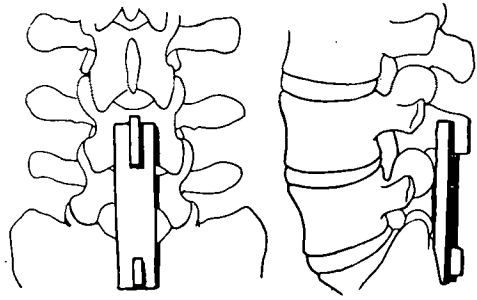


Fig. 7 (after Bosworth).

osteosynthesis are to be found in the works of *K. Bierring* (1924) and *Friberg* (1939) for which reason the author refers to these works.

From that which has been said above it appears that:

In a condition of lumbago and sciatica, complete freedom from pain is achieved by extirpation of disc prolapses in many cases. In others the back trouble can remain or increase after this intervention. Many of these are freed from pain through osteosynthesis. This can be done either primarily or secondarily. As osteosynthesis is a major intervention necessitating a long stay in hospital and as, primarily, one is unable to say whether a patient will be completely helped by extirpation of the prolapse, it would seem that primary fusion is a more violent action than necessity demands. The method that should be chosen seems to be secondary fusion. The disadvantage attached to this, however, is that it is necessary to perform two operations. The scanty information about fusion alone in disc prolapses does not give sufficient to go on as far as the value of this modus operandi is concerned.

In conditions of lumbago only the problem is more easily solved. If all conservative treatment has come to nothing and there is danger of a high degree invalidity combined with incapacity for work, one can choose surgical treatment (osteosynthesis).

The operative technique has varied. Autogenous, homogenous and heterogenous grafts have been used with evident satis-

factory consolidation. It would be desirable to make the stabilisation effective and the consolidation rapid. The greatest advance in this respect seems to be the method with locking graft described by Bosworth and by Breck and Basom.

CHAPTER VI

ANALYSIS OF 80 PATIENTS WITH LUMBAL DISC DEGENERATION TREATED BY SPINAL FUSION

The author presents a material of 80 patients suffering from lumbago or lumbago and sciatic pain treated by spinal fusion. In all the cases there are definite signs of degenerative changes in the lumbal or lumbo-sacral discs.

The principle in this material has been that osteosynthesis has been performed in conditions of severe lumbago without sciatica and as a secondary intervention after operations for disc herniation when severe back trouble has occurred or remained. Primary fusion in connection with extirpation of disc herniations has been made in certain individual cases but has not been the normal method. The material comprises all the patients who were operated on at the Clinic up to and including 1947. The author has personally examined 79 patients. One patient, a Norwegian Citizien, has been examined and roentgened by a Norwegian orthepedic surgeon in accordance with instructions given by the author. During the post examination, a roentgen examination with instability tests has been carried out and above a detailed past history and investigation of the objective findings. *Thirtysix of these patients were men and fortyfour were women.* In addition to these there are two cases that ended fatally in connection with the operation.

The cause of death in both cases was post-operative fat-embolism which was verified at a post mortem examination. The bone grafts were taken from the crista iliaca. These two cases are not included in this material.

The operations have been classified in accordance with the years as follows:

TABLE 28

Year	Number of operations	Year	Number of operations
1937	4	1943	7
1938	1	1944	21
1939	3	1945	16
1940	0	1946	9
1941	0	1947	18
1942	1		
	Total number of operations		80

The *localisation* of the clinically and roentgenologically manifested degenerations in the different intervertebral discs was as follows:

TABLE 29*)

Disc.	Men	Women	Total
L_2	0	1	1
L_3	0	2	2
L_4	7	11	18
L_5	11	19	30
L_2, L_3	1	0	1
L_3, L_4	3	2	5
L_4, L_5	10	9	19
L_3, L_4, L_5	4	0	4
	36	44	80

*) In this work the different discs are called after the vertebral body immediately above.

It will partly be seen from this table that the classification of the degenerations of the different discs for men and women are fairly similar and partly that the lumbo-sacral degenerations are most frequent, 30/80, after which comes degeneration in the 4th disc, 18/80. 51/80 are single disc degeneration and 29/80 are multiple. Predominant among the multiple are the cases with changes in the 4th and 5th discs.

The following table shows the *nature of work* performed:

TABLE 30

Nature of work	Men	Women	Total	%
Heavy manual labour.	18	22	40	50.00
Light manual labour.	8	9	17	21.25
No manual labour at all.	10	13	23	28.75
Totals:	36	44	80	

In this classification "heavy manual labour" the author has placed such trades that carry with them the lifting of heavy burdens and the carrying of them as well as repeated and violent bending forwards. This category also includes women who have to do heavy household work, hospital nurses and so on. As will be seen from the table, 50 % of the patients have to do heavy manual work.

The group "no manual labour at all" is dominated by patients whose work necessitates long periods of sitting. If prolonged sitting is counted as being a disadvantageous loading of the back, then light manual labour can be considered as being the most favourable which is confirmed by the fact that this group is the smallest.

The character of the trouble, with regard to back and sciatic trouble will be seen from table 31.

TABLE 31

Character of trouble	Men	Women	Total	%
Lumbago only.	16	23	39	48.75
Lumbago + sciatica.	20	21	41	51.25
Totals:	36	44	80	

This table shows that all the patients have had back trouble which has been the indication for operative intervention. In addition to back trouble, fortyone patients (51.25 %) had sciatic trouble. To a great extent there have been an equal number of men and women.

It has been very difficult to get a definite idea as to the character of the lumbago, since it has changed from time to time in many of the patients. The patients have been requested to give a detailed description of their back troubles and, supported by this, the following table has been drawn up:

TABLE 32

Type of back trouble	Number of patients
Mainly repeated, acute attacks of lumbago + nagging pains	10
Repeated, acute attacks of lumbago with intervals of freedom from pain cavering a period of many years and which went over to permanent nagging pains	6
Severe nagging pains accompanied by feelings of tiredness and instability in the low back	35
Continous nagging pains in the back with radiating pains on the posterior side of both thighs	20
Mainly severe nagging pains accompanied by feelings of tiredness and instability + repeated attacks of lumbago	9
Total	80

One finds two types of back trouble, partly in the form of acute attacks of lumbago and partly as a nagging pain with feelings of tiredness and instability. As will be seen from the table the latter type has been predominant in this material of severe dorsal insufficiency, which is only to be expected as this should give the patient by far more discomfort than acute attacks of lumbago with periods of total or almost total freedom from pain.

As far as *sciatic trouble* is concerned the author has tried in the same way as he did with the low back pain to arrive at the duration and degree of severity of these (see Table 33).

Of these 41 cases with sciatica, 25 presented neurological symptoms. Prior to fusion 17 patients had undergone operation for sciatic pains (see further on).

Table 34 shows the *age at the onset of the trouble.*

TABLE 33

Type of sciatic trouble	Right leg	Left leg	Both leg	Total
Severe trouble lasting about 1 year.....	2	11	0	13
Severe trouble lasting for many years	3	1	1	5
Moderate trouble lasting for many years	5	4	5	14
1 short attack of moderate trouble	2	2	0	4
Several short attacks of moderate trouble	1	0	4	5
Totals	13	18	10	41

TABLE 34

Age of patient in years	Men	Women	Total
13—16	0	1	1
17—19	4	4	8
20—24	6	9	15
25—29	9	7	16
30—34	13	11	24
35—39	1	8	9
40—44	2	3	5
45—49	1	1	2
Totals	36	44	80

From the table it will be seen that the trouble began with its greatest frequency between the ages of 20 and 35 years (of the eight female patients in the age-group 35—39, four were 35 years of age). The optimum lies between the ages of 30 and 35 years. These figures correspond well with the corresponding figures given for the material of those treated conservatively in table 17. If one places both groups together the following result will be obtained (see Table 35).

TABLE 35

Age of patient in years	Men	Women	Total
>20	6	6	12
20—24	17	18	35
25—29	18	21	39
30—34	18	20	38
35—39	4	8	12
40—44	3	4	7
45—49	3	6	9
50—54	1	2	3
Totals	70	85	155

The number of years of trouble prior to osteosynthesis operation appears from the following table.

TABLE 36

Years of trouble	Men	Women	Total
2	2	1	3
3— 4	4	6	10
5— 6	5	11	16
7— 8	0	6	6
9—10	5	3	8
11—12	4	7	11
13—15	7	2	9
16—18	4	2	6
19—21	2	2	4
22—24	0	3	3
25—27	3	1	4
Totals	36	44	80

It will be seen that no one has had trouble for less than 2 years and that there are only three patients that have had trouble for 2 years. Thirty patients have had trouble for from 5 to 10 years and thirtyseven patients suffered trouble for more than 10 years. Of these thirtyseven patients, eleven have had trouble for 19 years and over.

The following table gives the *interval elapsing between the first visit to the clinic and the time of the operation.*

TABLE 37

Number of years	Number of patients
Up to 1 year	45
» » 2 years	19
» » 3 »	5
» » 4 »	3
» » 5 »	1
More than 5 years	7
Total	80

The rather short observation time of up to one year in 45 cases is due to the fact that a number of patients were sent to our clinic after lengthy, fruitless conservative treatment in other hospitals. The time during which patients were observed and treated is, in point of fact, much longer than the figures given in the table would say. Further the period of working incapacity has often been so long that it was considered as

TABLE 38

Period of total working incapacity	Number of patients
3/12 year	4
½ »	13
1 »	11
1½ years	4
2 »	10
2½ »	3
3 »	1
4 »	6
5 »	1
6 »	3
10 »	1
Total	57

being an indication that the patient should be operated on fairly soon.

Working capacity has, in all cases, been reduced or vanished completely. Thus, twentythree patients were totally unable to work for short periods (1—2 weeks) and, periodically, partially unfit for work. Fifty seven patients were totally incapable for longer periods of doing any work (see Table 38).

Trauma, which the patient says was the cause of the trouble, has occurred in men in 10 cases and in women in 4 cases, making 17.5 % in all. Besides this, three women have said that pregnancy was the cause of the trouble. The nature of the trauma can be seen below:

TABLE 39

Natura of trauma	Men	Women
Lifted a motor car	1	—
Lifted 1100 kg (this patient was a circus performer)	1	—
Fell downstairs	1	2
Fell from a height	3	—
Slipped whilst carrying a heavy load	3	—
Run over by a car	1	
Direct blow in the back	—	2
Total	10	4

It will be seen that there is a difference between two types of traumatism i. e. a) hyperfunctional trauma, and b) trauma occasioned directly against the back. Five patients have been classified under the first group, namely those who have lifted heavy loads together with those who have slipped whilst carrying heavy loads. The latter, in an effort to regain their balance, have made a violent contraction of the dorsal muscles. There are nine cases who have had some direct act of violence on their backs.

Objective findings prior to the operation:

In order to get a comprehensive description of the objective findings prior to the operation, many difficulties have had to be overcome because the patients, for the most part, have had to be examined many times. The objective findings of the patients has varied during the different examinations. In the following table the author has noted the *objective findings that were immediately before the operation.*

TABLE 40

Objective findings	Number of patients
Throbbing pains + dorsal contracture and applanation + restricted dorsal mobility	15
Throbbing pains + dorsal contracture and applanation + positive bilateral Laségue's test	19
Throbbing pains + dorsal contracture and applanation + neurological symptoms	18
Throbbing pains + soft, normally configurated back + neurological symptoms	5
Dorsal contracture and applanation. No throbbing pains	2
Normal back + neurological symptom	4
Throbbing pains but otherwise normal back	10
Completely negative findings	7
Total number of patients	80

It will be seen that throbbing pain seems to be the most frequent symptom and was found in 67 cases. The throbbing pain symptom has been tested by striking of the spinous processes of the lumbal vertebrae and sacrum with a percussion hammer. When any of the spinous processes of the vertebrae surrounding the degenerated disc is struck, the reaction of the patient is a deep lumbal violent pain. Sometimes, lancinating pains are also perceived down the length of both thighs.

The next most usual symptom is the contracted low back with limited mobility which occurred in 54 cases.

The neurological symptom was observed in 25 cases, all of whom evinced a sciatic symptom in their past histories (see

page 107). The author has not classified the neurological symptom in the different radicular syndromes as there is no special interest attaching to this in this account.

Conservative treatment has been given to all the patients. In no case has this led to a permanent improvement, which fact has been the presupposition for operative intervention. The nature of the conservative treatment given will be seen from the following table:

TABLE 41

Type of conservative treatment	Number of patients
Plaster of paris or permanent corset + physical therapy	30
Plaster of paris or permanent corset	22
Physical therapy	7
Permanent corset + plaster of paris bed	2
Hospital treatment + various physical therapy	11
Roentgen treatment + physical therapy	6
Roentgen treatment + permanent corset	2
Total	80

Laminectomy with or without extirpation of disc prolapse prior to osteosynthesis was performed on seventeen patients who were all suffering from sciatic symptoms. The operations were performed partly at the Karolinska Institutet's orthopedic clinic and partly in other hospitals. The nature of the operations performed together with their results will be seen in Table 42.

It will be seen from the above table that the interventions were directed towards the termination of sciatic trouble. Of the 17 patients:

1) Eleven patients were operated on once,
2) four were operated on twice, and
3) two were operated on three times.

Ad 1. Prolapse was extirpated in six cases. Of these, four were freed from sciatic trouble but got worse in the back. One

TABLE 42

Number in case book	Nature of operation	Result	Time to fusion
	1 operation		
463/43	exploratory laminectomy. L4	worse in the back	15 months
5540/43	exploratory laminectomy. L3, L4, L5.	status quo	12 months
3575/42	exploratory laminectomy. L4, L5	sciatica improved	21 months
253/44	exploratory laminectomy. L4, L5	status quo	14 months
6058/42	exploratory laminectomy. L3, L4, L5	worse in the back	9 months
2239/47	extirpation of prolapse. L5	worse in the back, free from sciatica	3 months
3770/45	extirpation of prolapse. L5	worse in the back, free from sciatica	24 months
4474/45	extirpation of prolapse. L5	worse in the back, worse in the leg	20 months
1888/43	extirpation of prolapse. L5	status quo	6 months
584/43	extirpation of prolapse L4, L5	worse in the back, free from sciatica	24 months
5736/43	extirpation of prolapse. L5	worse in the back, free from sciatica	8 months
	2 operations		
4768/45	1) extirpation of prolapse L4	back and leg worse	26 months
	2) rhizotomy of L5 root	leg well	24 months
3910/40	1) extirpation of prolapse L3	status quo	32 months
	2) exploratory laminectomy L4, L5	status quo	22 months
5928/45	1) facetectomy + extirpation of lateral prolapse	status quo	10 months
	2) extirpation of prolapse L4	status quo	5 months
5833/45	1) extirpation of prolapse L4	status quo	11 months
	2) exploratory laminectomy L4	status quo	10 months

Number in case book	Nature of operation 3 operation	Result	Time to fusion
361/46	1) facetectomy + extirpation of prolapse L5	status quo	12 months
	2) facetectomy + exploratory laminectomy L3, L4, L5	status quo	4 months
	3) extirpation of prolapse L4	status quo	3 months
2953/43	1) extirpation of prolapse L4	status quo	19 months
	2) explor; laminect; L4	status quo	16 months
	3) extirpation of prolapse L5	status quo	12 months

patient showed no improvement at all and one got worse in the back and leg.

In five cases laminectomy was performed but it was not possible to find the disc herniation. In only one of these was there a manifestation of improvement of the sciatic trouble. In two cases the condition was unchanged after the operation. In two cases the sciatic trouble remained as before but the back trouble increased.

Ad 2. The first operation performed on four cases was extirpation of disc herniation. In three cases there was no improvement and in one case there was a worsening in the back and leg.

The second operation consisted, in one case, of excising the root of L5 which led to a freedom from sciatica but gave neurological symptoms. In one case it consisted of extirpation of the prolapse in the disc above (L4) and in two cases an explorative laminectomy was made: all three operations showed no improvement.

Ad 3. The type of operation and the results obtained can be seen from Table 42.

Summarily one finds (Table 43).

TABLE 43

Unchanged	8
Free from sciatic trouble but worse in the back	5
Improvement in sciatic trouble but no change in the back	2
Sciatic trouble as before but worse in the back	1
Worse in the back and leg	1
Total	17

Roentgenological picture before the operation.

The author will discuss the *lumbal, lumbo-sacral* and *multipe disc degenerations,* one by one.

The Lumbal: A classification of the disc degenerations has been made in the same way as was done with the conservatively treated cases and in accordance with the following scheme.

A) Cases where the diagnosis has been made because of changes in the disc but where vertebral changes have not been found.

B) Cases with vertebral changes, sclerosis and osteophytes and diminishing of the interspace. These cases have been classified after the diminishing of the disc into the following subheadings:

1. *Slight changes,* in which the disc is diminished but not to one half of the height of the disc.
2. *Moderate changes,* where the disc has diminished to one half or loss of its height.
3. *Pronounced changes,* where the disc is a mere fissure-like space.

Thus the classification has not been made according to the degree of sclerosis but rather in accordance with the height of the disc. As a matter of fact the author has found that the degree of sclerosis and the diminishing of the interspace coincide rather well. The author is of the opinion that a classification like this is possible since one can count on having a similar height in the lower lumbal disc and so have a definite

basis for comparison which is not the case as far as the lumbosacral discs are concerned. The author would again point out that this classification only concerns the degree of roentgenological changes and not the pathological-anatomic. There is, however, reason to suppose that the roentgenologic and pathological-anatomic coincide rather well.

A.

Instability only	1
Instability + retroposition	1
Diminished interspace	2
Total	4

B. According to the above, the *degree of roentgenological changes* for those having vertebral changes is as follows:

Slight	3
Moderate	10
Pronounced	4
Total	17

The *stability test* has shown:

Stabile	3
Instabile	10
Not tested	8
Total	21

Retroposition has been observed in seven cases and anteposition in 1 case.

The roentgenological picture in degeneration of the lumbosacral disc.

It has not been possible to take the interspace into con-

sideration here since the lumbo-sacral disc, though normal, can be low (see page 78). If a reduction in the height of the disc could be noticed during the different examinations it has been interpreted as a progress of the degeneration. Similarly the author has considered as being highly significant for disc degeneration the facts that the edges of the vertebral bodies have been considerably angularly placed and the posterior part very narrow or that the vertebrae have lain against one another.

In order to be able to arrive at a suitable gradation, the author has gone after the degree of sclerosis and osteophytes as was done in the cases with conservative treatment.

The following groups are then obtained:

A. Cases *without* vertebral changes.
B. Cases *with* vertebral changes classified as follows:
   1) slight changes,
   2) moderate changes,
   3) pronounced changes,
   4) total obliteration of the disc with fusion of the vertebrae.

A. *Without vertebral changes.* 4 cases.

Of these *four* cases, *one* had retroposition, *two* had retroposition + lowered posterior range of the disc, and *one* had lowered posterior range only. Neither the retroposition nor the lowered posterior range of the disc is absolutely significant for disc degeneration. That the diagnosis could be made is due to the fact that the lumbo-sacral disc herniation was extirpated in all four cases.

B. Sclerosis and osteophytes were found in *twentysix* cases and in various degrees.

1) slight changes,	5
2) moderate changes,	10
3) pronounced changes,	11
Total	26

In eleven of all lumbo-sacral cases there was a *marked lowering of the posterior range of the disc* where there was often a local sclerosis.

In twentyone cases there was *retroposition.*

In three cases, *vacuum phenomena* were manifest.

In three cases there was *instability,* in seven there was stability and sixteen cases were not examined.

Examination of the roentgenograms of the multiple disc degenerations was carried out in accordance with the same principles as above. It then proved to be most suitable to make a classification into the lumbal and lumbo-sacral discs and not in accordance with the cases themselves. There are 62 discs of which 39 are lumbal and 23 are lumbo-sacral.

Five discs had *no vertebral changes.* Of these, three lumbo-sacral where the diagnosis was made by operation, and two lumbal, one with instability and the other verified by operation (extirpation of disc herniation).

The *lumbal disc degenerations with vertebral changes* and *lowered interspace,* thirty seven cases, show the following classification:

1) slight changes	9
2) moderate changes	18
3) pronounced changes	10
Total	37

Instabile	13
stabile	13
not tested	11
Total	37

21 discs with *retroposition.*

2 discs (the same patient) with *vacuum phenomena.*

Twenty cases with *vertebral changes in the lumbo-sacral discs* have been classified as follows:

Slight changes	5
moderate changes	6
pronounced changes	9
Total	20

13 cases with *retroposition* comprising:
8 cases with *angular interstitium,*
1 case with *instability,*
4 cases with *vacuum phenomena.*

Table 44 shows the *ages of the patients when operated on for osteosynthesis:*

TABLE 44

Age of patient in years	20—24	25—29	30—34	35—39	40—44	45—49	50—54
Number of cases	2	6	11	19	24	15	3

It will be seen from this table that the majority were operated on between the ages of 30 and 49 years. The patient's past history points out that disc degeneration trouble reaches its maximum at these ages. The patients usually say that the trouble began very slightly between the ages of 20 and 25 years and that progress takes place and reaches its maximum between the ages of 35 and 40 years. Some patients even think that by the time they are 35—45 years old, they have had their trouble for so long that they realize that neither time nor conservative treatment can cure them of their severe trouble.

Operative technique in osteosynthesis.

Albee with grafts only in the spinous process 7

Albee + fusion between the arches 18

(5 of these cases were also subjected to arthrodesis in the intervertebral joints).

Bilateral grafts on the renovated arches (Fig. 8) 11

Unilateral graft on the renovated arches + bonechips on the renovated arches of the other side 24

(3 of these cases were also subjected to arthrodesis in the intervertebral joints) (Figs. 9 and 10).

Bilateral grafts on the arches that were *not* renovated 2

H-shaped graft locking graft between spinous processes + fusion between the arches + arthrodesis in the intervertebral joints 18

Of these the graft has been placed within an interstitium in eight cases i. e. in the 4th in four cases and in the 5 th in the other four (Fig. 11).

In two cases the graft was placed within 2 interstices with resection of the intervening spinous process, both L4—S1.

In five cases the graft was placed within 2 interstices but with a hole in the graft for the intervening spinous process, both L4—S1. (Fig. 12).

In three cases one has used instead a *spool-shaped graft* between L4 and S1 having the top and bottom ends entering and getting support from the spinous process. The spinous process of L5 was split and sutured around the graft.

The osteosynthesis was placed within the following interstices (see Table 45).

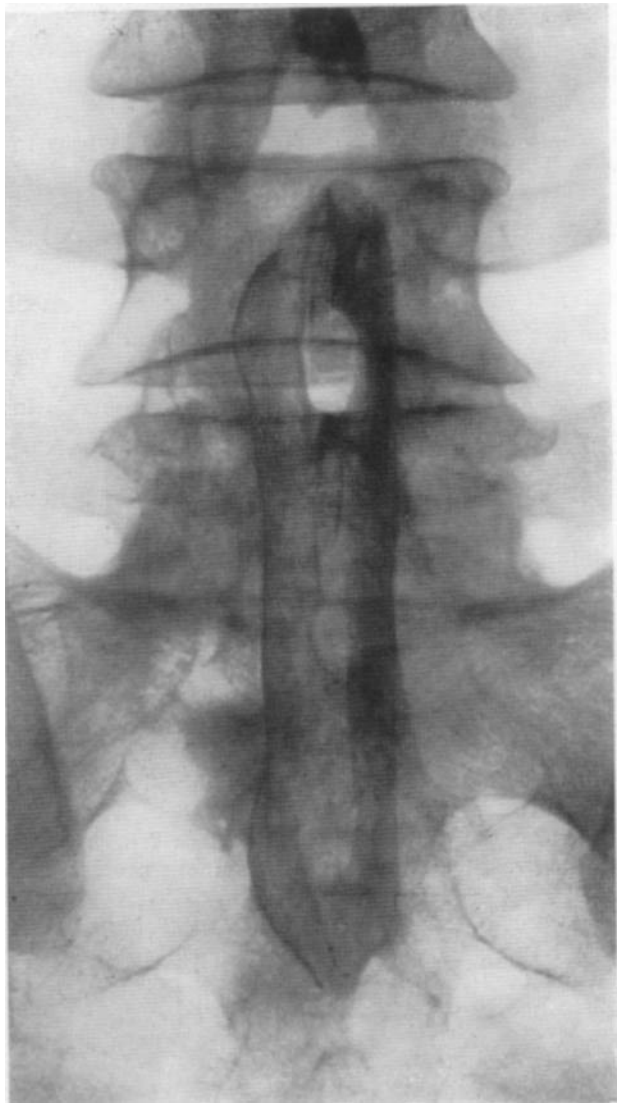


Fig. 8.

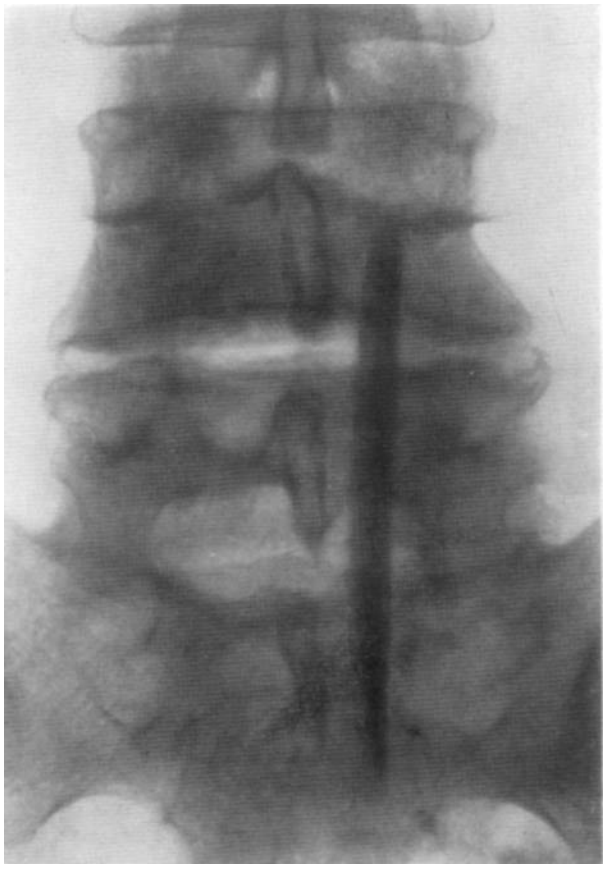


Fig. 9.

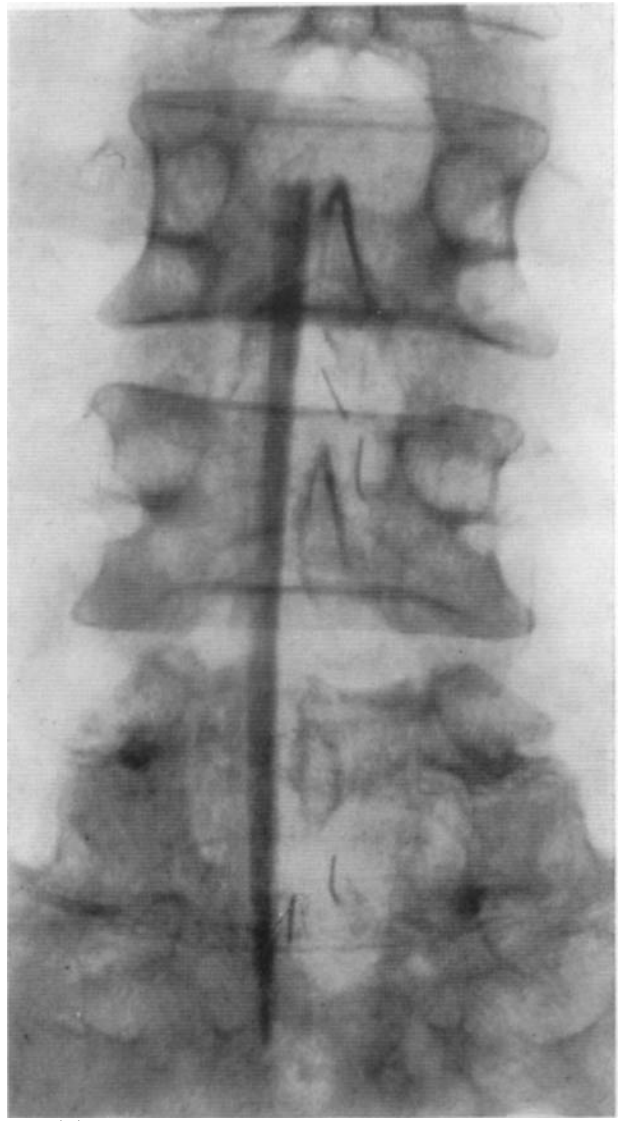


Fig. 10.

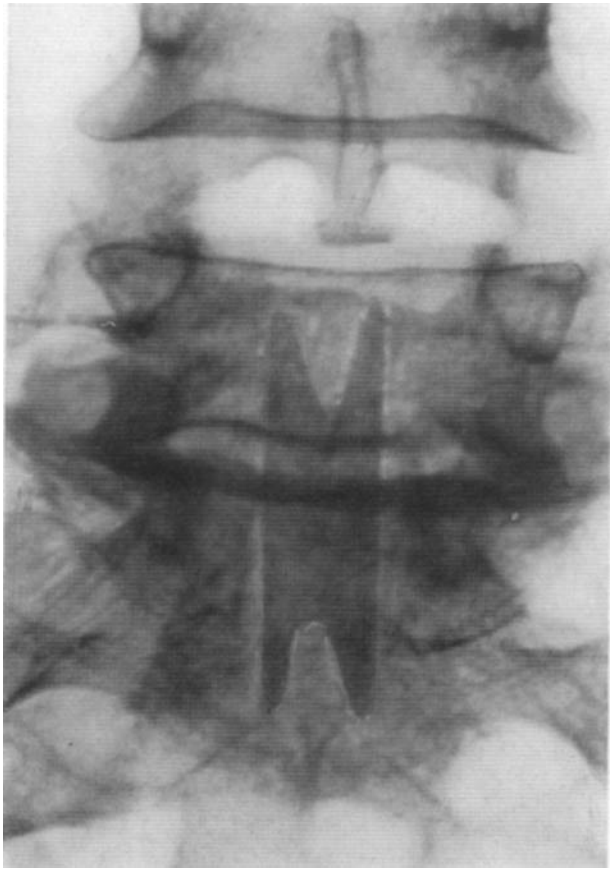


Fig. 11.

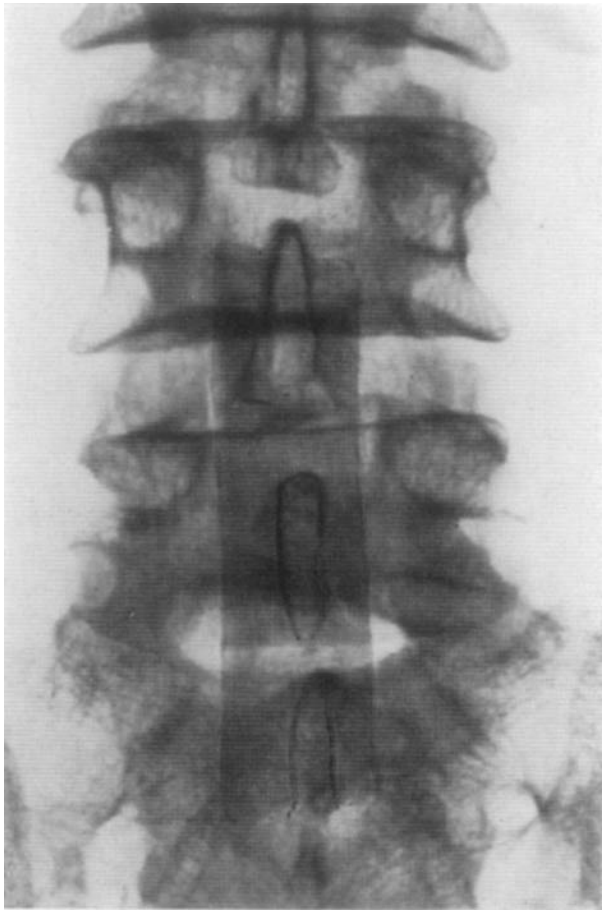


Fig. 12.

TABLE 45

Interstice	Cases
5th	14
4th—5th	41
3rd, 4th—5th	14
2nd, 3rd, 4th—5th	2
4th	4
3rd—4th	2
2nd—3rd	1
2nd	1
3rd	1
Total	80

Seventeen explorative laminectomies with negative findings were performed in connection with the osteosynthesis operation. Of these, eleven were lumbo-sacral and three in the 4th disc. In two cases the 4th—5th disc was explored and in one case the 3rd—4th disc was explored.

In connection with the osteosynthesis operation three *disc herniations were extirpated* of which two were in the 4th interstice and one in the 5th interstice.

In eight cases (including the two fatal cases previously mentioned) the grafts was taken from the *crista iliaca.* In the other cases the transplant or transplants were taken from the *crista anterior and facies medialis tibiae.*

In two cases the *osteosynthesis was faultily placed* so that it did not embrace the roentgenologically manifest disc degeneration. In the one case with lumbo-sacral disc degeneration the graft was placed only in the 3rd and 4th interstice whereas in the other with degeneration in the 3rd, 4th—5th disc, it was placed in the 4th and 5th interstices.

After the operation the patients have been placed in plaster-of-paris bed embracing the back and pelvis but not the thighs or head. They have remained in these from 6 to 12 weeks, the shorter periods have applied to patients who were operated on with locking graft. It has been thought that the graft is then so well fixed that there is no risk of its being dis-

placed. During the latter part of the time spent in bed physical therapy has been given to the lower extremities, but not to the back. When the patient gets up a plaster-of-paris corset is immediately supplied and is worn for from three to six months. This corset is then exchanged for one made of cloth or leather which is worn for up to one year except in cases where the patient is not freed from pain when it is worn for a longer period.

Postoperative complications of any importance have not been registered except the two cases where fat embolism caused death and which have been previously mentioned in this work.

Table 46 shows *the time of postoperative incapacity for working,* including the time that was spent in hospital. Fourteen cases were totally unfit for work after the operation.

TABLE 46

Time of working incapacity following the operation	Number of patients
3 months	3
4 months	4
5 months	6
6 months	12
7 months	6
8 months	7
9 months	7
10 months	5
11 to 12 months	5
13 to 15 months	4
16 to 20 months	5
21 to 24 months	1
3 years	1
Total	66

It will be seen from the table that twenty five patients were able to take up their work again within six months, and fifty five within one year after the operation (68.75 %).

Eleven patients were not able to return to work until more than one year had elapsed after the operation.

Result of post examination.

The following table shows the *interval between the time of discharge from hospital and the post examination.*

TABLE 47

Time	Number of patients
1 year	29
2 years	21
3 years	4
4 years	15
5 years	3
6 years	1
7 years	0
8 years	2
9 years	2
10 to 12 years	3
Total	80

No patient has been examined until one year has passed from the time of *discharge from hospital.* It appears that fifty patients were examined within 3 years after discharge. One patient has been under observation for 12 years.

Subjectively the patients have stated, when they were post examined (Table 48).

TABLE 48

Completely recovered	53 (66.25 %)
Improved	12 (15.00 %)
No improvement	15 (18.75 %)
	80 (100 %)

The subjective symptom which the patients have had when post examined was *back trouble* in every case (27 cases). But besides this, twelve had a remaining *sciatic trouble.* Nine of these patients with sciatic trouble belong to the subjectively unimproved group whilst three belong to the improved group.

In no case has there been any increase of or any new sciatic trouble following osteosynthesis. It appears from this material that *the risk of any sciatic trouble arising after an osteosynthesis is minimal* but in cases where there was sciatic trouble already at the time of the osteosynthesis operation, it did not always disappear. This is of great interest to know because one has always feared that a disc herniation, demanding a laminectomy, would occur after an osteosynthesis. Laminectomy such as this must ever be difficult to perform as one is forced to penetrate large masses of bone in order to get at the disc.

Working capacity: Thirteen patients, all of whom belonged to the unimproved group at the time of the post examination, were found to be incapable of doing any work. A change over to lighter work took place in *six* cases of the whole material. Two of these belonged to the cured group, three to the improved group and one to the unimproved group.

On *examination of the objective factors* in this material, the following circumstances were placed in the foreground:

1) localization of disc degeneration,
2) the number and character of laminectomies,
3) the consolidation and the stabilizing effect of the osteosynthesis,
4) the occurrence of fresh changes, and
5) the progress of the degenerative changes.

Having the *localization of the disc degeneration* as a point of departure we get the following results.

TABLE 49

Localization	cured	improved	not improved	total number
Solitary lumbal disc degenerations	13 (62 %)	4 (19 %)	4 (19 %)	21
Solitary lumbo-sacral disc degeneration	23 (76.7 %)	4 (13.3 %)	3 (10 %)	30
Multiple disc degenerations	17 (53.8 %)	4 (14.1 %)	8 (27.6 %)	29
Totals	53	12	15	80

In order to be able to compare these three groups, it is necessary to register the number of times that laminectomy has been performed as well as the occurrence of graft complications and fresh changes.

In the *lumbal disc degenerations* these have been as follows:

TABLE 50

Laminectomy only	5
Laminectomy + graft complications	2
Only graft complications	4
Fresh disc degeneration + spondylolisthesis	1
Total	12 cases

In twelve cases (57.13 %) of the lumbal disc degeneration complications have been registered.

The following complications were registered in the *lumbo-sacral disc degenerations:*

TABLE 51

Laminectomy only	7
Laminectomy + graft complications	2
Graft complications + fresh disc degenerations	1
Only graft complications	5
Fresh disc degeneration	3
Total	18 cases

In eighteen cases (60 %) of the lumbo-sacral disc degenerations, complications have occurred.

The following complications were registered in the *multiple disc degenerations:*

TABLE 52

Laminectomies	8
Laminectomies + graft complications	3
Laminectomies + graft complications + fresh disc degeneration	1
Laminectomy + non-stabilized disc degeneration	1
Graft complication + fresh disc degeneration	1
Graft complications only	4
Graft complication + non-stabilized disc degeneration	1
Total	19 cases

Nineteen cases (65.51 %) with multiple disc degenerations have had complications.

These figures show that the complications arising within the different groups have been approximately of as many per cent. This seems to speak for *the best prognosis for isolated lumbo-sacral disc degenerations. The prognosis is worse in the isolated lumbal disc degenerations and worse in the multiple disc degenerations.* The author also discovered this difference when examining a material of 46 patients in 1948.

In the first place the author wishes to make a general survey of the different groups wherein the patients have stated that they were *subjectively cured, improved or not improved.*

The subjectively cured.

TABLE 53

Free from complications	27
Laminectomy only	12
Laminectomy + graft complications	1
Laminectomy + faulty positioning of the osteosynthesis	1
Graft complications only	9
Graft complications and "fresh" disc degeneration	2
"Fresh" disc degenerations only	1
Total number of patients	53

It will be seen that out of fifty three subjectively cured patients, *twenty seven are totally free from complications whilst twenty six have complications.*

An examination of the *subjectively improved* cases gives us the following:

TABLE 54

Free from complications	3
Laminectomy only	2
Laminectomy + graft complications	2
Graft complications only	4
Fresh disc degenerations	1
Total number of patients	12

It will be seen that of the twelve patients who were subjectively improved, *three of them are free from complications whilst nine of them have complications.*

An examination of the *subjectively unimproved* cases gives us the following:

TABLE 55

Free from complications	1
Laminectomy only	5
Laminectomy + graft complications	3
Laminectomy + graft complications + fresh disc degeneration	1
Laminectomy + fresh disc degeneration	1
Graft complications	3
Fresh disc degeneration + spondylolysis aquisita	1
Total number of patients	15

It will be seen that of the fifteen cases there was only *one that was free from complications.* As these unimproved cases are all of special interest, a short case report will be given of each.

Case Reports.

1) *Record No. 2432/43 E. M.* Hospital nurse. Born 1898.
Disc degeneration: L4.
Subjective symptom: back trouble.
Roentgenological diagnosis: 28/10/1946, slight sclerosis + instability.
Operated on 15/12/1947: locking graft with spool-shaped transplant + fusion between both arches + arthrodesis in intervertebral joints.
Post examination on 21/1/1949: same trouble continues in the back. Objective symptom, contracting throbbing low back pains. Roentgen examination: partial resorbtion of the upper part of the graft. Instability impossible to test on account of contraction.

2) *Record No. 2835/38 E. E.* Female hospital employee, born 1905.
Disc degeneration: L4.
Subjective symptom: back trouble.
Roentgenological diagnosis: 14/10/1943, slightly lowered interspace + instability.

Operated on 4/12/1944: tibia transplant to the right on L3-sacral arches + fusion between the arches.
Post examination on 13/1/1949: back trouble as before.
Objective symptom: instability and throbbing low back pains.
Roentgen examination: graft well fixed between the arches L3 to sacrum. In addition a bilateral spondylolysis on the arch of L3 with typical inter-articular columnar formations (spondylolisthesis aquisita and fresh disc degeneration of L3, with instability (fig. 13).
This case was described in Acta Ortopedica 1950, by the author*).
As far as the author can ascertain from the literature, *this is the only case of verified spondylolisthesis aquisita that has been reported and even the only one where spondylolysis has occerred above a lumbal osteosynthesis.*

3) *Record No. 3575/42, E. B.* Housewife, born 1901.
Disc degeneration: L4.
Subjective symptom: lumbago + sciatica.
Roentgen: 25/4/1944, lowered interspace, sclerosis and osteophytes.
Explorative laminectomy on 16/11/1942 (hemi-laminectomy on L5 and major laminectomy on L4).
Status unchanged.
On 21/8/1944, graft on L4-sacrum on the remnants of the arches.
Post examination on 20/2/1949: pain in the back and in both legs, incapable of working.
Roentgen showed satisfactory osteosynthesis.

4) *Record No. 6058/42, A. C.* Hospital nurse, born 1906.
Disc degeneration: L4.
Subjective symptom: low back and sciatic pains.
Roentgen on 25/4/1944: lowered interspace, sclerosis and osteophytes. On 18/11/1943 major laminectomies on L3—L4—L5—S1. After this the patient was free from sciatica but the back trouble increased.
Osteosynthesis on 17/8/1944: graft on arches of L4-sacrum + roughening up of the arches.
No subjective improvement.
Roentgen showed on 11/12/1945 a pseudo arthrosis of the graft on L4.
Re-operated on 12/12/1945: fixation of the graft.
Post examination on 5/5/1949: severe back trouble. Incapable of work.
Roentgen showed a good fixation of the arch.

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*) in reprint.

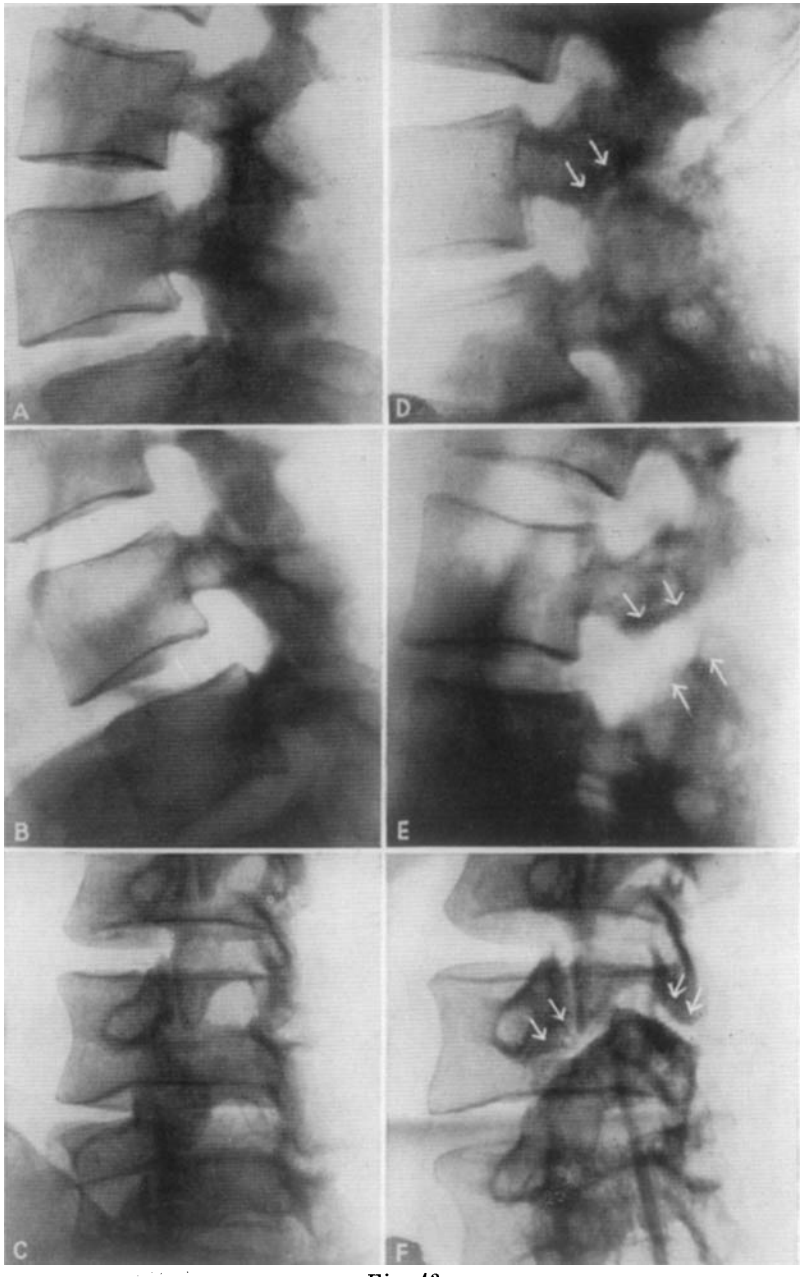


Fig. 13.
To the left: before operation. *To the right:* 5 years after operation. A-D: backwardbending, B-E: forwardbending and C-F oblique projection in forwardbending.

5) *Record No. 3620/46, A. J.* Tinsmith, born 1905.
Disc degeneration: L5.
Subjective symptom: back trouble.
Roentgen, 28/8/1946: Sclerosis, instability, retroposition.
Operated on 24/9/1946: graft on side of spinous process. No fusion between arches.
Same trouble in back. Incapable of working.
Roentgen, 31/1/1949: graft fixed to sacrum only. Instability remains.
Re-operated on 1/2/1949. The graft was found to be completely loose from the spinous process of L4 and L5. Fixation of the loosened graft + fusion between the arches.
As the time of observation was so short it is not possible to say what the result of this operation is.

6) *Record No. 1115/39 M. W.* Housewife, born 1911.
Disc degeneration: L5.
Subjective symptom: back trouble.
Roentgen,21/3/1939. Lowered interspace posteriorly. Marked retroposition.
Operation, 2/2/1945: graft to left of spinous process + fusion between the arches + bone chips L4—S1.
Post examination, 21/2/1949: Subjectively the same back trouble. Objectively contracted back. Roentgen: progress of disc degeneration in L5. It was also seen that the interstice of the disc L4 was diminished (one cannot say whether this is a sign of disc degeneration or whether it is a sequence of fusion with the atrophy of inactivity).

7) *Record No. 3770/45 K. H. A.* Tailor, born 1907.
Disc degeneration: L5.
Subjective symptom: Lumbago + sciatica.
Roentgen, 18/8/1945: The lumbo-sacral space lowered posteriorly to its maximum. Myelography showed points of appui for disc herniation L5.
20/8 1945 extirpation of a protruding disc L5. Free from pain in the leg but increasing pain in the back.
16/9/1947: fusion with locking graft L5—S1 + fusion between the arches and arthrodesis in the intervertebral joints. Free from pain in eight months but then a relapse to the former back trouble. As the patient complained of a severe throbbing pain above the transplant, disc degeneration was suspected at this place.
Re-operated on 21/12/1948. Instability was found in the 4th disc which was regarded as being disc degeneration. Fixation of the 3rd and 4th discs by means of a fresh osteosynthesis.

Post examination on 15/11/1949. No improvement. Incapable of working.
Roentgen: the latest osteosynthesis has healed well.

8) *Record No. 3910/40, G. R.* Heavy-weight lifter in a circus, born 1905.
Disc degeneration: L3 and L4.
Subjective symptom: low back and sciatic pain.
Roentgen 1942. Moderate disc degeneration. Myelography with iodipin showed disc protrusion in L3.
6/2/1942: Extirpation of prolapse L3.
17/2/1943: Explorative laminectomy L5—S1.
15/11/1944: Hemi-laminectomy L3 to L5 + fusion L2-sacrum.
Post examination on 25/1/1949. Subjective symptom: very much pain in the back and left leg. Objectively the back was completely stiff. Laségue positive. Neurological symptom.
Roentgen: The transplant on L2-sacrum well healed. In the corresponding disc L5 there is a pseudo arthrosis. (In this case there were complications in connection with the myelography in that the contrast was injected extradurally: further the dura had to be opened in order to evacuate the contrast medium. During the latter operation one found an adhesive meningitis as a consequence of this).

9) *Record No. 4474/45, L.* Farmer, born 1915.
Disc degeneration: L4 and L5.
Subjective symptom: Lumbago + sciatica.
Roentgen on 29/8/1945 showed lowered interspace and sclerosis in both interstices. In the 5th disc there was also retroposition. The lowering of this disc is placed in the posterior range.
17/2/1944: Extirpation of prolapse L5. (two major laminectomies were performed on this occasion).
No improvement in either the back or leg.
18/10/1945. Explorative laminectomy L5—S1 + fusion in accordance with Albee, L4-sacrum. Nothing done to the arches.
Post examination on 21/2/1949. Pains in back and left leg as before.
Objectively, contracted back and throbbing pains.
Roentgen showed that graft was not fixed to the skeleton but lies loosely in the soft parts. Stability test not possible as the back is stiff.

10) *Record No. 361/46, T. O. G.* Bricklayer, born 1916.
Disc degeneration: L4 and L5.
Subjective symptom: low back and sciatic pain.
Roentgen on 17/6/1946: negative. Myelography positive for disc herniation L5.
29/7/1946: Disc puncture with injection of contrast in the disc.
31/7/1946: Facetectomy + extirpation of prolapse L5.
2/4/1947: Facetectomy + exposure of nerves L4, L5 and S1.
12/5/1947: Extirpation of prolapse L4.
21/7/1947: Fusion with graft on one side of the arches L3-sacrum.
19/4/1948: Rhizotomy of L5.
21/9/1948: Rhizotomy of S1.
Postexamination on 3/12/1948. No improvement. Contracted back and considerable neurological symptom. Incapable of working.
Roentgen showed no fixation of transplant to the sacrum.

11) *Record No. 5540/43, L.* Manual labourer, born 1908.
Disc degeneration: L4 and L5.
Subjective symptom: low back and sciatic pain.
30/9/1943, roentgen showed lowered interspace, sclerosis and osteophytes.
28/1/1944: Explorative laminectomy L3—L4—15. (Major laminectomies).
No improvement in either the leg or back.
27/9/1944: Fusion with graft L3-sacrum + fusion between arches. No improvement.
17/9/1948: Roentgen showed that osteosynthesis had healed but that there was pseudo arthrosis L4—L5.
Re-operation on 11/10/1948: During the operation one could establish an abnormal mobility in the 2nd lumbal disc indicating disc degeneration (roentgen negative). Osteosynthesis of this disc together with chiselling into the pseudoarthrosis in the osteosynthesis.
Post examination 15/11/1949: Subjective no improvement. Pain in the back and left leg as before. *Objectively*, completely stiff in the back, Laségue positive, neurological symptom.
Roentgen: Satisfactory consolidation of the osteosynthesis. Incapable of working.

12) *Record No. 3085/37, G.* Housewife, born 1899.
Disc degeneration: L4 and L5.
Subjective symptom: Lumbago.

Roentgen on 8/3/1938, shows sclerosis and osteophytes on the vertebrae surrounding disc L5. No sign of disc degeneration L4.

15/8/1948: operation in accordance with Albee L4-sacrum. Nothing done to arches and intervertebral joints.

Post examination on 5/5/1947: Subjectively the same trouble in the back. Incapable of working. Objectively: Contracted and stiff back. No neurological symptom. Roentgen showed signs of disc degeneration L4 with lowered interspace. The graft fixed to sacrum only. There are also two instabilized degenerated discs. If the operation has been successful, the 5th and the 4th discs, which later showed signs of degeneration, had been stabilized.

13) *Record No. 2952/43, E. G.* Clerk, born 1919.
Disc degeneration: L4 and L5.
Subjective symptom: lumbago + sciatica.
Roentgen on 18/1/1944: Low interspace L4, retroposition of L5, instability L4.
16/7/1943: extirpation of prolapse L4.
27/10/1943: laminectomy in 4th and 5th discs. A marked cicatricial formation was observed round the root and dura.
14/1/1944: Extirpation of prolapse L5.
12/1/1945: explorative laminectomy L5 + rhizotomy of S1 + fusion between L4 and sacrum with graft to one side of and rougening
Post examination on 22/3/1949: Subjectively pain in back and both legs. Objectively the back was fine. Lasegue negative bilaterally. Neurological symptom. Incapable of working.
Roentgen: The osteosynthesis healed well. Progress of disc degeneration L4. There was now a roentgenological sign of disc degeneration L5 (previously confirmed by disc herniation at this place).

14) *Record N. 253/44, S.* Female clerk, born 1918.
Disc degeneration: L4 and L5.
Subjective symptom: low back and sciatic pain.
Roentgen 18/1/1944: low interspace L4, instability and retroposition of L5. No vertebral changes.
16/2/1944: explorative laminectomy L4—L5. During the operation one saw signs of disc degeneration but no prolapse.
11/4/1945: explorative laminectomy L5—S1 + fusion to sacrum with graft on one side of the arches and roughening up of the arches.
15/3/1949: *Post examination:* Subjectively free from trouble in the leg but pains in the back as before. Capable of working. Ob-

jectively: stiff back. Laségue positive. Neurological symptom from the right leg.

Roentgen: good consolidation of the osteosynthesis. Disc degeneration as before.

15) *Record No. 5763/44, K. I. A.* Lorry driver, born 1900.
Disc degeneration: L3, L4 and L5.
Subjective symptoms: lumbago + sciatica.

19/12/1944: sclerosis and osteophytes as well as a lowered interspace in the 3rd and 4th discs. Roentgenologically the 5th disc showed nothing in particular.

6/6/1944: Exploration L5. One found signs of disc degeneration but no prolapse. Fusion between L3 and sacrum with graft to the left. Bone chips and arthrodesis in the intervertebral joints.

Post examination on 15/2/1949: Subjectively the leg is well but the same troubles exist in the back. Objectively: contracted back. Laségue positive bilaterally. Incapable of work as before. Roentgen: good consolidation of the osteosynthesis.

It is of interest to give a closer *analysis of the laminectomies* that have been performed. In the table below the number of laminectomies as well as their character under the headings, cured, improved and unimproved are set out. Besides this, the other complications that have occurred in each case are noted. When describing the character of the laminectomies the author, when using the term "small", means that nothing much larger has been recessed than that part of the arch where the ligamentum flavum is attached. By "moderate" is meant that a somewhat larger part of the arches has been removed. By "major" is meant when larger parts or the whole has been recessed. When the author talks about the arch it is meant half of an arch. Total laminectomy has not been performed. The magnitude of the laminectomies has been assessed with the support of the operation report and the roentgenograms.

Table 56 shows *laminectomies performed in the cured cases,* fourteen out of fifty three (26.6 %).

TABLE 56

Record number	Localisation of disc degeneration	Laminectomy (number, character and vertebrae)	Complications
4768/48	L4	1 small L4—L5	0
463/43	L4	2 small L4—L5	0
1152/47	L4	1 small L4—L5	0
5833/45	L4	2 small L4—L5	0
2239/47	L5	1 small L5—S1	0
3645/44	L5	1 small L4—L5—S1	0
2721/36	L5	1 small L5—S1	0
387/42	L5	1 small L5—S1	0
5736/43	L5	1 small L4—L5—S1	0
5274/43	L5	1 small L4—L5	Pseudoarthrosis on the upper fastening at L3
584/43	L3 and L4	1 small L4—L5	0
82/41	L4 and L5	1 small L4—L5—S1	0
2702/45	L4 and L5	1 small L5—S1	0
1294/36	L3, L4 and L5	1 moderate L4—L5 bilat.	Osteosynthesis does not embrace disc L3 which is instabile.

Table 57 shows the *laminectomies performed on the improved cases*, four out of twelve (33.33 %).

TABLE 57

Record number	Localisation of disc degeneration	Laminectomy (Number, character and vertebrae)	Complications
3789/43	L4	1 small L4—L5	Pseudoarthrosis on level of L4—L5
203/44	L5	1 major L5—S1	0
1888/43	L5	1 small L5—S1 1 major L5—S1 1 major (post fusion)	Infection from sore Resection of root of L5
5928/45	L4 and L5	1 small L4—L5 1 major with facetectomy L5—S1	0

The following table shows the *laminectomies performed in the not improved cases,* 10 out of 15 (66.67 %).

TABLE 58

Record number	Localisation of disc degeneration	Laminectomy Number, character and vertebrae	Complications
3575/42	L4	1 major L4—L5	0
6058/42	L4	1 major L4—L5 and L5—S1	Pseudo arthrosis at fastening of graft in L4
3770/45	L5	1 small L5—S1	Disc degeneration in 4th disc above the graft
3910	L3 and L4	1 small L3—L4 1 major L4—L5—S1 1 major L3—L4—L5	Pseudo arthrosis at level of L5—S1
4474/45	L4 and L5	1 moderate L5—S1 1 moderate L5—S1	No fixation of the graft to skeleton
361/46	L4 and L5	1 major (facetectomy) L5—S1 1 major (facetectomy) L4—L5 1 major L4—L5	Rhizotomy on roots of L5 and S1
5540/43	L4 and L5	1 moderate L3—L4—L5—S1	Pseudo arthrosis L4—L5, disc degeneration above graft
2952/43	L4 and L5	1 moderate L4—L5 1 moderate L4—L5 1 moderate L5—S1 1 moderate L5—S1	0
253/44	L4 and L5	1 small L4—L5 1 moderate L5—S1	0
5763/44	L3, L4 and L5	1 moderate L5—S1	0

The *fate of the graft* will be seen from the following table which gives the localization of the disc degeneration, the placing of the graft, the consolidation of the graft, the stability in the degenerated disc as well as other complications which includes laminectomy.

Graft complications in the "cured" cases, eleven out of fifty three cases (20.75 %).

TABLE 59

Record number	Localisation of disc degeneration	Placing of graft	Consolidation of graft	stab = + instab = −	Other complications
1266/44	L4	L4-sacrum	knocking off and extirpating of graft	+	0
3402/42	L4	L4-sacrum (Albee)	graft not healed in spinous process of L4, pseudoarthrosis at spinous process of L5	−	0
4437/44	L5	L4-sacrum (fusion of arches, arthrodesis in intervertebral joints)	pseudoarthrosis at L5 and at the fixation of L4's spinous process	+	Disc degeneration in 3rd—4th discs with instability
576/37	L5	L4-sacrum (Albee)	pseudoarthrosis between spinous process of L5, S1	+	0
33512	L5	L3-sacrum (fusion of arches)	graft fixed to L5 and sacrum only	+	
2522/39	L5	L3-sacrum (fusion of arches)	upper end not fixed to L3. Pseudoarthrosis at spinous process of L5	+	0
3016/42	L5	L3-sacrum (fusion of arches)	graft not fixed to L4	+	0
5274/43	L5	L3-sacrum (fusion of arches)	graft not fixed to L3	+	1 small laminectomy
1493/42	L3 and L4	L3-sacrum (fusion of arches)	pseudoarthrosis between L5 and S1 (fracture during operation)	+	0
464/37	L4 and L5	L3-sacrum (Albee)	graft fixed to sacrum only	−	fresh disc degeneration in L3
2442/44	L4 and L5	L3-sacrum (fusion of arches, arthrodesis in intervertebral joints)	fracture at the operation on graft. Total consolidation	+	0

The following table shows *graft complications in cases under the group "improved"*, five out of twelve cases (46.67 %).

TABLE 60

Record number	Locality of disc degeneration	Placing of graft	Consolidation of graft	Stab = + Instab = —	Other complications
2730/42	L4	L4-sacrum (fusion of arches)	pseudoarthrosis at spinous process L5	+	0
3789/43	L4	L4-sacrum (fusion of arches)	pseudoarthrosis between spinous process L4 and L5	+	1 small laminectomy L4—L5
2528/44	L4 and L5	L3-sacrum (fusion of arches)	pseudoarthrosis at spinous process L3	+	0
2669/44	L4 and L5	L4-sacrum (fusion of arches)	knocking off and extirpation of the whole graft	stab. not possible to test	0
4271/44	L3, L4 and L5	L4-sacrum (fusion of arches + arthrodesis in intervertebral joints)	pseudoarthrosis between L5 and sacrum	stab. not possible to test	the degenerated disc L3 not stabilized

The following table shows *graft complications in cases under the group "unimproved"*, six cases out of fifteen (40.0 %).

TABLE 61

Record number	Locality of disc degeneration	Placing of graft	Consolidation of graft	Stab = + Instab = −	Other complications
2432/43	L4	L4-sacrum (locking graft, fusion of arches, facet-arthrodesis)	graft partly resorbed at upper fixation in L4	stab. not possible to test	0
3620/46	L5	L4-sacrum (Albee)	graft fixed to sacrum only	—	
3910/40	L3 and L4	L2-sacrum	pseudoarthrosis between L5 and sacrum	stab. not possible to test	3 laminectomies of which 2 were major
361/46	L4 and L5	L4-sacrum (fusion of arches)	graft not fixed to sacrum	—	5 laminectomies
5540/43	L4 and L5	L4-sacrum (fusion of arches)	pseudoarthrosis at upper fixation in L4	stab. not possible to test	Laminectomy in 3rd, 4th and 5th discs. Fresh disc degeneration in L3 disc
3085/37	L4 and L5	L4-sacrum (Albee)	graft fixed to sacrum only	—	0

An examination of the above tables shows the following:

1) *Unsatisfactory fixation of the upper part of the graft,* either so that the attachment gives a picture of a pseudoarthrosis or that it lies freely in the soft parts, was observed in nine cases (Fig. 14).

2) The graft was fractured in seven cases, of which six

showed *remaining pseudoarthrosis* (Figs. 15 and 16). In one case fracture occurred during the operation but healed by callus in connection with the healing of the graft.

3) *Unsatisfactory fixation at the upper attachment of the graft and remaining pseudoarthrosis* was observed in three cases.

4) *Unsatisfactory fixation of the lower end* has occurred in only one case.

5) In two cases there was a *knocking off and extirpation of the graft.*

The recovered cases have only half as many graft complications as the improved and unimproved cases. The *post operative stability in the degenerated discs* has been tested in the usual manner by maximum bending backwards and forwards. *Twelve cases were found to be stabile and five instabile.* In five cases it was not possible to carry out the stabilizing test as the patients had contraction in the lumbal muscles.

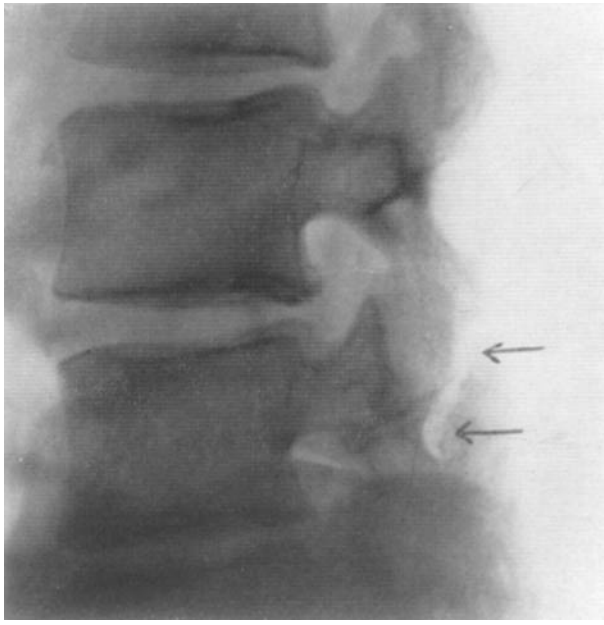


Fig. 14.

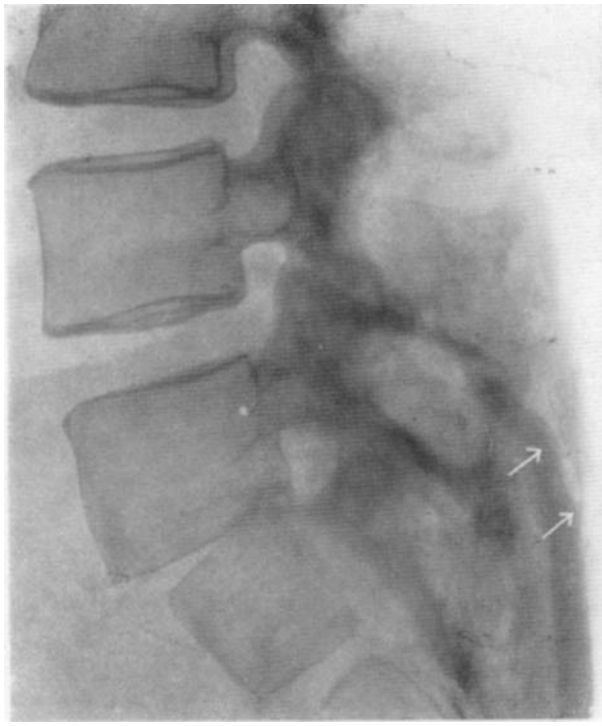


Fig. 15.

It is of interest to know what happened to the graft in the *seven* cases that were *operated on in accordance with Albee* and that are included in the material (see Table 62).

TABLE 62

Placing of the graft	Pseudoarthrosis − +	Fixation of the graft to the spinous process
L3-sacrum	+	Fixation to sacrum only
L4-sacrum	+	Fixation to sacrum only
L4-sacrum	+	Well healed
L4-sacrum	−	Fixation to sacrum only
L4-sacrum	−	Graft completely loose in the soft parts
L4-sacrum	−	Fixation to sacrum only
L5-sacrum	−	Well healed

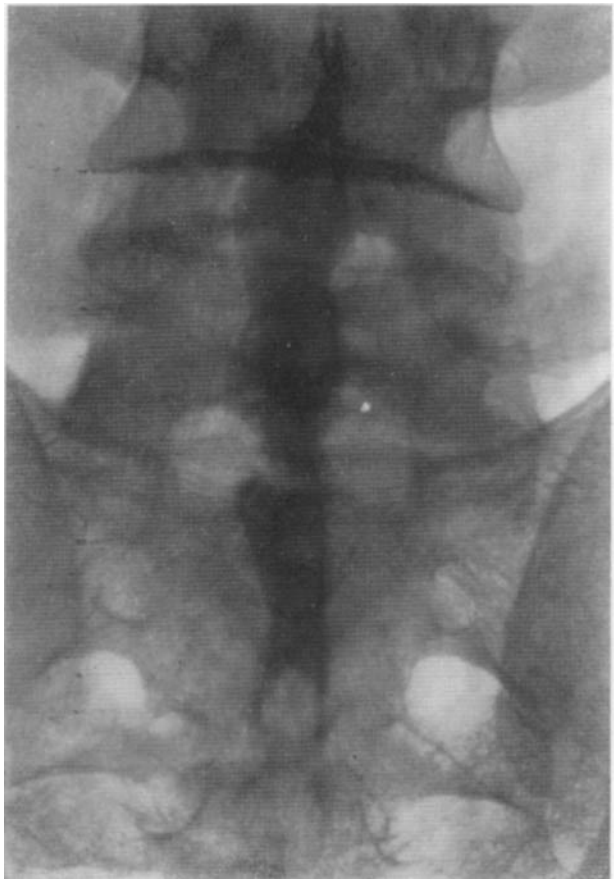


Fig. 16.

It will be seen that complete healing without fracture has taken place in one case only. This case was a graft between L5 and sacrum that is a short graft that was not subjected to the same wear and tear as a long one. The experience gained from a large material of tuberculous spondylitis operated on in accordance with Albee's technique, has proved satisfactory (Albee, 1930, Bierring, 1934, Odelberg-Johnsson, 1934). The anatomic and mechanical conditions are quite different in disc degeneration where instability between the vertebrae is

the dominating phenomenon. In tuberculous spondylitis a spontaneous fusion of the vertebrae takes place and the disc goes under quickly. Therefore, there is no instability. *This indicates that osteosynthesis in accordance with Albee, with only the placing of the graft in the spinous process, is insufficient to attain stability in disc degeneration.*

Great expectations are placed in the method of locking graft, the H-shaped graft that is placed in between the spinous process and which is combined with fusion of the arch and arthrodesis in the intervertebral joints, as this has been thought to give possibilities to lessen the post-operative confinement to bed. Only one of the eighteen cases in this material have shown complications. This was a case of an atypically performed operation where the graft was pointed and placed into the spinous process. The upper part of the graft had been resorbed here. *This indicates that the method of locking graft can be regarded as being very good partly because it decreases the time of treatment and partly because it gives good consolidation.* The satisfactory results with locking graft has meant that it has become a routine method in the orthopedic clinic of the Karoline Institute. It has become even more valuable because the bone material can now be obtained from a bone bank that now exists in the clinic. This means that one gains an additional advantage from the fact that the operative intervention is less and that more bone material can be made use of. No bone from a bone bank has been used in this material as the bone bank was first set up during the spring of 1949.

In seven cases *degeneration of the disc has been diagnosed immediately above the osteosynthesis.* These cases are registered in the following table.

TABLE 63

Record number	Locality of the original disc degeneration	Osteosynthesis	Fresh disc degeneration	Reoperation	Subjective
3835/38 (see Fig. 13)	L4	Perfect fixed to L3-sacrum	Spondylolisthesis on L3 arches + disc degeneration in L3 with instability	0	No improvement
4437/44	L5	Graft L4-sacrum not fixed to L4	Degeneration in L3 and L4 with instability	0	Well
729/44	L5	Perfect fixed to L5-sacrum	Degeneration in L3 and L4 with instability	0	Well
2213/45	L5	Locking graft with good fixation to L5-sacrum	Degeneration of L4 with instability	0	Improved
3770/45	L5	Locking graft with good fixation to L5-sacrum	Degeneration of L4. (Observed during operation).	fixation of L3 and L4	No improvement after 1st operation
5540/43	L4 and L5	Perfect fixed to L4-sacrum	Degeneration with instability in L3. (Observed during operation).	fixation of L3	No improvement after 1st operation
464/37	L4 and L5	Albee graft L3-sacrum. Fixation to sacrum only	Degeneration with instability in L3	0	Well

One sees from this table that three patients are free from trouble despite the unfixed disc degenerations with instability that was roentgenologically manifest. Disc degeneration presupposes not that the person so afflicted has trouble. This is known. The author points this out in the chapter about patients with conservatively treated disc degenerations.

Of great interest in this connection is that *disc degeneration occurs above the osteosynthesis for some considerable time after the operation.* One can imaging two things. Partly that disc degeneration existed at the time of performing osteosynthesis and that it has gradually become roentgenologically manifest. This only shows that by means of unsatisfactory diagnostic resources one has placed the osteosynthesis wrong. Partly, also, that the degeneration has occurred after the operation.

It is true that one has suspected that, because of the osteosynthesis, there has been an increased load on the part of the back above the osteosynthesis, first of all to the disc above. By means of experimental investigations the author has been able to show, in this work, that on backs of cadavers there has been an increase in the load on the disc above an osteosynthesis. Further the author refers to the case of acquired spondylosis previously described and also included in this material (Fig. 13). *There are, therefore, points of appui supporting the idea that the above described disc degenerations are a consequence of the osteosynthesis.*

From the works of *Friberg* and *Hirsch* (1949) we know that advanced degenerative changes in the intervertebral discs can be impossible to discern in the roentgen for a long time. The following problem then arises. In a case where the result of the operation is good anatomically and no complications occur, but the patient is nevertheless not free from trouble, is it possible that the trouble can be caused by a suchlike disc degeneration above the osteosynthesis that has not been manifest on the roentgenogram? Having this as a point of departure, *Hirsch* (1948) endeavoured, by means of puncture in the disc

to diagnose changes therein at an early stage. Hirsch found that in cases of relapsing low back pain a transdural puncture of one or both of the two lowest lumbar discs produced pain identical with the patient's spontaneous pain. Hirsch was of the opinion that, by this method, a clinical diagnosis on the level of the lesion in lumbago was possible. *Lindblom* (1948) has tried to get an idea about the condition of the disc by injecting perabrodil into the disc followed by roentgen. Lindblom's method enables one to see the ruptures in the annulus and the cavities in the disc.

If a patient has back trouble and a verified disc degeneration above an osteosynthesis it is almost possible to be able to stabilize it. So also has been done in two cases in this material. There should then be a risk that the disc above this new osteosynthesis would be degenerated. The material now shows, however, that the dreaded risks are not so great as to contraindicate an osteosynthesis operation. One should, however, be fully aware of the risks of this complication.

Roentgenologically provable progress of the degenerative changes in the discs taking the form of further lowered interspaces and, in some cases, sclerosis have occurred in *nine* of the lumbal cases. The corresponding figures for the lumbosacral cases are *16. Fourteen* patients with multiple disc degenerations have shown progress (28 discs). Thus there are 53 disc degenerations that have shown progress. Of these there are six, all lumbo-sacral, where the disc was completely obliterated leaving the vertebrae in direct contact with eachother. This has been called progress of disc degeneration. One has even thought that it is not a progress at all but rather an inactivity atrophy in the disc which has become considerably unloaded through osteosynthesis.

The cases that have been *totally free from complications,* that is those on whom no laminectomies has been performed and where there have been no graft complications, show, subjectively, the following:

TABLE 64

Locality of disc degeneration	Number	Subjectively		
		Well	Improved	Unimproved
L2	1	1	0	0
L3	2	2	0	0
L4	6	4	2	0
L5	12	10	1	1
Multiple disc degeneration	10	10	0	0
Total	31	27	3	1

Fig. 17 shows a case with good consolidation of the fusion.

SUMMARY

1) The material comprises 80 patients with low back or low back and sciatic pains who all presented definite signs of disc degeneration in the lumbo-sacral back and were operated by osteosynthesis. Osteosynthesis was performed either primarily in conditions of severe lumbago or secondarily after operations for disc herniation if the back trouble remained or increased. Primary fusion in connection with operations for disc herniation has not been the normal method.

2) The material comprises all cases operated on up to and including 1947. The first case was operated on in 1937. Besides these eighty cases there were two that ended fatally (fat embolism).

3) Fifty one cases were simple disc degenerations of which twenty one were lumbal and thirty were lumbo-sacral. Twenty nine cases were multiple disc degenerations. There were approximately as many men as women.

4) 50 per cent were engaged in heavy manual work, 21.75 per cent did light manual work whilst 28.75 per cent did no manual work.

5) Trauma which was regarded by the patients as being the cause of the trouble was given by fourteen patients (17.5 %), of whom ten men and four women.

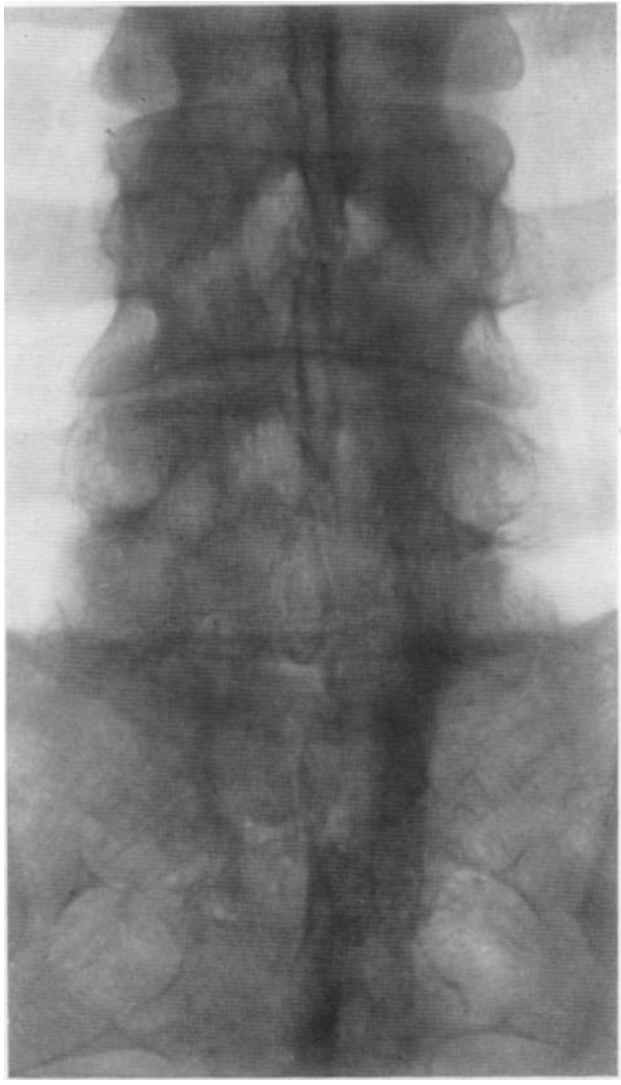


Fig. 17.

6) In 55 per cent the trouble commenced before the age of 35 years. The prevalant age seems to be between 30 and 35 years.

7) None have had the trouble for less than two years. Three patients had two year's trouble. Thirty patients (37.5 %) had trouble from five to ten years and thirty seven patients (46.25 %) have had trouble for more than ten years. Of the thirty seven patients, eleven had trouble lasting for nineteen years or more.

8) In all cases the *working capacity* has been somewhat lowered. Thus twenty three patients (28.75 %) have been totally unfit for work for short periods (1—2 weeks) besides being at times partially incapable of working. Fifty seven patients (71.24 %) have been incapable of working for longer periods (3 months and more). The total time of working incapacity amounts to 114 years which means that each of the eighty patients averaged 1.4 years.

9) Thirty nine patients (48.75 %) had back trouble only, forty one (51.75 %) had back trouble and had, or had had, sciatic trouble as well. There were about as many men as women. To a large extent there were two types of back trouble i. e. the acute attacks and the continuous nagging trouble. The latter type was dominant. Of the forty one patients that had sciatic trouble, eighteen were left-sided and thirteen were right-sided whilst ten had trouble in both legs either simultaneously or on different occasions. The back trouble had a chronic, lengthy course whilst the sciatic trouble occurred more in attacks.

10) The pre-operative, objective findings showed that 69 patients had symptoms from the back in the form of muscular contraction, restricted mobility or throbbing pain. Of these, twenty one had neurological symptoms. In seven cases the objective findings was quite negative. The dominating back symptom was throbbing pain which ocurred in sixty seven cases.

11) The conservative treatment prior to the operation consisted for the most part in corsets and physical treatment.

12) Prior to osteosynthesis, seventeen patients (21.25 %) were surgically treated with the idea of removing the sciatic pains. Eleven were operated on once, four, twice and two, three times. In this way fifteen disc prolapses have been extirpated: in nine cases laminectomy has given negative results. In three cases facetectomy has been performed.

The results of these interventions have been as follows:

Result	Number
Condition unchanged	8
Free from sciatica but worse in the back	5
Sciatica improved but no change in the back	2
Sciatica unchanged but back worse	1
Sciatica worse and back worse	1
Total	17

13) Fifty nine patients (73.75 %) were between 30 and 49 years old at the time of "fusion". Eight patients were under 30 years of age and three were more than 50 years old.

14) The operative method was as follows:

Operative method	Number
Albee	7
Albee + fusion between arches (five of these with arthrodesis in the intervertebral joints)	18
Bilateral graft on the renovated arches	11
Unilateral graft, bone chips on the other side (of these, 3 with arthrodesis in the intervertebral joints)	24
Bilateral graft on arches that had *not* been renovated	2
Locking graft	18
Total	80

15) The osteosynthesis has been fixed by its lower end to the sacrum in seventy one cases: in nine cases it was placed between vertebrae higher up. The highest point that osteosynthesis has reached was L2: In fortyone cases to L4.

16) In twenty patients laminectomy has been performed in connection with fusion. Disc herniation could be extirpated in three of these.

17) Twenty five patients (31.25 %) were able to *resume their work within six months after the operation,* thirty (37.5 %) patients *within one year after the operation.* Thus 68.75 were able to resume their work within one year after the operation. Eleven patients were unable to resume their work within one year and thirteen patients remained incapable of working after the operation.

18) Fifty patients were post examined within 3 years after the operation, but none earlier than one year from the date of discharge from hospital (not from the time of operation). The patients stated their *subjective status* during the post examination as follows:

Completely recovered	53 (66.25 %)
Improved	12 (15.00 %)
No improvement	15 (18.75 %)
Total	80 (100 %)

It turned out that all who had trouble had low back pain but that 12 had sciatic pains as well. In no case, however, was there any increase in the sciatic trouble nor, had any fresh sciatic trouble arisen. Thirteen patients were incapable for work and six had taken lighter trades.

19) The following factors were especially observed when the patients were examined objectively:

1) Localisation of disc degeneration,
2) The number of laminectomies and their magnitude,
3) The consolidation and the stabilizing effect of the osteosynthesis,
4) The occurrence of fresh changes,
5) The roentgenological progress of disc degeneration.

20) Having the localisation of the disc degeneration as a starting point, *the simple lumbo-sacral disc degenerations show the best results with 76.7 % recoveries; after this comes the single lumbal with 62 % and worst the multiple with 58.3 % recoveries.* When judging this, regard has been taken to complications such as graft complications, laminectomies and freshly occurring changes.

21) If we take the laminectomies that have been performed,

the graft complications and the freshly occurring changes as a starting point, we find that of the fifty three who were subjectively fully recovered, twenty seven were free from complications whilst twentysix had complications. Of the twelve subjectively improved cases there were three who were free from complications whilst nine had complications. Of the fifteen subjectively unimproved cases, only one was free from complications.

22) In the subjectively recovered cases, 14 laminectomies (26.6 %) were carried out, in the subjectively improved there were 4 (33.33 %) and in the subjectively unimproved cases there were 10 (66.67 %). The magnitude of these laminectomies have been registered as well as the number performed on each patient. In this way we have seen that the smallest laminectomies were performed on the recovered cases and that, as a rule, only one laminectomy was performed on each case. The laminectomies performed on the improved and unimproved cases were of greater magnitude and were more in number. It seems that from this one can draw the conclusion that *major laminectomies carried out on many vertebrae made the prognosis worse.*

23) *Graft complications* were registered in eleven of the recovered cases (20.75 %), in five of the improved cases (46.67 %) and in six or the unimproved cases (40.00 %). These graft complications were as follows:

Unsatisfactory fixation of the upper end of the osteosynthesis	9
Fracture of graft with remaining pseudoarthrosis	6
Fracture of graft with remaining pseudoarthrosis + unsatisfactory fixation of the upper end of the osteosynthesis	3
Unsatisfactory fixation of the lower end of the osteosynthesis	1
Knocking off and extirpation of the graft	2
Fracture of the graft during the operation but which healed	1
Total	22

Roentgenological testing of stability has shown that twelve cases were stabile, five instabile and five that it was not possible to test because of the state of contraction existing in the lumbar muscles. Of the instabile cases, two were recovered and three were unimproved.

24) Of the seven cases that were *operated on in accordance with Albee's method,* only one healed satisfactorily, a short graft between L5 and the sacrum. The other grafts, five L5 — sacrum and one L3 — sacrum, have all shown fractures and insufficient fixation to the spinous process. This indicates *that Albee's method is insufficient in disc degeneration where a considerable instability is often present.*

25) The eighteen cases that were *operated on by locking graft* have all, except one, consolidated in a satisfactory manner. The case that did not do so had been operated on in an atypical manner. Instead of using an H-shaped graft, a spool-shaped one was used and driven into the spinous process. The upper part of the graft had resorbed. Those cases that were operated on by the locking graft method were confined to their beds for 3—6 weeks only. *One has therefore gained a decrease in the time of treatment by this method as well as good and rapid consolidation of the osteosynthesis.*

26) Degenerative changes have arisen in the disc just above the osteosynthesis in seven cases. In one of these cases there was also spondylolysis on the arch of the upper vertebra in the osteosynthesis. This indicates that the disc situated immediately above the osteosynthesis is exposed to increased wear and tear. That this is really so has been proved in the experimental section of this work. Of the seven cases, three were completely free from trouble.

27) The roentgenological changes in the operated cases have been examined in accordance with the same plan as was used on those who were not operated on. Nine of the twenty one lumbal disc degenerations have shown progress, sixteen of the thirty lumbo-sacral have progressed as is also the case with fourteen of the 29 cases of multiple degeneration. A total of 28 discs have shown progress in the multiple cases. One

might ask whether it really is a question of progress; one can also consider it as being an inactivity atrophy as a consequence of the osteosynthesis.

28) The *cases completely free from complications,* those without graft complications, laminectomies and freshly arisen changes were thirty one 38.75 %. Subjectively, 27 of these were recovered, three were improved and one showed no improvement.

CHAPTER VII

DISCUSSION ABOUT THE CLINICAL MATERIAL

The object of this work has been to study the clinical course and the results of the treatment of low back and sciatic pains. The two hospital materials have therefore been scrutinized. In the hospitals there is an ever increasing observation that the frequency of low back and sciatic pain has increased the last years. In order to find out the actual magnitude of this group of disease, the author, in addition to the two hospital materials, has taken up the question of the frequency of this complaint within two groups of inhabitants.

The *first group* comprises a material of a Sick Benefit Society that can be said to represent the general population of a large city. The patients have been registered as suffering from back or sciatic trouble. It has, on the other hand, not been possible to investigate the frequency of degenerative changes within the lumbar vertebrae, disc degeneration and spondylosis deformans.

The *second material* made up from the staff and employees of the Stockholm Tramway Company represents a certain trade group. Otherwise this material has been arranged in the same way as that of the Sick Benefit Society. As was the case with the first material, it has not been possible to register degenerative changes in the discs of the lumbo-sacral region.

The *third group* is a hospital material consisting of patients, suffering from back and sciatic trouble, in whom degenerative changes within *one* disc in the lumbo-sacral column have been

found. The selection of the material has been done, with the roentgen picture as a starting point. No regard has primarily been taken in respect of objective and subjective symptoms.

The *fourth group*, which is also a hospital material, represents a group of patients who have had such severe trouble that all conservative treatment has been fruitless and, for that reason, surgical intervention has been indicated. All were operated on by means of osteosynthesis and, in some cases, disc herniation has been extirpated or else a decompressive laminectomy has been resorted to. Besides this, definite degenerative changes within one or more discs in the lumbosacral vertebrae have been found. This material of osteosynthesis comprises only 2.17 % of all the cases who visited the orthopedic clinic of the Karoline Institute for lumbago or sciatic trouble with roentgen points of appui for disc degeneration. *Friberg* and *Hirsch* (1949) have found 3,672 cases of lumbal or lumbo-sacral disc degeneration when going through the material belonging to the Clinic for the period 1936—1946. The material for fusion covers a period 1937—1947 for which reason a comparison seems permissable.

As will be seen, these two materials, the unoperated and the operated, have one thing in common, namely, degenerative changes in the lumbar intervertebral discs. The difference is in the method of treatment. The subjective trouble in the operated cases has been great but many of the unoperated cases have also stated great trouble and long periods of inability to work. Nevertheless the operated material shows a higher figure in regard to incapacity for work (the preoperative) than does the unoperated material. One can therefore say that the *operation material represents a group having greater subjective trouble.*

One finds that of the unoperated cases 57.3 % and of the operated cases 50 % did heavy manual work. The corresponding figures for those who did light work are 26.7 % for unoperated and 21.25 % for operated, and for those who did no manual work there were 16 % for unoperated and 28.75 % for operated cases. The percentage is rather similar for both

materials. The high figure for the heavy manual workers is registered. This figure, however, does not say anything definite about the high frequency of disc degeneration amongst the manual workers. It only says that the heavy manual workers are in the maajority as far as trouble is concerned.

Severin (1943), who investigated a material of 210 cases of disc degeneration in the lumbo-sacral column, found similar figures, namely 53.2 % for heavy manual workers, 30.9 % for light manual workers and 15.8 % for those who did no manual work at all. Severin says: "These figures indicate that heavy work causes a disposition toward disc degeneration or at least for spinal symptoms". But the comparison between the hospital material and the employees of the Stockholm Tramway Company is more significant in this discussion. The tendency in this large material points to a considerably higher frequency of low back pains and sciatica amongst the employees of the tramway company.

Trauma, which has been given by the patients as being the cause of their trouble and where this has arisen in direct connection with trauma, has occurred in 17.3 % of the unoperated cases and in 17.5 % of the oprated cases. *Severin* (1943) found 15.2 % in his material. The low figures are surprising. It is usual that people connect trauma and a state of chronic pain with one another. Therefore the author has especially taken care, when taking down the past history, to see that the patient's statements regarding trauma were exact especially in regard to the time elapsing between the occurrence of the trauma and the onset of the trouble. Further, it hardly ever happened in this material that patients got their trouble in connection with an accident whilst working and therefore they had no interest in drawing attention to anything in the nature of an accident. From these figures it is possible to reckon definitely that disc degeneration can arise without any traumatic genesis. On the other hand one cannot come to any decision as to how a trauma, that has happened on one cocasion, can be responsible for a fresh injury to the disc with the accompanying symptoms. The only possibility of deciding

this is if the patient dies in close connection with a trauma and a post mortem examination is made. It can then even be questioned whether it is possible to differentiate, with any degree of certainty, between a fresh and an old change in the disc. For this reason the author agrees with the hypothesis expounded by, amongst others, *Güntz* (1936) and *Severin* (1943) that minor, repeated traumas and strains occurring whilst performing heavy manual work can bring about disc degeneration, whereas a trauma occurring later on can only cause trouble from the changed disc. This seems to gain further support from the high frequency of trouble among heavy manual workers and the high figure for lumbago and sciatica found in the traffic staff of the tramway company. It must be considered as being probable that the continuous shaking which the latter are subjected to puts a strain upon the intervertebral discs.

The age when the trouble makes its first appearance in both materials of disc degeneration lies at 34 years and less in 80 %. In the materials of the Sick Benefit Society and the Tramway Company one finds that the frequency of lumbago and sciatica is high during the same age. Further one finds that of the 75 unoperated cases, 60 % have had manifest disc degeneration before the age of 40 years, of these, 12 (17.3 %) between the age of 20 and 30 years. *Friberg* and *Hirsch* (1949) showed that out of 3.672 cases of disc degeneration, 45 % had roentgenologically manifest disc degeneration before the age of 40 years. This shows that disc degeneration and low back and sciatic pains attack young people to the same extent as it does older people in whom diverse degenerative changes within the supporting apparatus, arthrosis deformans and spondylosis deformans begin to manifest themselves.

The duration of the trouble in the unoperated cases has been less than 10 years in 30.7 % and more than 10 years in 69.3 %. The longest duration was 38 years. The corresponding figures for the operated cases, that is to say up to the time of operation, were that 60.75 % had their trouble for less than 14 years and 39.25 % for more than 14 years. These are

minimum figures as, in the unoperated cases, only 38.7 % were cured when they presented themselves for post examination whereas the others still had trouble and in the operated cases the operation had partly or completely caused the trouble to cease in many of them.

The best objective opinion of the patient's subjective trouble can be seen from a scrutiny of their *capacity for work.* Fifty seven of the operated patients were incapable of working for longish periods (more than three months). Twenty three patients had previously been totally incapable of working. If one adds up the time of working incapacity it amounts to 114 years. If this figure is spread out over the 80 patients, an average of 1.4 years of incapacity per person is obtained. Of the unoperated cases, sixty four were totally unfit for work for a total period of 61.8 years which gives an average of 10 months per patient for the seventy five cases. Besides this, twelve operated cases and 13 unoperated cases were incapable of working when post examined.

The number of sick days for men and women suffering from lumbago or sciatica in the Stockholm Sick Benefit Society were 73429 days for men, and 11365 days for women, making an average of 0.68 days per male and female member of the Society. The figures for the traffic staff of the Tramway Company are 6,817 sick days which, spread out over the 4,569 employees, makes an average of 1.46 days per person. For the 1,240 employees in the waggon and workshop departments of the tramway company, there were 2,316 sick days which gives us an average of 1,87 sick days per employed person.

It will appear from these figures *that it is a very considerable period of total incapacity for work from lumbago and/or sciatica.* It will also be seen that these diseases have a very great economic significance because of the long period of working incapacity.

In both materials of roentgenologically manifested disc degeneration, the *character of the trouble* has been very carefully analysed. Of the operated cases, 48.75 % had lumbago only whilst 51.25 % had lumbago and sciatica. Of the unoperated

cases 33.33 % had back trouble only, 64.00 % had lumbago and sciatica and 2.67 % had sciatica trouble only. It seems from both materials that back trouble has had a very prolonged course and that it was mostly characterized by nagging pains, feelings of instability and tiredness in the back. To a large extent the long periods of trouble can be placed on a par with the duration of back trouble.

In general, sciatic trouble has been of a shorter duration, coming in attacks and often in one attack only. Investigation shows further that *lumbago often occurs without sciatica but that sciatica nearly always comes together with lumbago.* In both materials *the sciatic trouble has shown a higher frequency of left-sided.*

Severin (1943) has made the same observation. He says: "the symptoms of disc degeneration in the lumbar region vary greatly, but the chief complaint is lumbar pain. Not less than 201 of 210 patients (95.7 %) stated that their most distressing symptom was pain in the lumbar region". He says further: "pains of sciatic type were reported in 124 out of 210 cases (59.0 %).

Treatment:

The *one* material was treated conservatively. Many have been treated with corsets and physical therapy. The immediate effect of the conservative treatment was as follows:

Completely cured	20	26.67 %
Improved	43	57.33 %
No improvement	12	16.00 %
Total	75	100.00 %

One sees that 84 % have either been cured or have improved by the conservative treatment. When post examined, and when many patients had had no treatment for a long time, the result was as follows:

Completely cured	29	38.67 %
Improved	12	16.00 %
No improvement	34	45.33 %
Total	75	100.00 %

This means that only 54.67 % were either cured or had improved. These figures would seem to indicate that conservative treatment gives fairly satisfactory results but that its effect is of short duration. The patients are compelled to wear a corset constantly or/and have physical therapy.

In the *other* material, all were operated on by osteosynthesis and, in addition to this, laminectomy with or without extirpation of the disc herniation was carried out on thirty eight cases. *These patients differ from the previous in that the conservative treatment gave no results.* The results from operative intervention were as follows:

Cured completely	53	(66.25 %)
Improved	12	(15.00 %)
No improvement	15	(18.75 %)
Total	80	(100.00 %)

It will be seen that 81.25 % were completely cured or improved. The figure for the result of the conservative treatment is approximatively the same. But if one looks at the figure for the subjectively cured in both materials one will see a highly essential difference, namely, that the figure for the subjectively completely cured among the cases in the operation material (66.25 %) is more than the double of those who were treated conservatively (26.67 %).

The final result of the surgical treatment has been better than that of the conservative. It has previously been pointed out that the working incapacity can serve as a standard for the degree of severity of the subjective trouble, and the preoperative incapacity for work was greater in the operated material. Further, the conservative treatment in this material has

not given any results. This can be considered as constituting a collection of the patients that have been resistent to conservative treatment. This seems to indicate that the operated patients represent a group that have had more severe trouble than the other group. Despite this, the result of the treatment has been better. As was previously pointed out, *osteosynthesis seems to counteract the occurrence of sciatic trouble, that is to say, the risk of disc herniations can be counteracted.* This would seem to indicate that osteosynthesis in more severe conditions of lumbago, where degenerative changes exist within the lumbar intervertebral discs, is of great value. Because of the long time spent in hospital and, especially in the case of manual workers, the frequently lengthy post operative periods of working incapacity as well as the risks attaching to a major operative intervention, *osteosynthesis should be reserved for severe cases of lumbago in which the working capacity is totally or partly reduced for lengthy periods, and the conservative treatment has proved to be fruitless. Cases in which the working capacity is not essentially influenced, but where the trouble causes great suffering, should be queried as being cases for operation.* No case, however, should be operated on until satisfactory conservative treatment has been administered and found fruitless.

CHAPTER VIII

INVESTIGATION OF THE PRESSURE CONDITIONS IN THE LUMBAL INTERVERTEBRAL DISCS WITH REGARD TO THE EFFECT OF LUMBAL OSTEOSYNTHESIS

Osteosynthesis in the lumbar vertebrae has been discussed in the previous chapters. It is thought that when the osteosynthesis has quite healed and that there is stability, it is reasonable to presuppose a condition of freedom from pain. The stabilizing effect of an osteosynthesis has been discussed. The clinical possibilities to form an objective opinion about the stabilizing effect of osteosynthesis have been roentgenological examinations of the back in a forward and backward bending position and to observe the internal relation of the vertebrae one to the other and study the structural alterations of the bone.

The author has mentioned the complications arising immediately above the osteosynthesis and which seem to be caused by increased strain on the intervertebral disc above the osteosynthesis.

One does not know, however, what the position is in the case of the loading of the intervertebral discs in an osteosynthesis on the spinous process and arches. Is it really a total unloading of the intervertebral discs that is stabilized by fusion? Is the intervertebral disc lying above the osteosynthesis exposed to any increased strain? How do matters stand in regard to the discs if the lumbar back is subjected to loading?

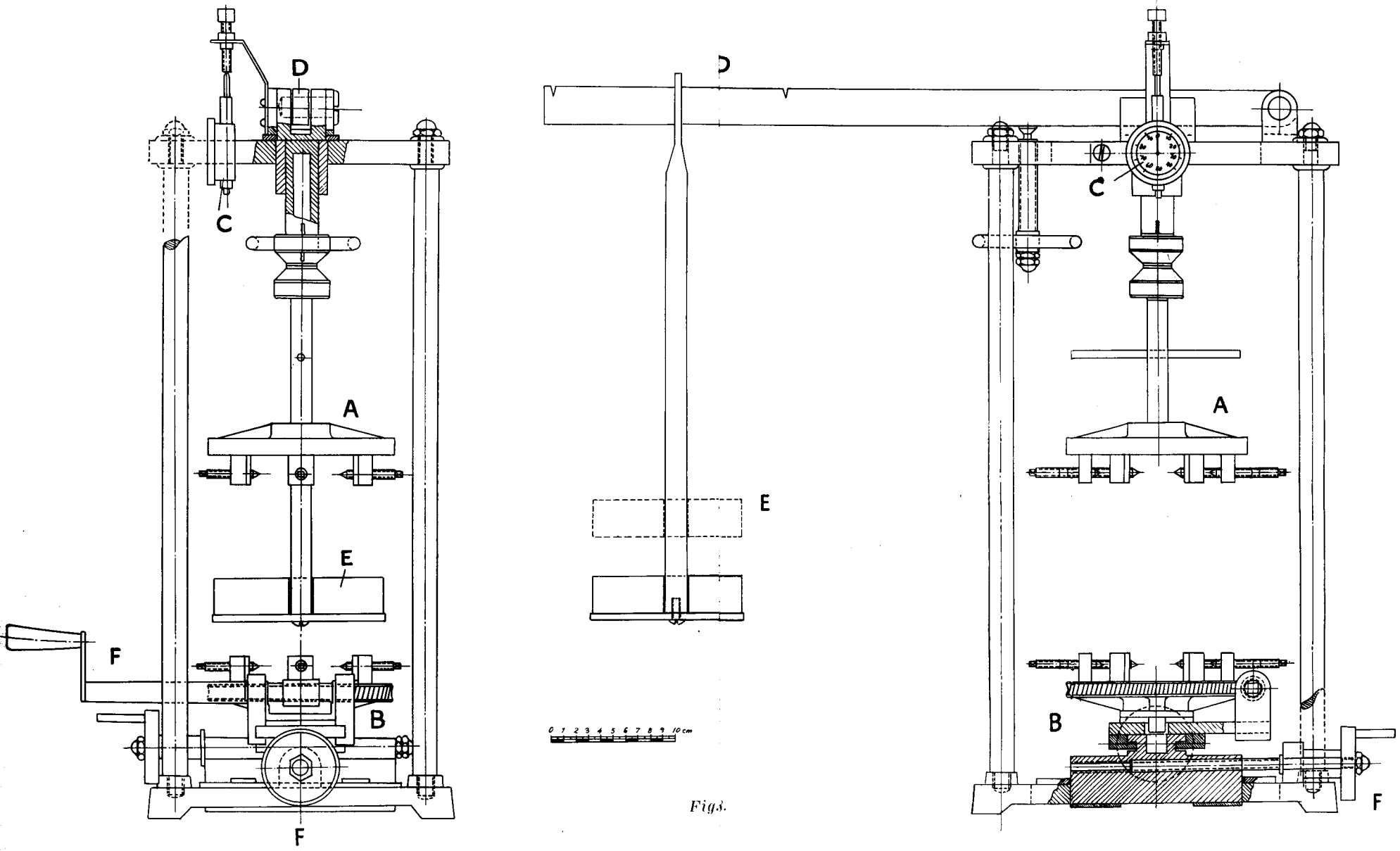
In order to answer these questions, the author has considered the possibility of trying to find an explanation of the pressure in the disc. If it were possible to measure this pressure or find a correlation for the pressure, one should get a good record of the strains that the intervertebral disc is subjected to. It has been presumed that the intervertebral disc is continuously under pressure that varies in accordance with the different postures of the body *Fick* (1911), *Bradford* and *Spurling* (1945), *Saunders* and *Inman* (1947), *Waris* (1948) and others. No registration of these pressure conditions has been made. The pressure that is exercised along the spinal column is apportioned to the different discs. In this way the discs exercise a counter pressure. As the disc is elastic this counter pressure of the disc takes place simultaneously with a compression of the disc.

The author will give an account of a method of experimental registration of the pressure conditions in the intervertebral discs in lumbo-sacral spines from cadavers, by measuring the firmness of the disc when the back is subjected to a rising loading with and without fixation of the spinous process (fusion of the spinous process).

Instruments. When making this investigation, the author has made use of instruments constructed by Hirsch (see figs. 18 & 19).

DESCRIPTION OF THE EXPERIMENT

In connection with post mortem examinations which usually take place 12 hours after death, the lumbar vertebrae and sacrum have been removed in one piece from the body. One has avoided making preparations from patients who have had tumours, osteoporosis, infectious processes and malformations of the spinal column. The experiments have commenced as soon as possible after the preparations have been made ready. The preparations have been freed from the muscles and the intervertebral discs scrutinized to make sure that no damage has been done to them during preparation. Obviously a dam-



Figs.

aging of the disc makes the investigation impossible. The preparation is then placed in a vice and roentgenograms are taken from a frontal and sagittal aspect. In order to find out whether there is instability in the discs, roentgenograms are also taken in forward and backward bending postures.

The preparation is then placed in the *loading apparatus* (see fig. 18). The sacrum is fixed in the lower clamp (B) and the upper part of the back in the upper clamp (A) which is connected with the movable system that exercises pressure. The preparation is fastened with screws. The lower clamp is movable horisontally and can be shifted by means of graduated screws towards the other at right angles. This arrangement makes it possible to place the dorsal preparation in a position corresponding to the normal posture in life.

The *pressure measuring apparatus* (fig. 19) consists of a stand with an inner movable system. The stand has four legs (I) that should rest against the anterior surfaces of the vertebrae around the disc. The construction of the apparatus only allows the front side of the preparation to be measured. In order to make the fixing of the stand stabile towards the vertebrae, small holes have been drilled into the corticalis on the anterior surface of the vertebrae. The stand is pressed against the vertebrae and a pelott (G) having a radius of 1 mm, is pressed against the disc at a certain pressure. By means of a spring (J) and a scale (H) it is possible to control exactly the force of the pressure that is brought upon the disc in accordance with the same principle used in a spring balance. In this experiment the pressure that was brought on the disc amounted to one, two and three kilograms. An indicator meter (K) is connected to the pelott in such a way that it shows movement of this to an exactitude of up to 0.01 mm. From this apparatus, then, one can get readings of deformities occurring to the surface of the disc should it be subjected to a certain pressure from without.

Measurements have first been made on unloaded preparations. The preparation has then been loaded with increasing weights (E), 12.5 kg, 25 kg and 37.5 kg, and the same measure-

ments taken. Loading of the preparation is accomplished by means of weights hung on to the lever (D). An indicator meter (C) is connected with the movable system in order to indicate when the compression has ceased, that is to say, when balance has been achieved. When possible, the measurement has been made on the 2nd, 3rd and 4th lumbal disc of every preparation. Because of the construction of the instrument it has not been possible to measure deformities on the 5th lumbal disc. Five readings have been taken for each measurement. The results have been worked out statistically.

The next stage of the investigation has been a fixation of the spinous process by means of metal plates in imitation of an osteosynthesis on a spinous process. The metal plates, which have been made so as to follow the dorsal curve, have been placed in pairs on the side of the spinous process. The metal plates have several holes to take screws for fastening them to the spinous process — there are at least three screws in each spinous process. It has been possible to control that no shifting of the spinous process has taken place by seeing that the screw holes are round and not destroyed when the screws have been removed. The same measurements have been made with this artificial fusion.

As soon as the measuring has been completed, the discs have been dissected out. An incision has been made horizontally near the end plate on one side. The other end of the disc has been kept fixed to the vertebral body which has been split by means of a horizontal incision. In this way one has obtained the disc together with half of a vertebral body. This has enabled the shape of the disc to be maintained. The preparation has been fixed in formalin. Macro photographs of the discs have then been taken.

Twelve preparations have been examined in this way. In eleven cases the fixation with the metal plates has been done between the 3rd lumbal and the sacrum whilst in one case it has embraced the spinous processes of the 4th and 5th lumbar vertebrae. From this one sees that in eleven cases the 3rd and 4th discs have been fixed by fusion, but the 2nd disc, the

one above the fusion, has been free and in one case the 2nd and 3rd disc have not been fixed whereas the 4th disc has. The ages of the patients from whom the preparations have been taken are: 31, 39, 40, 46, 47, 54, 55, 57, 57, 59, 62 and 70 years. Six were women and six were men.

Besides these 12 cases with artificial fusion, five cases were also examined without fusion. These five are not included in this collocation.

We have, therefore, the following information for the judging of every intervertebral disc:

1) *Roentgenograms including instability pictures,*
2) *Macro photographs,*
3) *The results of pressure measurements with and without fusion.*

CASE REPORTS

Case No. 9.

Man, aet 39 years. Cause of death: Acute cardiac insufficiency.

Discs examined: L. II, L. III, L. IV.

Fusion: L. III-sacrum.

Roentgen: No changes (fig. 20).

Macro photography: No certain changes (fig. 21).

Pressure measurement: L II increased pressure.
(Diagram 5). L III diminished pressure.
L IV diminished pressure.

Case No. 10.

Woman, aet 46 years.

Cause of death: Chronic Glomerulonephritis + uremia.

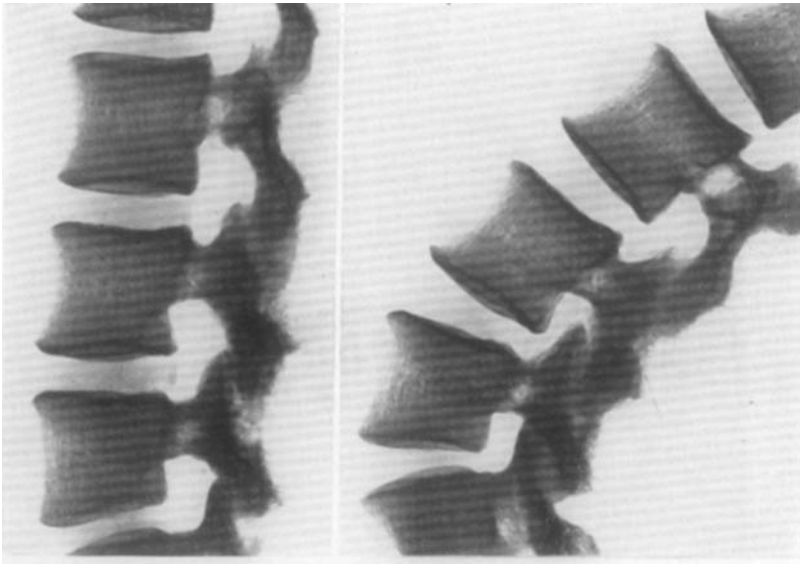
Discs examined: L. II, L. III and L. IV.

Fusion: L. III-sacrum.

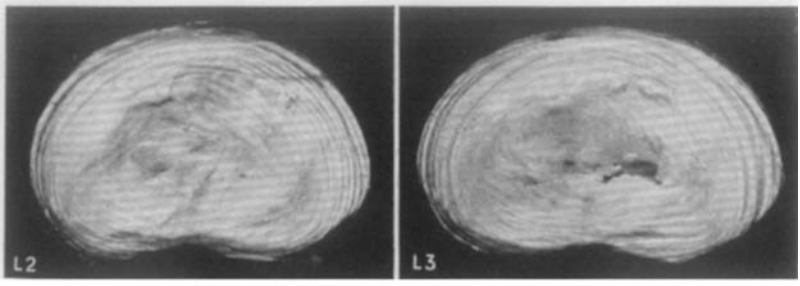
Roentgen: No changes (fig. 22).

Macrophotography: L. IV shows posterior rupture of the annulus (fig. 23).

Pressure measurement: L. II no change of pressure.
L. III diminished pressure.
(Diagram 6). L. IV diminished pressure.



a. *Fig. 20.*)* b.



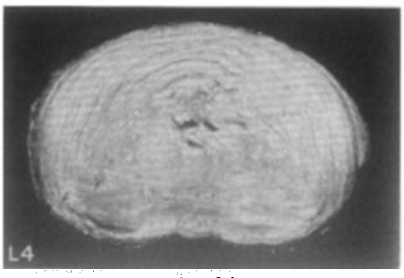


Fig. 21.

*) a = forwardbending.
b = backwardbending.

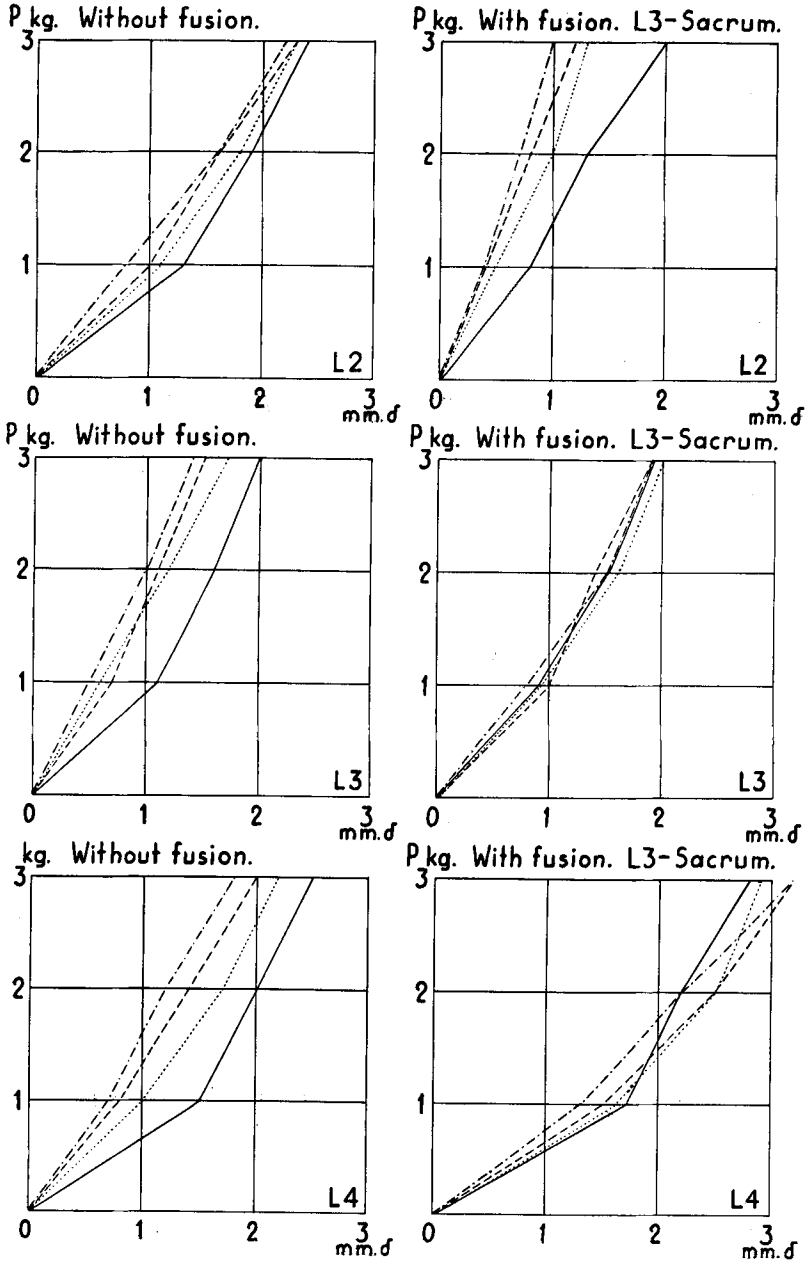


Diagram 5.)

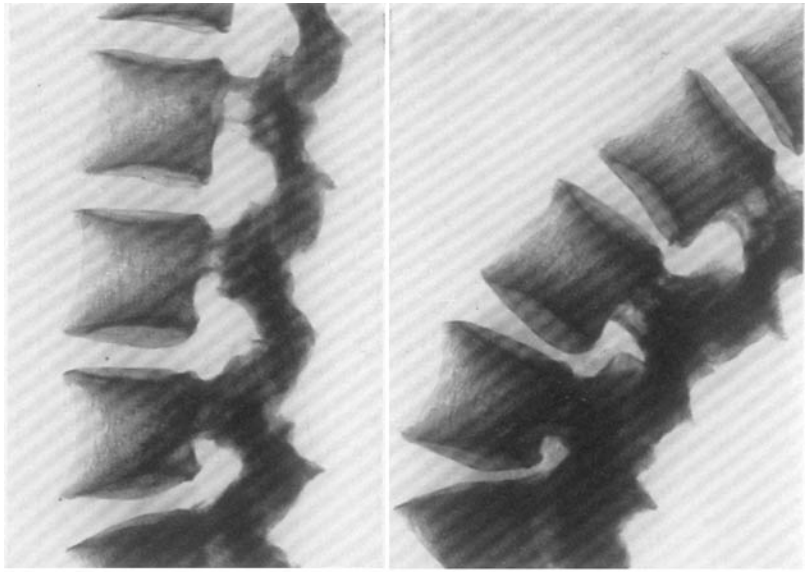
*) In the diagrams a displacement of the lines to the left means increased pressure in the disc and to the right diminished pressure.

Unloaded: ————

Loaded with 12.5 kg: .....

» » 25 » — — — —

» » 37.5 » —·—·—·—



a. *Fig. 22.* b.

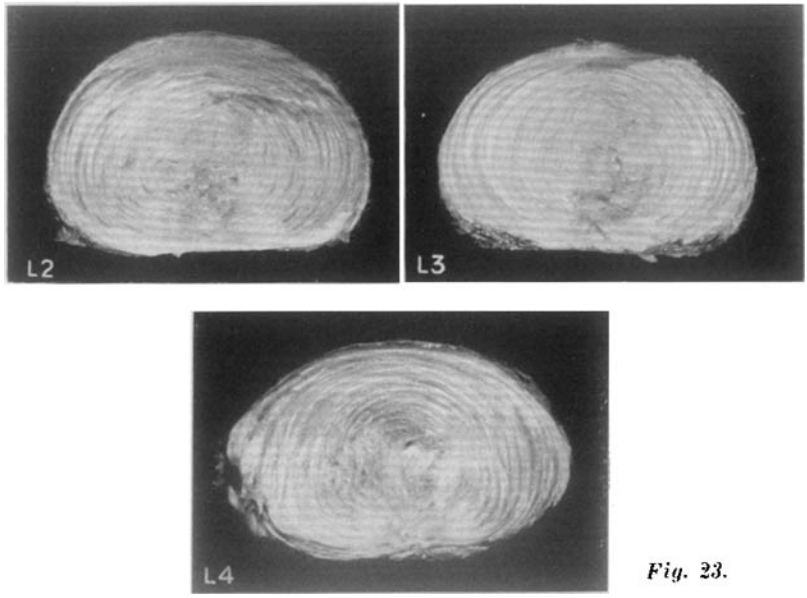


Fig. 23.

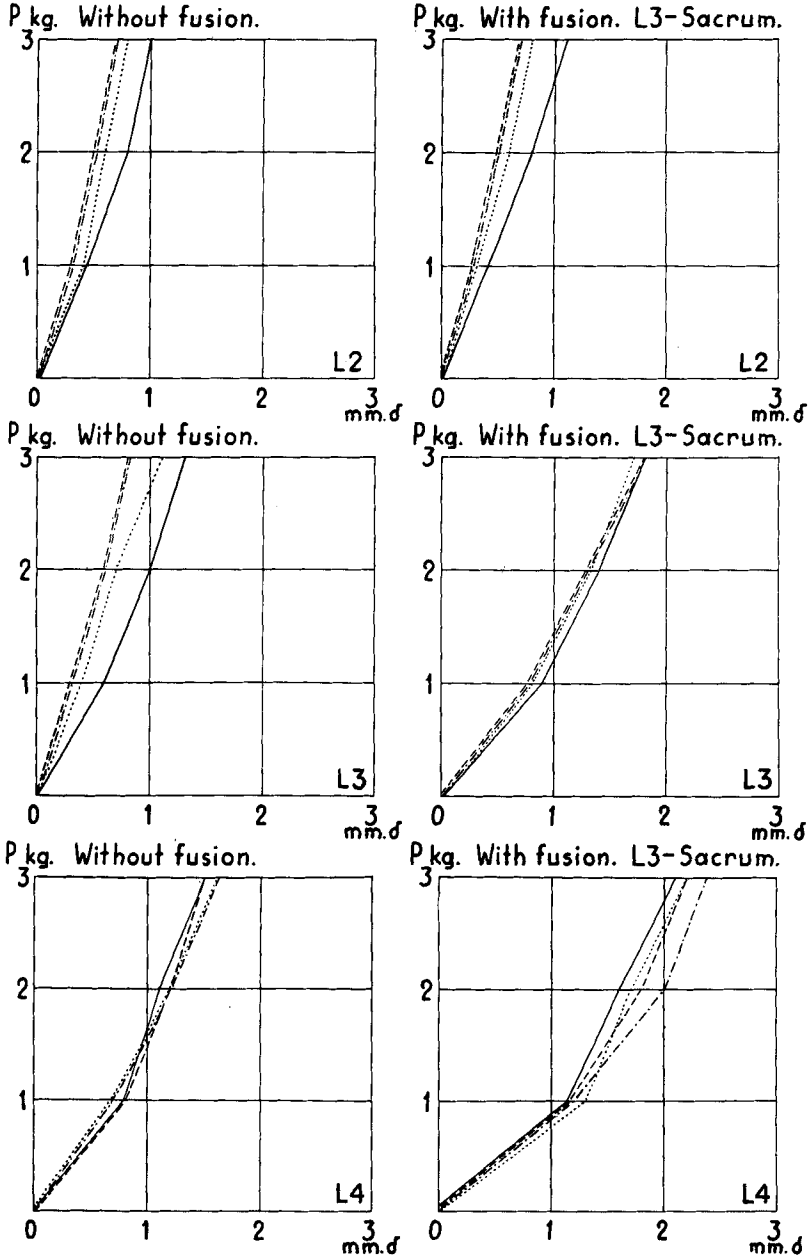

P kg. Without fusion.
P kg. With fusion. L3-Sacrum.
L2
L3
L4
0
1
2
3
mm.δ

Diagram 6.

Case No. 13.

Man, aet. 57 years.

Cause of death: Cardiac rupture.

Discs examined: L. III and L. IV.

Fusion: L. IV—L. V.

Roentgen: Small osteophytes on lower edge of L. II and on the upper edge of L. III (fig. 24).

Macro photography: Anterior rupture of the annulus on L. II (fig. 25).

Pressure measurement: (Diagram 7). L. II not possible to measure. L. III insignificant diminishing of pressure. L. IV diminishing of pressure.

Case No. 14.

Woman, aet. 59 years.

Cause of death: Cardiac insufficiency.

Discs examined: L. II, L. III and L. IV.

Fusion: L. III-sacrum.

Roentgen: Instability in L. IV (fig. 26).

Macro photography: L. IV posterior rupture of the whole annulus (fig. 27).

Pressure measurement: (Diagram 8). L. II, pressure unchanged. L. III, diminished pressure. L. IV, pressure unchanged.

The extraordinary change in the diagram for the 4th disc is, the author thinks, caused by instability in the disc. The macro photographs show a comprehensive posterior rupture of the annulus. When loading, there was a diminishing in the pressure in the disc. In all probability the intervertebral joints have had to take up the load.

Case No. 15.

Man, aet. 40 years.

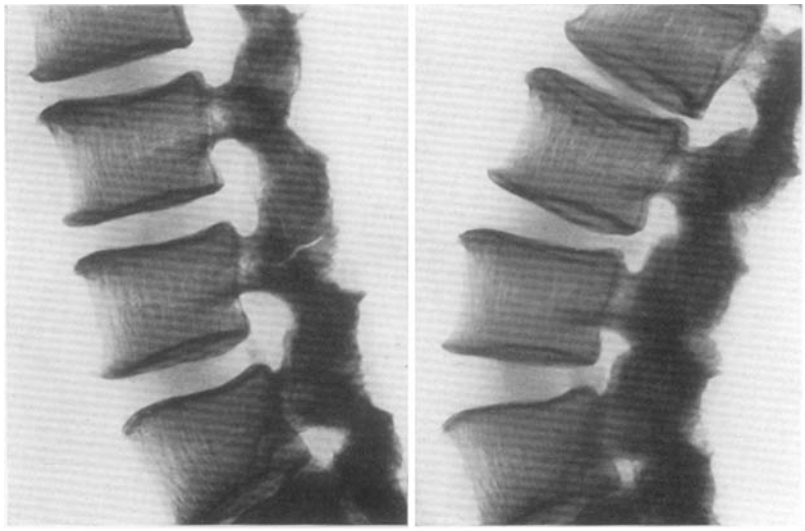
Cause of death: Cardiac insufficiency.

Fusion: L. III-sacrum.

Roentgen: Retroposition of L. III and L. IV (fig. 28).

Macro photography: Posterior rupture of annulus in L. III and L. IV (fig. 29).

Pressure measurement: (Diagram 9).
L. II, increased pressure.
L. III, diminished pressure.
L. IV, diminished pressure.



a. *Fig. 24.* b.

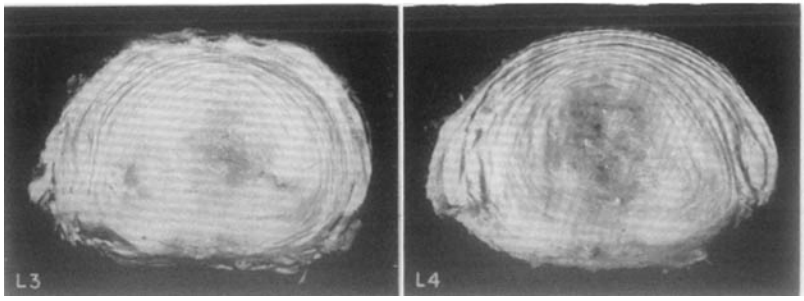


Fig. 25.

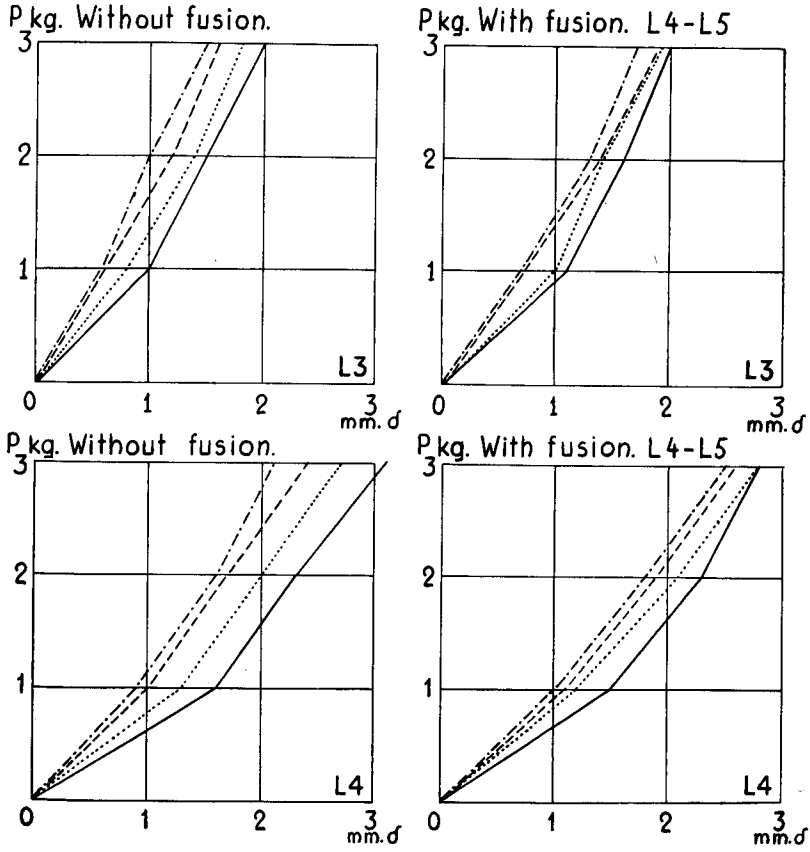

P kg. Without fusion.
P kg. With fusion. L4-L5
P kg. Without fusion.
P kg. With fusion. L4-L5
L3
L3
L4
L4
0
1
2
3
mm. d

Diagram 7.

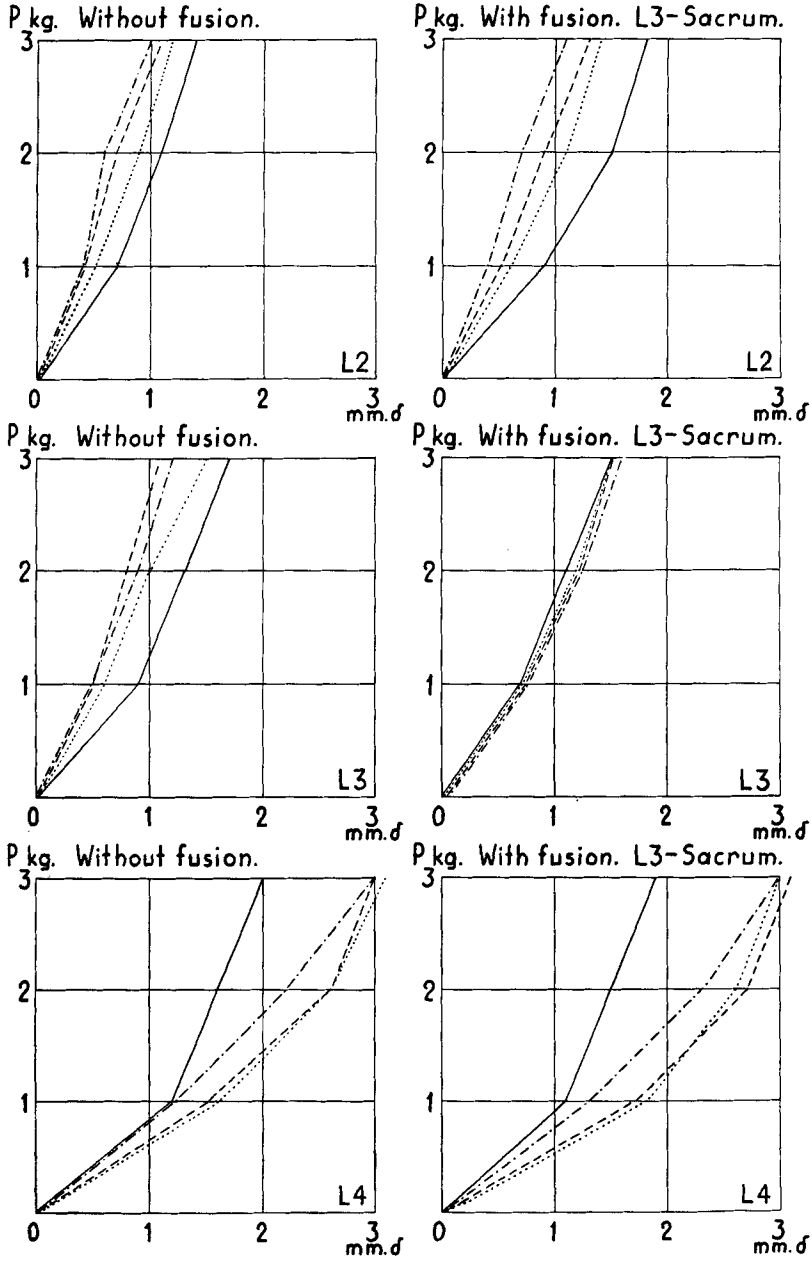
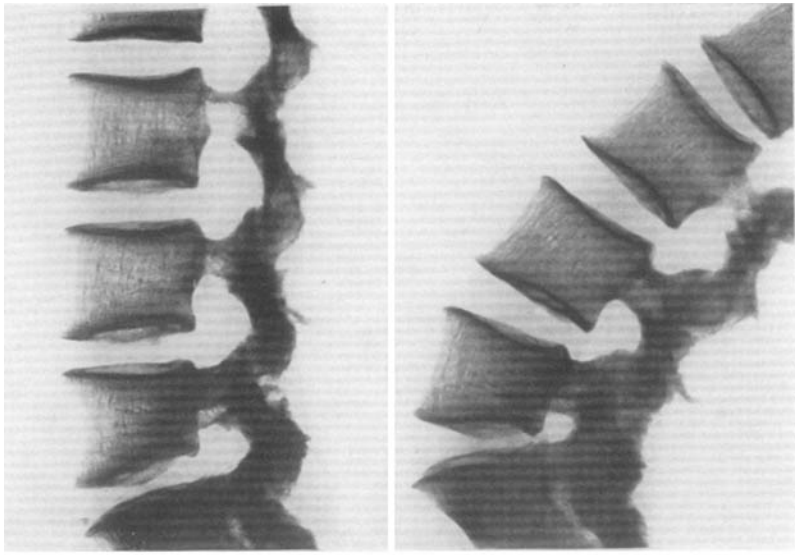

P kg. Without fusion.
P kg. With fusion. L3-Sacrum.
L2
L3
L4
mm. δ
0
1
2
3

Diagram 8.



a. *Fig. 26.* b.

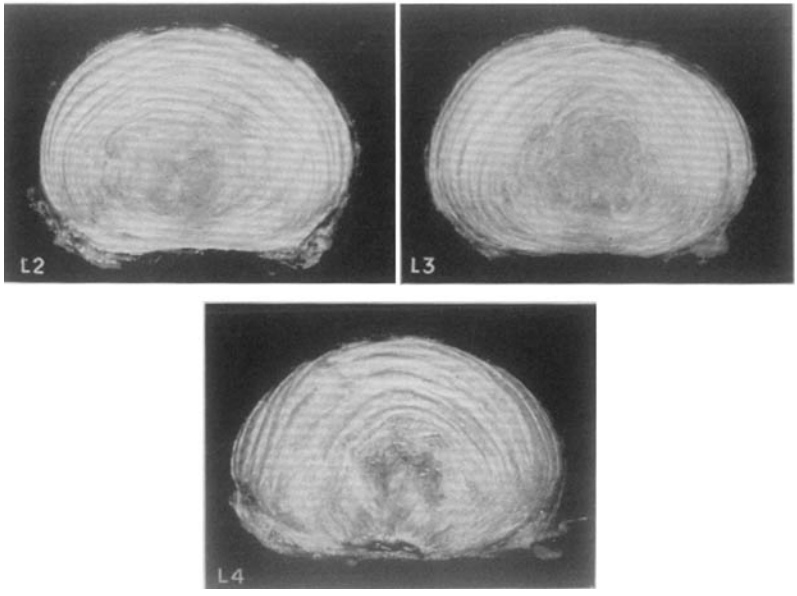
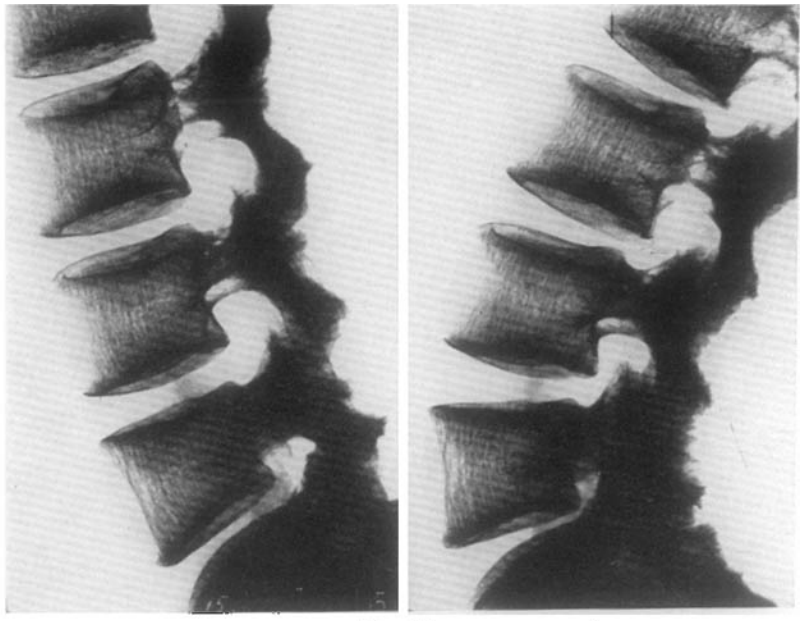


Fig. 27.



a. *Fig. 28.* b.

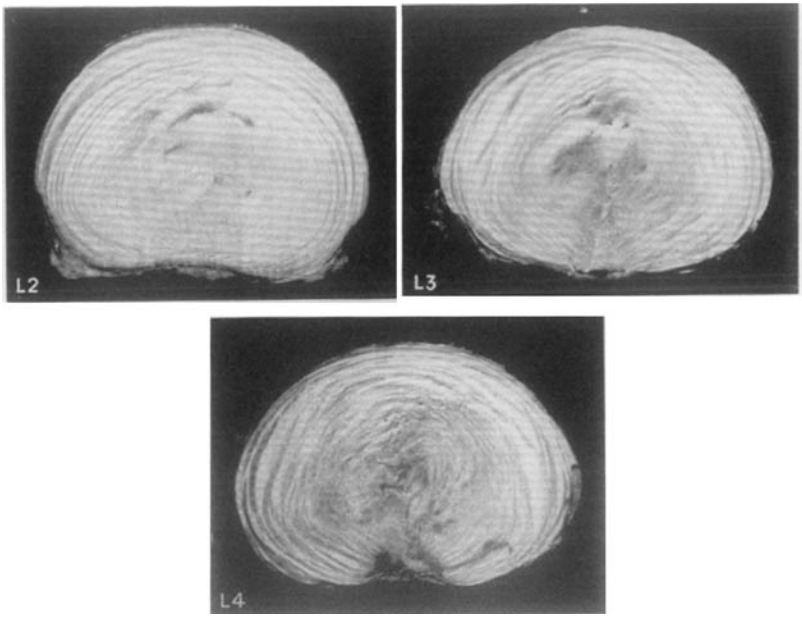


Fig. 29.

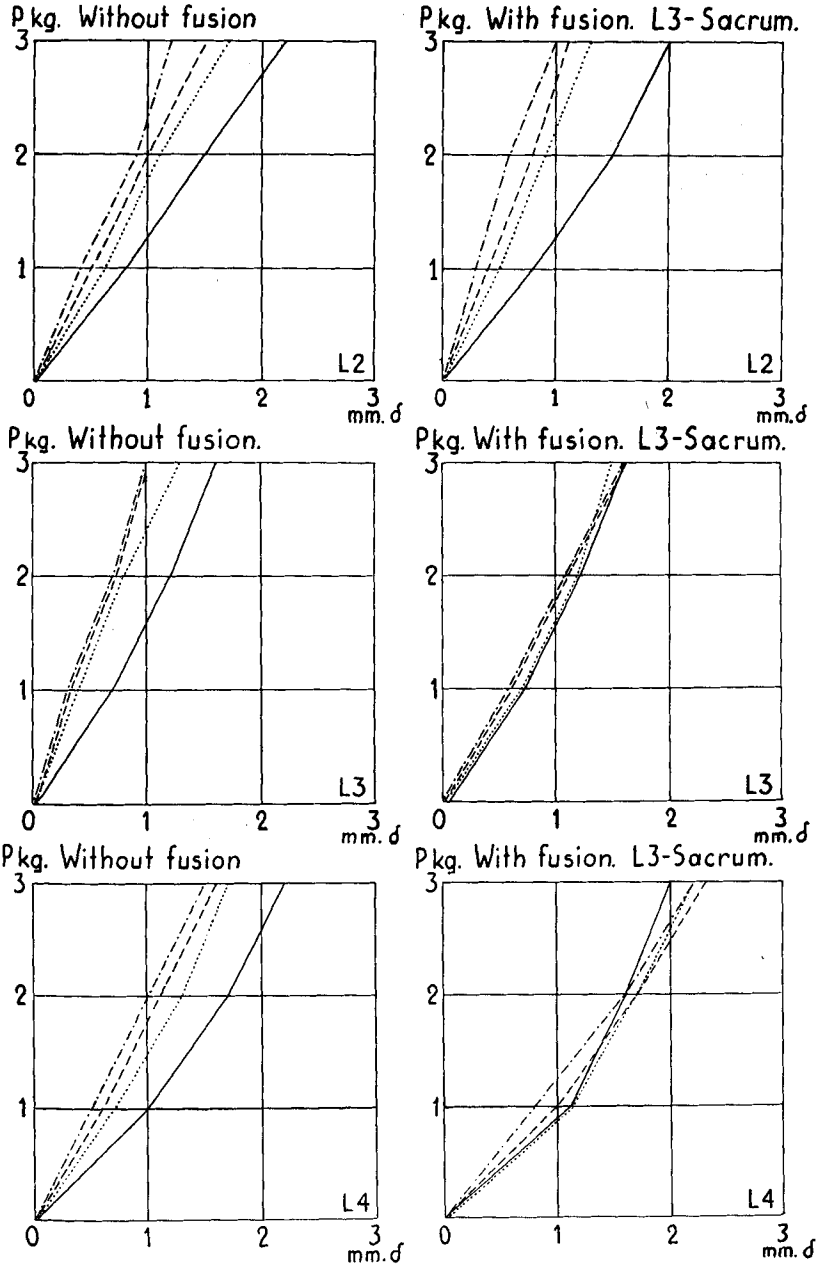

P kg. Without fusion
P kg. With fusion. L3-Sacrum.
L2
L3
L4
mm. δ
0
1
2
3

Diagram 9.

Case No. 16.

Man, aet. 57 years.

Cause of death: Tumour of the kidney (no metastasis in the skeleton).

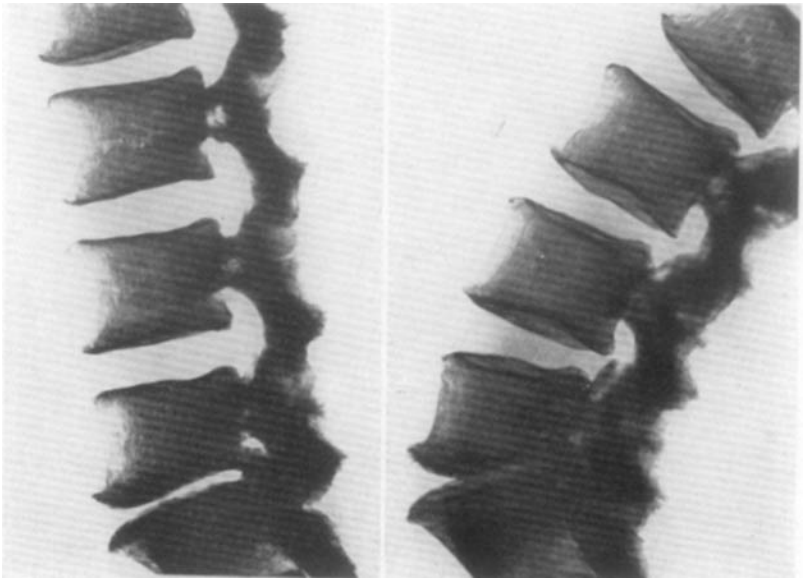
Discs examined: L. II and L. III.

Fusion: L. III-sacrum.

Roentgen: Instability in L. II (fig. 30).

Macro photography: L. II shows lateral rupture of the annulus (fig. 31).

Pressure measurement: (Diagram 10). L. II, increased pressure. L. III, diminished pressure.



a. *Fig. 30.* b.

The curve without fusion shows a diminishing of pressure for L. II when the back is loaded. It is probable that this is due to the instability which, in its turn, leads to the pressure being unloaded by the intervertebral joints.

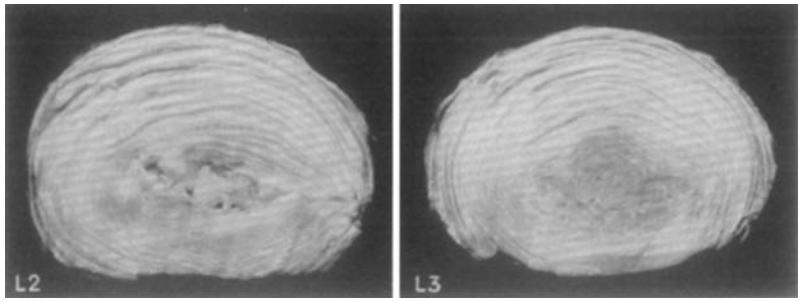


Fig. 31.

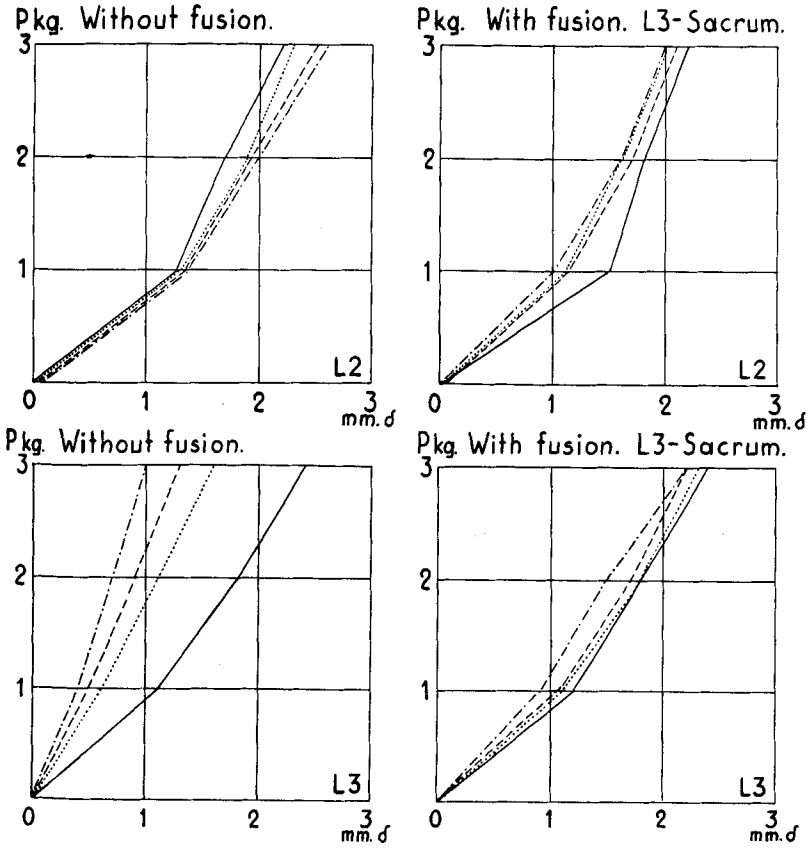


Diagram 10.

Case No. 17.

Woman, aet. 31 years.

Cause of death: Chronic nephritis.

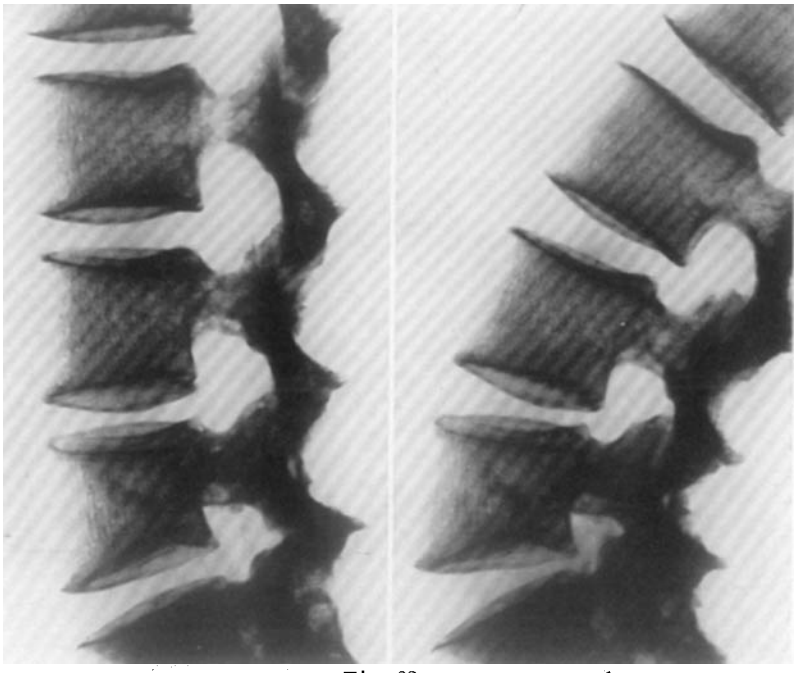
Discs examined: L. II, L. III and L. IV.

Fusion: L. III-sacrum.

Roentgen: No changes (fig. 32).

Macro photography: Points to postero-lateral rupture of the annulus (fig. 33).

Pressure measurement: (Diagram 11). L. II, increased pressure. L. III, diminished pressure. L. IV, diminished pressure.



a. *Fig. 32.* b.

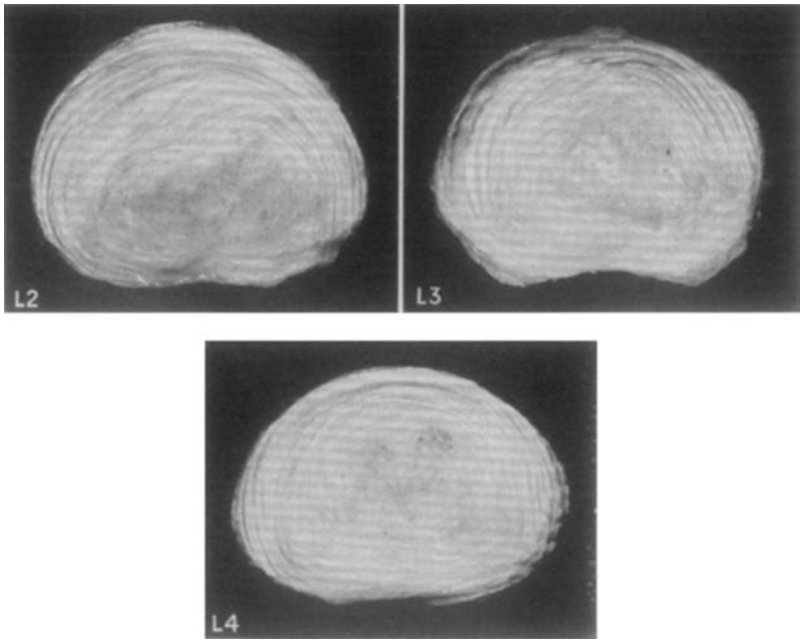


Fig. 33.

Case No. 18.

Woman, aet. 54 years.
Cause of death: Haemorrhagia cerebri.
Discs examined: L. II, L. III and L. IV.
Fusion: L. III-sacrum.
Roentgen: No changes (fig. 34).
Macro photography: (Fig. 35). L. II, severe anterior rupture of the annulus.
L. III, nothing of note.
L. IV, slight postero-lateral rupture of the annulus.
Pressure measurement: (Diagram 12). L. II, increased pressure.
L. III, diminished pressure.
L. IV, diminished pressure.

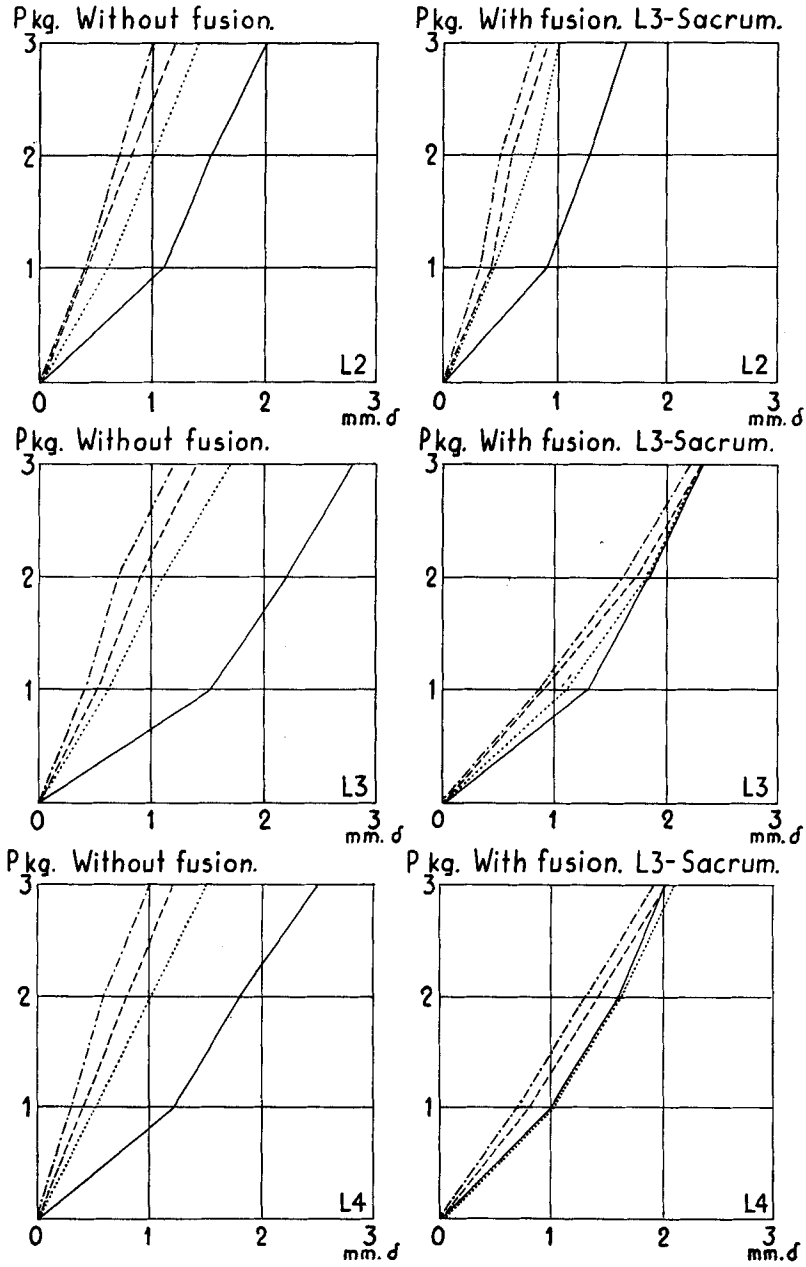
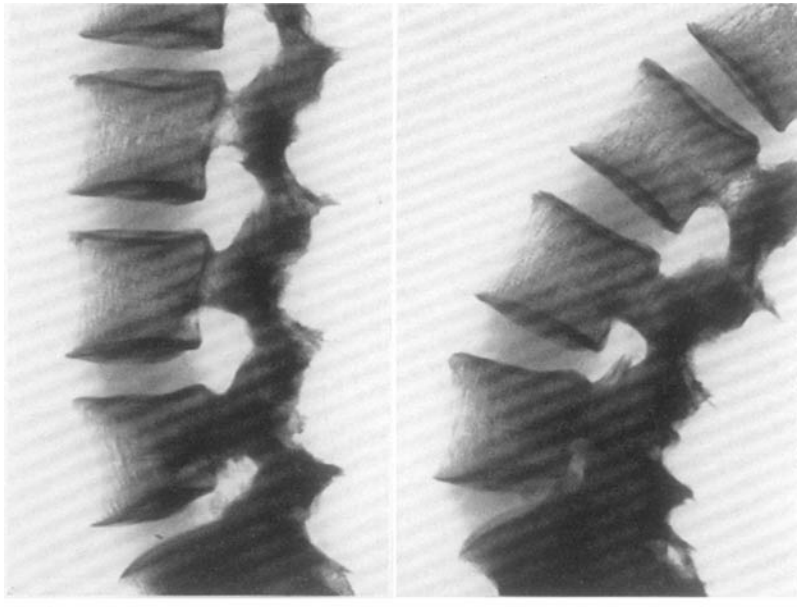

P kg. Without fusion.
P kg. With fusion. L3-Sacrum.
L2
L3
L4
0
1
2
3
mm. δ

Diagram 11.



a. *Fig. 34.* b.

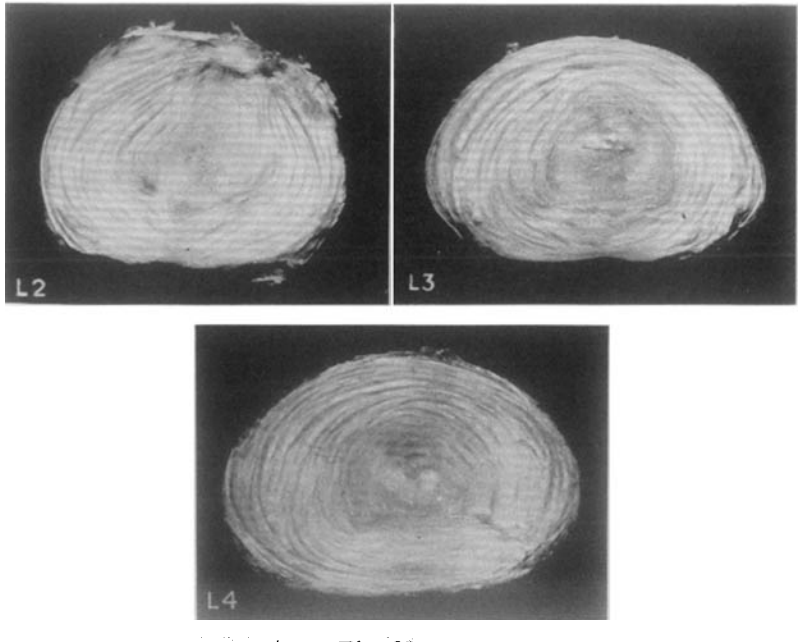


Fig. 35.

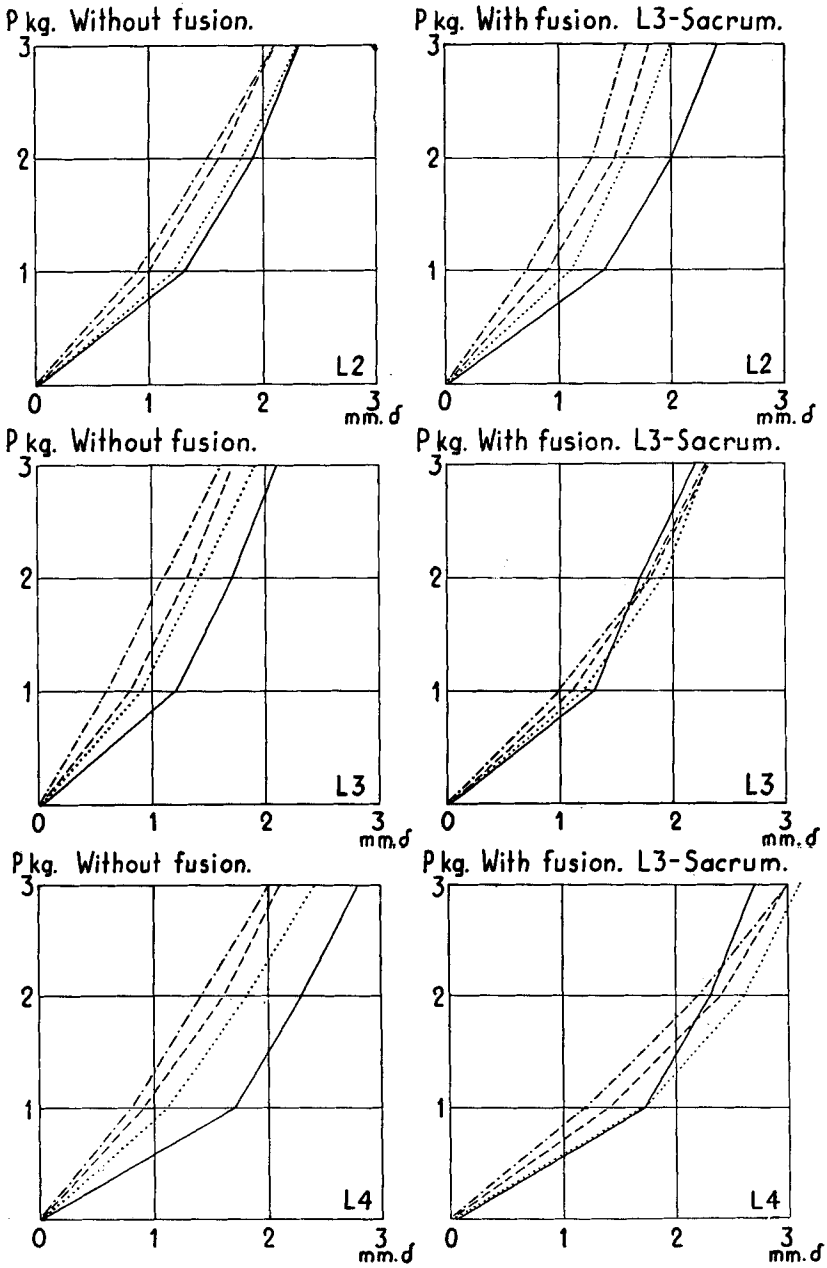

P kg. Without fusion.
P kg. With fusion. L3-Sacrum.
L2
L3
L4
mm. d
0
1
2
3

Diagram 12.

Case No. 19.

Woman, aet. 70 years.

Cause of death: Cardiac insufficiency.

Discs examined: L. II, L. III and L. IV.

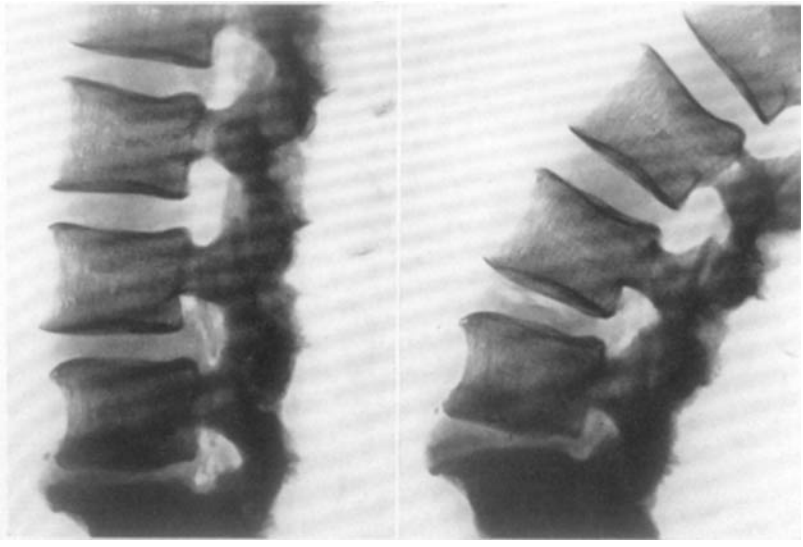
Fusion: L. III-sacrum.

Roentgen: L. IV, vacuum phenomenon, instability, sclerosis and osteophytes. Lowered interspace (fig. 36).

Macro photography: (Fig. 37). L. II, large posterior rupture of the annulus.
L. III, slight postero-lateral rupture of the annulus.
L. IV, massive degeneration with marked fibrosis.

Pressure measurement: (Diagram 13). L. II, no change in pressure.
L. III, diminished pressure.
L. IV, no change in pressure.

The fact that no change in pressure has been achieved by fusion in the 4th disc is probably due to the marked fibrosis.



a. *Fig. 36.* b.

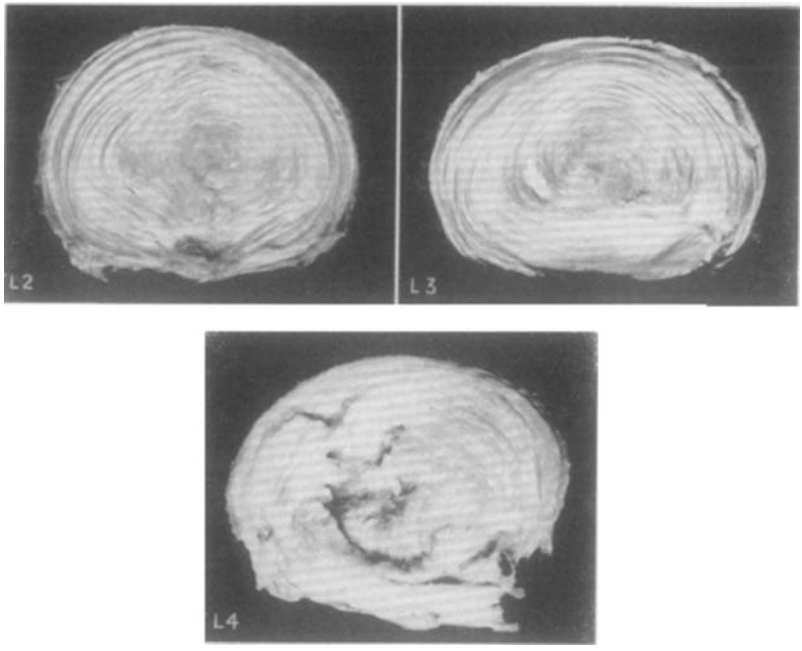


Fig. 37.

Case No. 20.

Woman, aet. 55 years.
Cause of death: Cardiac insufficiency.
Discs examined: L. II, L. III and L. IV.
Fusion: L. III-sacrum.
Roentgen: No changes (Fig. 38).
Macro photography: Postero-lateral rupture of the annulus on L. III and L. IV (Fig. 39).
Pressure measurement: (Diagram 14). L. II, increased pressure. L. III, diminished pressure. L. IV, diminished pressure.

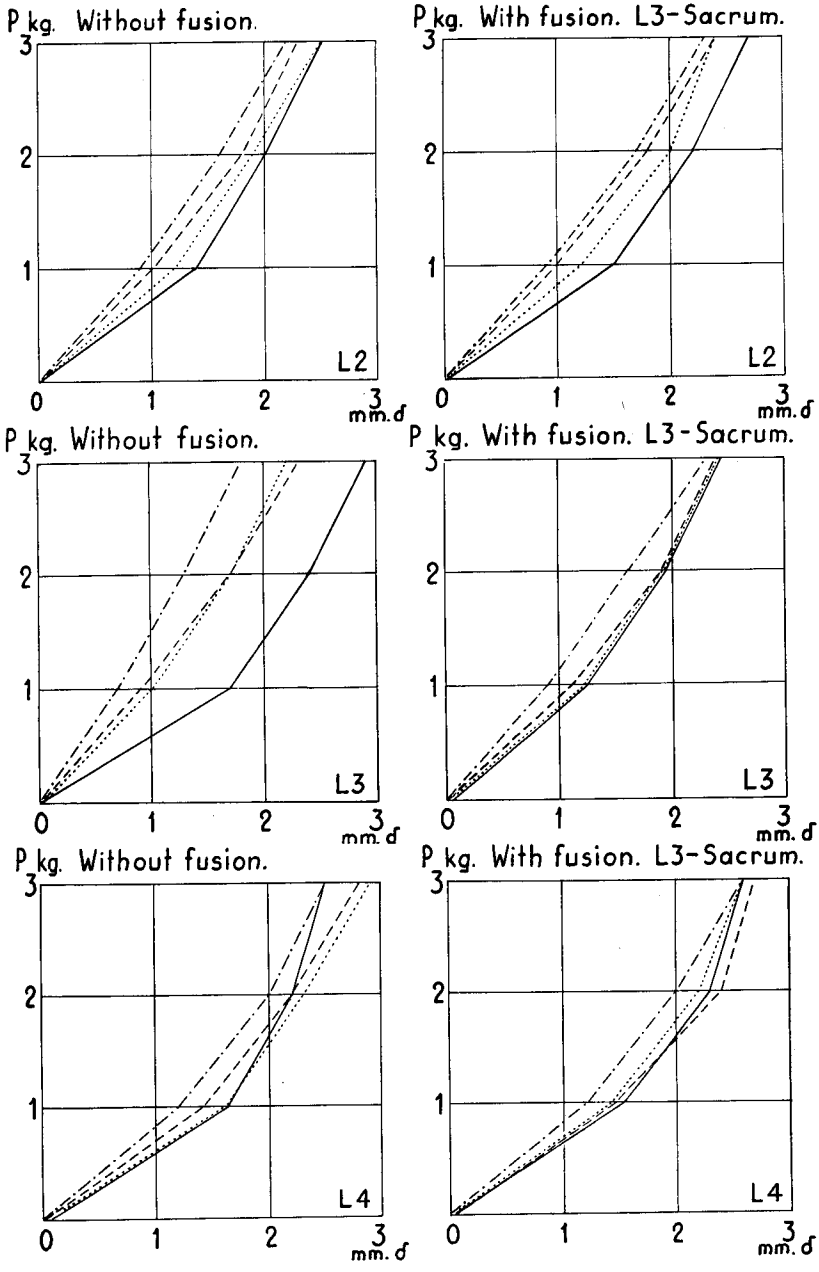
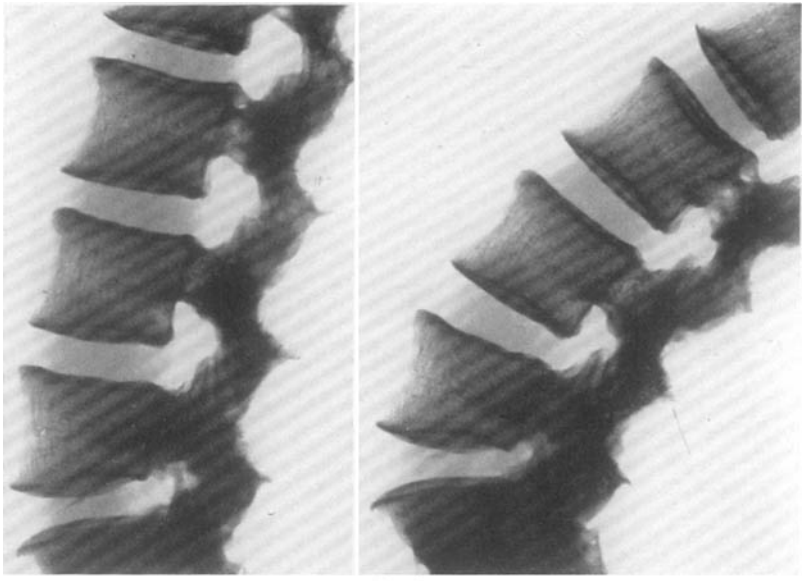

P kg. Without fusion.
P kg. With fusion. L3-Sacrum.
L2
L3
L4
mm. d
0
1
2
3

Diagram 13.



a. *Fig. 38.* b.

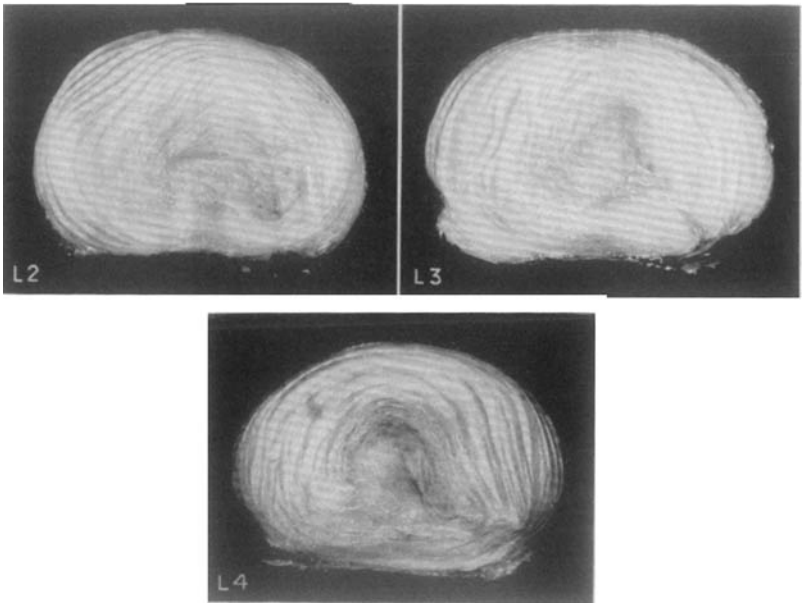


Fig. 39.

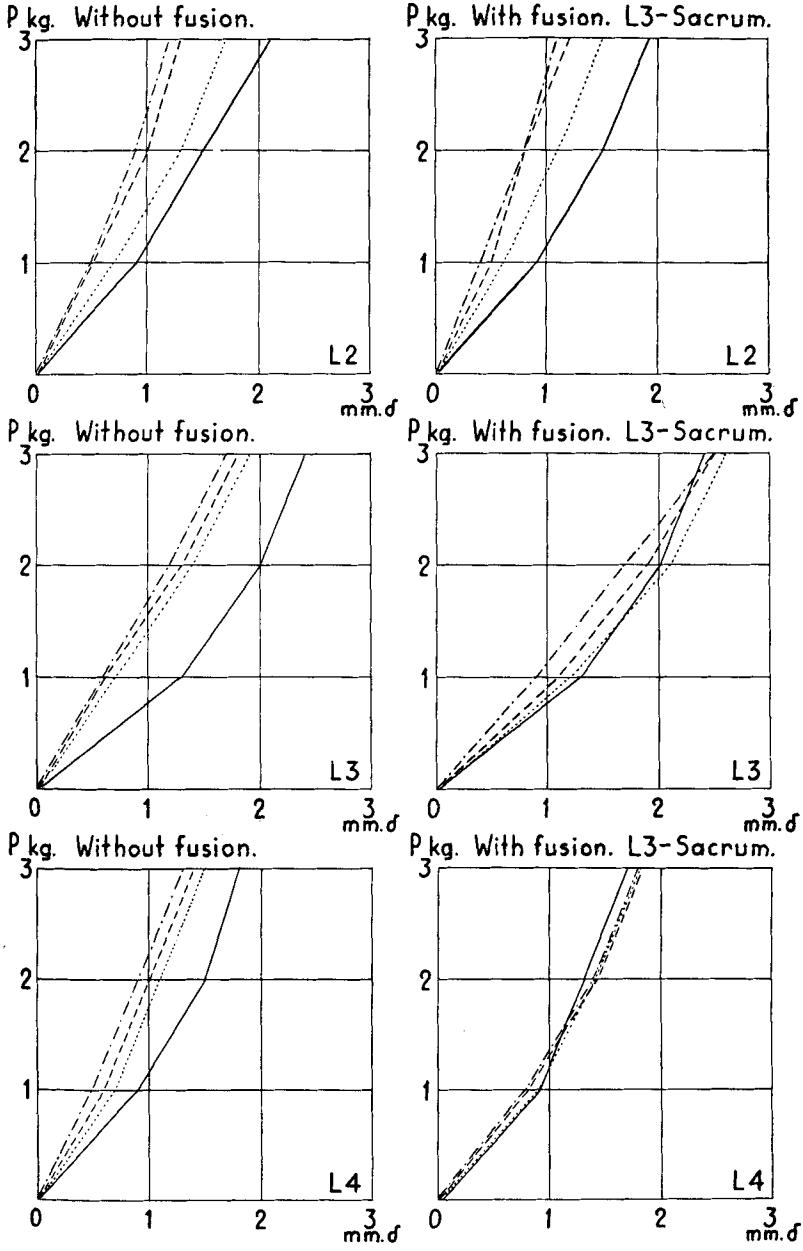

P kg. Without fusion.
P kg. With fusion. L3-Sacrum.
L2
L3
L4
mm.d
0
1
2
3

Diagram 14.

Case No. 21.

Man, aet. 47 years.

Cause of death: Pulmonary tuberculosis.

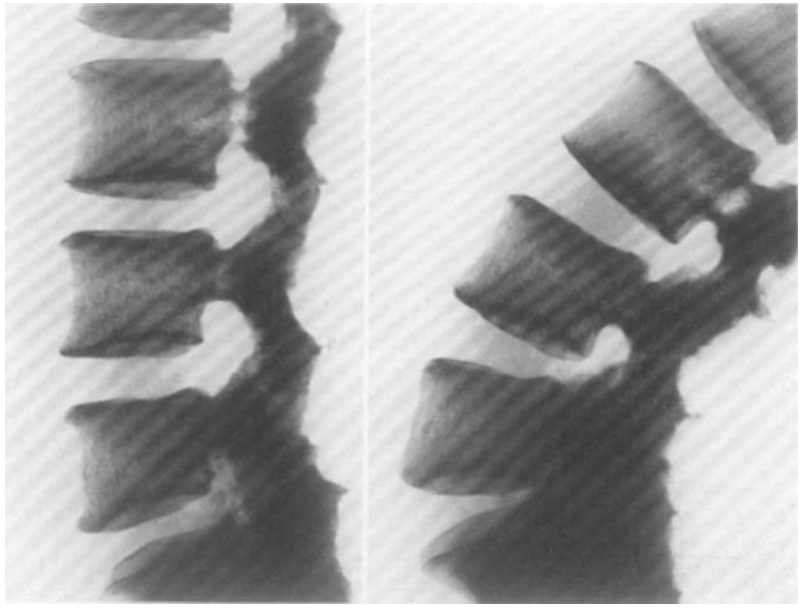
Discs examined: L. II, L. III and L. IV.

Fusion: L. III-sacrum.

Roentgen: No changes (Fig. 40).

Macro photography: (Fig. 41). L. II, degeneration of posterior part of disc.
L. III, degeneration of posterior part of disc.

Pressure measurement: (Diagram 15). L. II, increased pressure.
L. III, diminished pressure.
L. IV, diminished pressure.



a. *Fig. 40.* b.

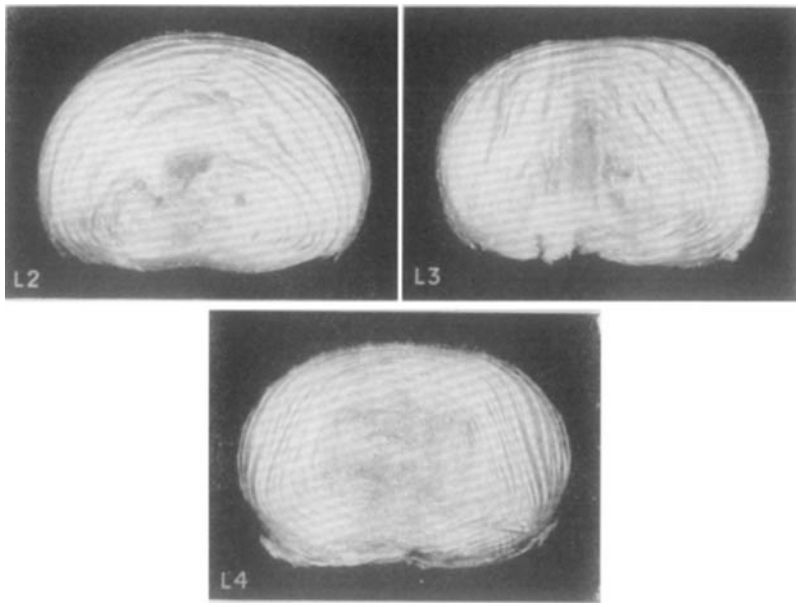


Fig. 41.

Case No. 22.

Man, aet. 62 years.

Cause of death: Acute pancreatic necrosis.

Discs examined: L. II, L. III and L. IV.

Fusion: L. III-sacrum.

Roentgen: In L. III lowered interspace. Marked sclerosis and osteophytes. No mobility in the disc when tested for stability (Fig. 42).

Macro photography: (Fig. 43). L. III, massive degeneration of the whole disc with marked cicatricial formation.
L. IV, moderate degeneration with small anterior, posterior and lateral ruptures of the annulus.

Pressure measurement: (Diagram 16). L. II, increased pressure.
L. III, no change in pressure.
L. IV, diminished pressure.

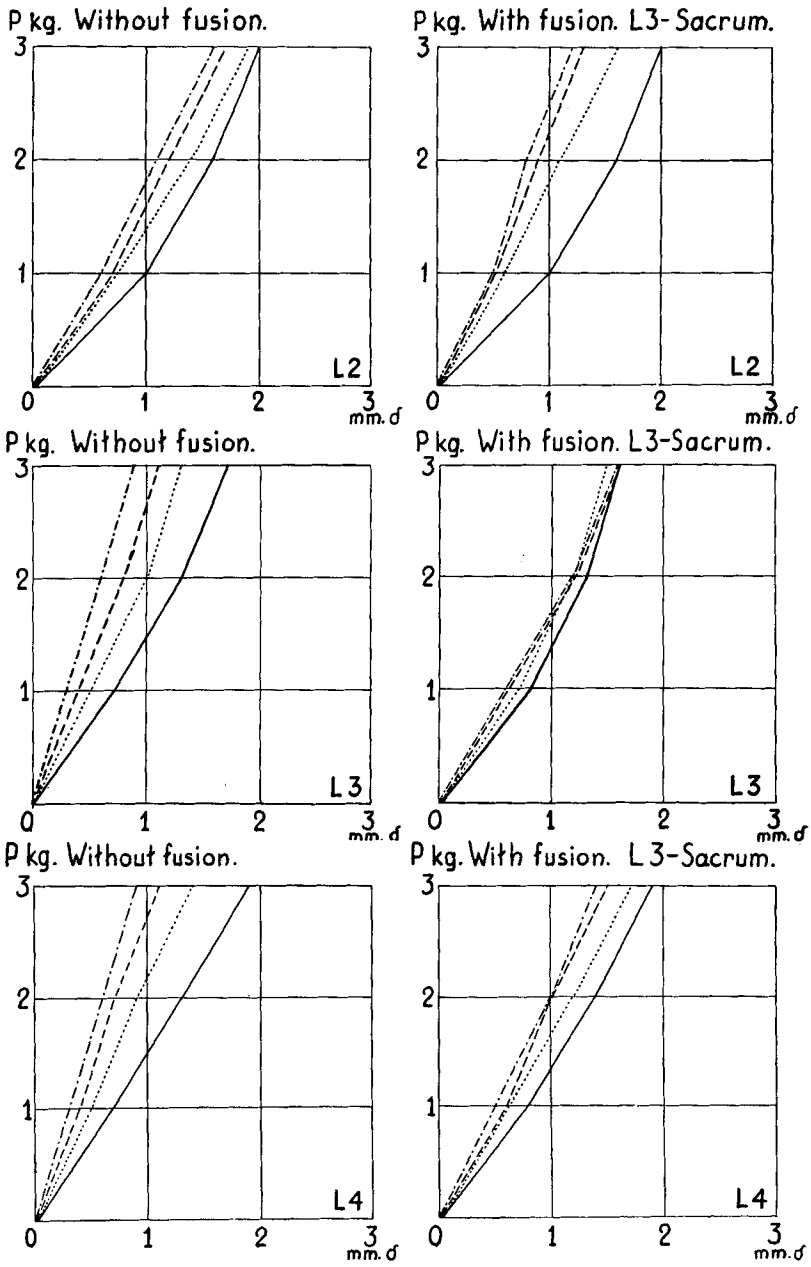
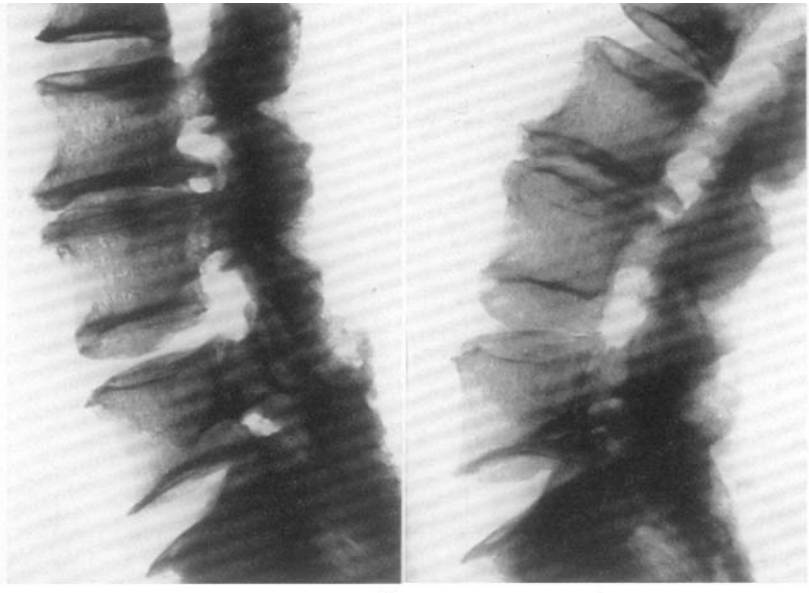

P kg. Without fusion.
P kg. With fusion. L3-Sacrum.
L2
L3
L4
mm. d
0
1
2
3

Diagram 15.



a. *Fig. 42.* b.

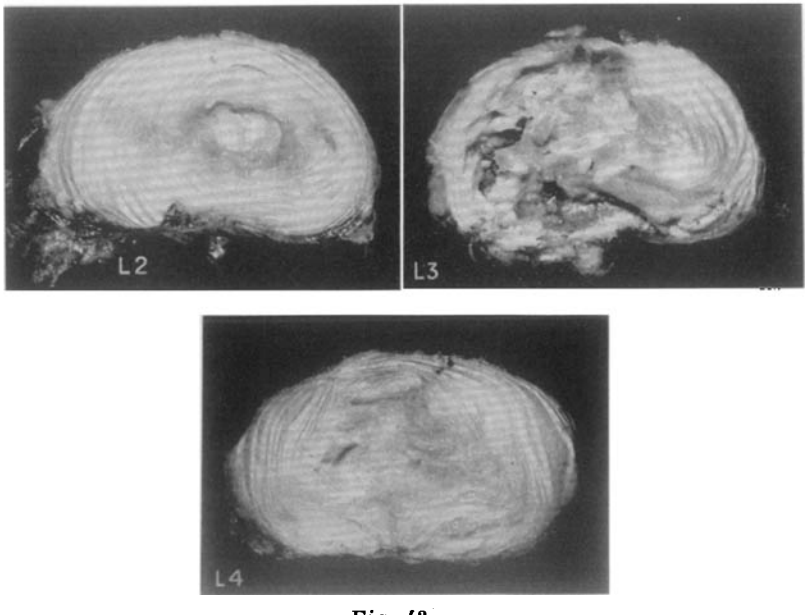


Fig. 43.

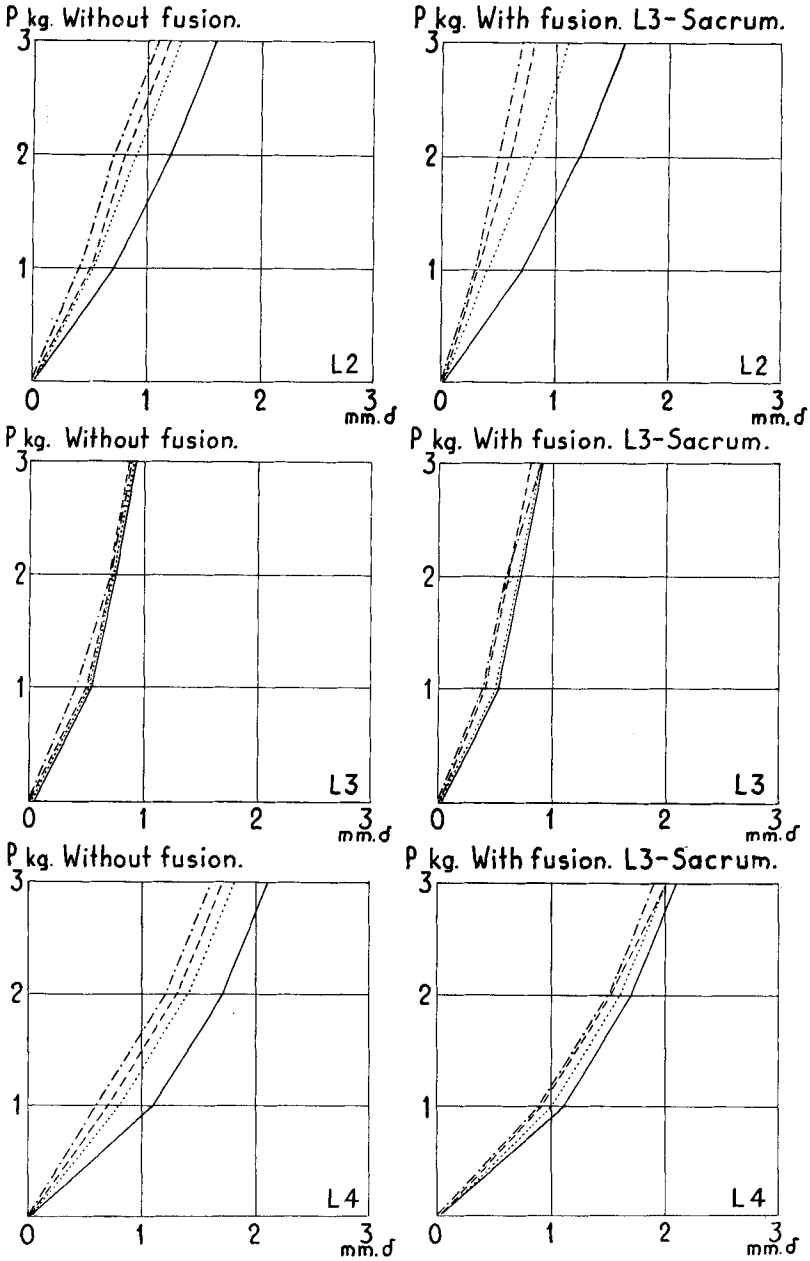

P kg. Without fusion.
P kg. With fusion. L3-Sacrum.
L2
L3
L4
mm.d
0
1
2
3

Diagram 16.

It will be seen that *out of twelve intervertebral discs, that were situated immediately above the osteosynthesis, there was an increase of pressure manifested in eight cases.* No change of pressure could be registered in three cases. In one case (No. 13 with fusion L. IV—L. V) the unstabilized disc, L. III, showed a slight diminishing of pressure.

Twentytwo discs were fixed by fusion. A diminishing of the pressure was manifest in nineteen cases. No change of pressure took place in three cases. Two of these showed marked degeneration with profuse fibrosis. Obviously a loading of up to 37.5 kg was not sufficient to produce any change in the pressure conditions of these discs.

Observations made during the experimental investigation:

1) The deformity that is effected on the anterior surface of the disc when a pelott is pressed to a certain degree of power against the disc is an expression of the pressure in the intervertebral disc.

2) Gradual loading of the back brings about a proportional diminishing of the size of the deformity, if this is registered by means of a pelott that is pressed with a constant pressure (1,2 or 3 kg.). This reduction of the deformity is an expression for the increase of pressure in the disc. This means that the strain to which the disc is subjected, when the complete lumbal column is loaded, is proportional to the amount of loading (within limits up to 37.5 kg). The functional value of the observation that deformity is in direct proportion to the load that is placed on the back, is that every disc, as a pressure receiving unit, has a well suited and decided mechanical function. It is therefore not a mere matter of chance as to how the back takes up a load, but that there are definite laws governing the mechanical function of the disc.

3) If the spinous process is fixed by metal plates so that there is a cessation of mobility between the spinous processes (because of the elasticity of the bone, slight mobility is unavoidable), and the same load is placed on it and a measure-

ment of pressure taken, the following will be noticed in the stabilized disc: the deformity decreases with rising loads, that is to say, the pressure in the disc increases, but the manifestation one gets in the stabilized disc is essentially greater, that is to say, the increase of pressure in the disc is considerably less when it is stabilized than when the disc is not stabilized. This means that fusion embracing the spinous process is therefore not sufficient to eliminate all mobility between two or more vertebrae. That this is so is only to be expected as, in these experiments, mobility in the intervertebral joints was not eliminated.

4) Straining of the discs immediately above an osteosynthesis are greater than they were before fusion. This indicates the fact that the measured deformities give a lower value than before fusion, that is to say, the pressure in the disc has increased.

SUMMARY

In *Chapter I* a description of the anatomy, physiology, pathology and patho-physiology of the intervertebral discs is given.

In *Chapter II* a survey is made of previous investigations of the roentgenological picture, the connection with trauma and the effect of conservative treatment resorted to in lumbal disc degeneration.

In *Chapter III* an account is given of an investigation of the frequency of low back and sciatic pains that were notified during 1948 in The Stockholm City Central Sick Benefit Society and The Stockholm Tramway Company Ltd.

In 1948 there were 296.777 registered members of the Stockholm City Central Sick Benefit Society of whom 116.767 had reported sick. Of these, 4.5 % were cases of low back and/or sciatic pain. The frequency for men and women between the ages of 15—39 was approximately the same. But between the ages of 40—64 the frequency was considerably higher in respect of men. The average number of sick days in respect of low back and/or sciatic pain was 0.68 for men and women alike, whilst the figures for all diseases averaged out at 11.4 for men and 16.8 for women. 426 of the members of the Sick Benefit Society were trated in hospital, and 39 had undergone operations. 57.59 % had been sick for 22 days or less.

Of the 6.948 male employees of the Stockholm Tramway Company, there were 408 diagnosed cases of low back and/or sciatic pain. The largest category, the traffic staff, having 4.659 employees, which was considered large enough to be worked out statistically, showed the same tendency as the male

members of the Central Sick Benefit Society, but the frequency was approximately twice as high. This seems to indicate a connection between lumbago and sciatica and the nature of the work performed. The average number of sick days per person in respect of lumbago and/or sciatica is estimated at 1.46 for the traffic staff and 1.87 for the employees in the waggon and work-shop departments. 58.69 % of the traffic staff and 63.50 % of the employees in the waggon and work-shop departments had been sick for 22 days or less.

In *Chapter IV* an examination is made of seventy five patients of whom thirty four are men and forty one are women, suffering from lumbago and/or sciatica and having roentgenological signs of disc degeneration within *one disc* and who have been treated conservatively or not treated at all. The observation time has been from 18 to 3 years. 57.3 % of these did heavy manual work. 26.7 % did light work and 16 % did no manual work at all. Trauma, that was stated by the patient as being the cause of the trouble, was present in 17.3 %. In 56 % the trouble manifested itself between the ages of 20 to 29 years and in 4 % up to the age of 19 years. 85.33 % were incapable of working for one month or longer. The total time of working incapacity amounted to 61.8 years. 33.33 % had back trouble, 64 % had back and sciatic trouble and 2.6 % had sciatic trouble only. Thirty patients had left-sided sciatic trouble, fourteen had right-sided and 6 had bilateral sciatic trouble. On the whole the back trouble was of a nagging character with a lengthy course whilst the sciatic trouble was of shorter duration. 40 % had their trouble for from 1 to 10 years and 60 % had it for more than 10 years. 36 % presented objective signs from the back, 24 % presented objective symptoms from the back as well as neurological symptoms from the legs and 40 % presented no objective signs at all. The immediate effect of conservative treatment was that 26.67 % were cured, 57.33 % showed an improvement and 16 % were unimproved. When post examined, when, in many cases, no treatment had been given for a long time, 38.67 % were cured, 16 % were improved and 45.33 % showed no improvement at

all. The post examination also showed that 82.67 % were capable of working whilst 17.33 % were not able to work. Lowered interspace, sclerosis of the vertebrae surfaces and osteophytes, instability and vacuum phenomena have been taken as being positive roentgenological signs of disc degeneration whilst retroposition has been considered as a probable sign of it. *Lumbal* and *lumbo-sacral* disc degenerations that differ from each other because the height of the disc cannot be given any significance in the latter group are discussed separately. A classification of the cases *with* and *without* vertebral changes has been made. In order to obtain a standard for the degree of roentgenological changes, the cases have been classified into *slight, moderate* and *pronounced* forms together with a group where the *disc* has been completely *obliterated.* In this connection special regard has been taken of the height of the disc in the lumbal and of sclerosis and osteophytes in the lumbo-sacral discs. Of the 35 lumbal cases, various degrees of progress was registered in 17 cases and in 20 of the 40 lumbo-sacral cases. More pronounced progress in the lumbo-sacral. Twentytwo lumbal and twentyeight lumbo-sacral showed retroposition. Twentyone lumbal and only four lumbo-sacral showed instability. "Fresh disc degeneration" was found in four of the lumbal cases and in seven of the lumbo-sacral. It is pointed out that it is uncertain whether these are "fresh disc degenerations" as no instability tests were made when these cases were examined for the first time. Besides, some of these became manifest only when tested for instability in the postexamination. This indicates that disc degeneration occurs on one occasion either singly or manifoldly and not by mere chance at any time during life. The vacuum phenomenon was manifest in only two lumbal cases, but in twenty of the lumbo-sacral cases of which in fourteen it was manifest only when bending backwards (during instability tests). Spondylosis deformans of a slight degree appeared in nine cases. Lumbo-sacral discs having a very low, thread-like posterior region, but without any other changes, give a suspicion of disc degeneration which is elucidated by three cases. No conclusions

about the patient's subjective trouble can be drawn from the roentgenological changes not even when there is instability.

In *Chapter V* an account is given of previous experiences of surgical treatment of disc degeneration in the lumbo-sacral spine, extirpation of disc prolapse and fusion.

In *Chapter VI* a report is given about the result of fusion in eighty patients suffering from lumbago and/or sciatica who have all presented signs of disc degeneration in the lumbar and lumbo-sacral spine. Osteosynthesis has either been performed primarily in severe lumbago or as a secondary measure in operations for disc herniation should back trouble have remained or increased. Primary fusion in connection with operations for disc herniation have not been the normal method. Disc degenerations in 21 cases were single lumbal, in 30 cases lumbo-sacral and in 29 cases they were multiple. 50 % had done heavy manual work, 21.25 % had done light manual work and 28.75 % had done no manual work at all. 17.5 % gave trauma as the cause of the trouble. The trouble made its first appearance before the age of 35 years in 55 %: 37.5 % had trouble from 5 to 10 years and 46.25 % had it for more than 10 years. No one had had trouble for less than 2 years. 71.25 % were incapable of working for 3 months and more, 28.75 % were incapable of working for shorter periods. The time of working incapacity amounted to a total of 114 years. 48.75 % had back trouble only, whilst 51.25 %, in addition to their back trouble had, or had had, sciatica. 18 had left-sided sciatica, 13 had right-sided and 10 had bilateral sciatica. Of 69 patients with subjective low back symptoms, 21 had neurological symptoms in the lower extremities, whilst the findings in 7 cases were negative. Seventeen patients were operated on by laminectomy with or without extirpation of the disc prolapse prior to osteosynthesis being performed. In all 80 cases, conservative treatment had been tried and found fruitless. The operative method was Albee in seven cases, modified Albee with fusion between the arches in eighteen cases, grafting on the arches in 37 cases and "locking graft" in eighteen cases. Laminectomy in connection with fusion was performed in

twenty cases whereby disc herniations were extirpated in three of the cases. When post examined it was found that 53 (66.25 %) were completely cured, 12 (15 %) had improved and 15 (18.75 %) showed no improvement. The remaining trouble was lumbago as well as sciatica in twelve cases. The sciatic trouble had not increased and no fresh sciatic trouble had occurred. Sixtyseven patients were capable and thirteen incapable of working when post examined. The objective inspection has aimed at localizing the disc degeneration, estimating the number and degree of the laminectomies, the consolidation of the osteosynthesis, manifestation of fresh changes and the roentgenological progress of disc degeneration. After having taken into consideration the complications stated above, the single lumbo-sacral disc degenerations show the best results with 76.7 % cured, after which come the single lumbal with 62 % and the worst ones were the multiple with 58.3 % cured. Laminectomy was performed in 26.6 % of the subjectively cured cases, in 33.33 % of the subjectively improved cases and in 46.67 % of the cases that showed no subjective improvement: the magnitude of the laminectomy was least in the cured cases. In 20.75 % of the cured cases, 46.67 % of the improved cases and 40 % of the cases that showed no improvement, graft complications were observed consisting of unsatisfactory fixation in the upper or lower end of the osteosynthesis, pseudoarthrosis on the osteosynthesis and knocking off of the graft. In seven cases operated on by Albee's method there was healing of the graft in one case only. Graft complications were manifest in one case only of the eighteen operated on by "locking graft". This indicates that the latter method is the best and that Albee's method only is not satisfactory in fusion of the disc degeneration where instability of the disc is frequently significant. Disc degeneration above the osteosynthesis was manifest in seven cases in one of which spondylolysis occurred on the arch of the upper vertebra in the osteosynthesis. In thirty nine cases it was possible to establish progress of the degeneration. Thirtyone cases (38.75 %) were

entirely free of complications. Twentyseven of these were cured, three improved and one showed no improvement.

In *Chapter VII* the clinical material is discussed. Amongst other things it is emphasized that the result of the surgical treatment has been better than that obtained from conservative treatment despite the fact that the material of operated cases has consisted of more severe cases than that of the unoperated ones.

In *Chapter VIII* there is a description of a method of experimentally registering the pressure conditions in the intervertebral discs. A lumbo-sacral preparation from cadavers is placed in a loading apparatus which makes possible a loading of the back with 12.5 kg, 25 kg and 37.5 kg. By means of a pressure guage one can register the deformity that can occur on the surface of the disc if it is subjected to one, two and three kilograms pressure from a pelott. The 2nd, 3rd and 4th lumbar discs of twelve preparations have been examined. The experiments have been carried out with and without artificial fusion of the spinous processes. Fusion was made between L. III and the sacrum. In this way the 2nd lumbar disc has not been embraced by the fusion. The deformity achieved on the anterior surface of the disc, when a pelott is pressed against the disc at a certain strength is an expression of the pressure in the intervertebral disc. By gradually increasing the loading of the back, a proportional lessening in the size of the deformity is established. After fusion, and with continuous loading, a lessening of the deformity takes place, that is to say the pressure in the disc increases, but this increase of pressure in the disc is considerably less in fusion than if the disc was not stabilized. This implies that a fusion between the spinous processes is not sufficient to eliminate entirely all mobility between two or more vertebrae. The strain on the disc immediately above an osteosynthesis is greater than it was before the osteosynthesis.

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