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FROM THE STATE HOSPITAL OF TAMPERE
HEAD: PROFESSOR V. TUOMIKOSKI M.D.

LOW BACK PAIN AND SCIATICA

WITH SPECIAL REFERENCE TO SECONDARY LUMBOSACRAL INSUFFICIENCY

BY

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PREFACE

Low back disorders and radiated pain in the legs have been troubling man for centuries. Conservative treatment in various forms has generally prevailed. It was not till 1934 that the well-known discoveries by Mixter and Barr brought forth a more radical turn towards surgery. The main problems were now transferred into the field of neuro-surgery and they have since made an increasing appeal to both neuro-surgeons and orthopaedists. Plenty of work has been done and the operative results have improved side by side with the progress of diagnostics and of operative technique. We are however still far from the goal. It is of continual importance to collect fresh information and to investigate new material.

Another cause which has compelled me to deepen my knowledge in this difficult problem is the patient himself, the sick suffering human being. In the centre of a large district the surgeon cannot infinitely hide his ignorance inside a lighter or heavier corset. To leave the problem unsolved is only to aggravate the social burden of all of us. The explanation must be sought in the pathogenesis of the disease, for treatment without knowing the cause is really a depressing business.

In this connection I wish to express my gratitude to Professor VILJO TUOMIKOSKI, M.D., who as Head of the General Hospital of Tampere has put at my disposal the details of the treatment of low-back cases at this hospital. Since the year 1953 when I was appointed an associate surgeon at the above hospital, I have been given a free hand to work on the problems of low back disorders. Professor TUOMIKOSKI's constructive advice and instruction will lastingly be retained in the minds of his colleagues and pupils.

My thanks are also due to Dr. MATTI MELA, head of the x-ray department in our hospital, for all the x-ray examinations and myelograms of the cases in hand.

Miss IRMA KUUSNIEMI and Mrs. RAUHA SETÄLÄ, from the outpatient department, have industriously helped me to clear up many questions concerning the patients investigated here.

I remember with warm thoughts the staff of the operating theatre who with wise and perhaps even unwise advice kept my psyche well-balanced during the most crucial and exacting period of my work, i.e. during the treatment of the patients.

I am sincerely glad to be able to thank Professor K. E. KALLIO M.D., Head of the University Clinic for Orthopaedics and Traumatology, Helsinki. During my work Professor KALLIO has always been ready to offer the range of his wide experience for the benefit of my research.

I also wish to express my warm thanks to Mr. V. PENTTILÄ for his critical translation of the Finnish manuscript into English.

Last but not least I record my gratitude to the EMIL AALTONEN Foundation for financial aid.

I. INTRODUCTION

In hardly any other part of the human body are static causality and pain so closely connected as in the low back region. This state of things dates back to Oligocene time when man had progressed so far that he was able to forsake life in the trees. His superior intellect provided him with sufficient means of defence. A better lookout for danger made the upright position necessary and the new equilibrium thus established put new demands on the legs, the hips, and above all, the lower parts of the spine. It seems that the process of adaptation is still incomplete. The lumbosacral region which forms an angle of about 135 degrees with the vertical line of the body still remains one of the weakest points of support and one that is most liable to strain in the human locomotor system.

The upright position is maintained by means of the bone structure and of the ligament and muscle system of the spine. The static strain is apparent in the small articular facets of the arches of the vertebrae but most of this strain falls on the intervertebral discs. Degeneration of the discs, which as a rule begins during the second or the third decade of human life, calls forth typical pathological and anatomical changes. Later on these changes can be observed at the borders of the vertebral bodies through x-ray examination.

G. SCHMORL in Dresden carried out very noteworthy investigations of the anatomy and pathology of the changes of the intervertebral discs. Between 1927 and 1931 he published eleven papers on these questions. In collaboration with JUNGHANNS in 1932 he made a comparative study of the changes found out through x-ray examination and of those based on the normal and pathological anatomy of the intervertebral discs. It was in fact JUNGHANNS who, due to his investigations and experiences of pathology and anatomy, introduced the term »pseudo-spondylolisthesis» because no neural arch defect was to be found. This was afterwards called primary instability of the lumbar vertebrae (MORGAN, KING 1957). Thus was the tendency to olisthesis of the vertebral bodies explained.

It is interesting to observe that long before MIXTER and BARR in 1934 published their epoch-making paper on the connection between the lower lumbar discs and the »lumbago-sciatica» syndrome, all the information about these facts was already available. This does not, of course, reduce the value of this discovery. It is only one more proof of the fact that in scientific work the final goal can be reached through different ways of observation. Besides, in preantibiotic time operations of this kind envolved great risks due to the danger of infection.

As early as 1765 Dominico Contunio of Naples described sciatica as a clinical entity in his »De Ischiade Nervosa Commentarius» so well that this description holds true even today. He pointed out the neural origin of sciatica, which he clearly distinguished from »arthritic pains».

The first who reported on a traumatic displacement of the disc was KOCHER in 1896. A man of 26 had fallen one hundred feet in a standing position. During the autopsy a large posterior bulge of disc was discovered between L I and L II but no fracture of the vertebrae. He did not regard the changes as caused by protrusion but by proliferation.

It is to be noted here too that in 1896 DEXTER reported on a disease in a dog the syndrome of which was posterior paralysis caused by compression of the spinal cord. He suggested that the compression was caused by a neoformation which he found in one of the intervertebral discs.

MIDDLETON's and TEACHER's report dates from 1911. They described the case of a man aged 38 who felt something »snap» in his back while lifting a heavy weight. Local pain and paraplegia of the legs appeared during the following night. The patient died sixteen days later of urinary infection. Retropulsion of the disc material was found in the spinal canal between the last thoracic and the first lumbar disc. »The mass was white and firm and particularly resembled the central part of the intervertebral disc.»

GOLDTHWAIT's observations from the year 1911 are also of great interest in this context. He tried to find out how sciatica correlated with lumbosacral anomalies, sacralization, lumbalization, spina bifida, and with the developmental abnormalities of the small articular facets of the pedicles. It was however soon discovered that many patients with congenital anomalies did not suffer from sciatica, after all.

GOLDTHWAIT's attention was drawn to a patient who had suddenly developed the cauda equina syndrome while undergoing manipulation for sacro-iliac strain. GOLDTHWAIT concluded that subluxation of the lumbosacral joint was the commonest cause of the sciatica syndrome. He also believed that such subluxations were probably due to congenital anomalies

and in many cases accompanied by posterior displacement of the S I and L V discs.

Observations made during the following years were such as to contribute to the elucidation of the sciatica syndrome.

In 1916 ELSBERG wrote about the extradural chondromata of the spinal canal. Several papers were then published on the same subject, among others STEINKE (1918); CLYMER, MIXTER, and MELLA (1921); ADSON (1922); HOLM (1928); ELSBERG (1928); KORTZEBORN (1930).

DANDY (1929) reported that in two cases he had found cartilagenous fragments of nuclear tissue, which resembled tumours, lying loose in the spinal canal.

PUTTI (1927) suggested that radiculitis and neuritis in the region of the sciatic nerve was due to irritation of the nerve roots in the spinal foramina. He believed that this irritation was caused by arthritic changes in the intervertebral joints.

September 30th, 1933 is an epoch-making date in the history of the sciatica syndrome. It was on that day in the Annual Meeting of the New England Surgical Society in Boston that MIXTER and BARR explained the causal connection between a prolapsed intervertebral disc and sciatic pain. They also proved that this condition could be cured through surgical treatment.

This was really a big step forward. It was surprising how quickly this view found widespread acceptance. Surgeons' attention was drawn to this operation in different parts of the world. This again aroused an overflow of enthusiasm whose negative aftereffects still prevail in many quarters. Defective operative technique, insufficient neurological knowledge,underestimate of the statics of the low back, the part played by ossific anomalies and other factors contributed to the operative results falling short of expectations. Thus, in very many quarters the surgeons were inclined to fall back to old conservative treatment with its familiar results.

Today there are however surgeons who have done a thousand and even more low back operations. ARMSTRONG (1952) says as follows, »It is true to say that in general in my experience there is no other group in which a major surgical procedure has afforded so much satisfaction to both patient and surgeon.»

There are still many difficult problems in the surgery of low back pain and sciatica awaiting their answers. The question whether to perform a fusion after a disc operation and in what kinds of cases still remains unsettled. It has not yet been decided either what kind of fusion is the most suitable in each individual case. The operative treatment of unilateral sacralisation and

lumbarisation is still somewhat uncertain etc. Questions on post-operative immobilization call for more accurate answers etc.

BARR (1951) says, »There is considerable evidence that an unstable spine is one of the common causes of an unsatisfactory result.» BARR recommends a spinal fusion after almost all the nuclear prolapse operations.

The real nature of low back pain still remains obscure. Elsewhere in the periphery a compression usually calls forth a paresis. Why does a compression on the spinal nerve in the lumbar region give rise to a sensation of pain? What is the part played by the sinus vertebralis nerve as a transmitter of pain? This nerve was discovered and named by VON LUSCHKA in 1850. He was apparently the first to give a detailed description of the recurrent branch of the spinal nerve which re-enters the spinal canal and supplies the bones and blood vessels. LUSCHKA found that the intervertebral discs contained no nerve endings. He pointed out that the nervus sinuvertebralis chiefly contains branches of the spinal nerve and has also some connections with the sympathetic nervous system.

ROOFE (1940) was able, with silver stains, to demonstrate non-myelinic fibres deep in the posterior longitudinal ligaments and in the disc material, too. WIBERG (1949) also discerned nerve fibres in the posterior longitudinal ligaments. Nevertheless there is still plenty of confusion about the distribution of the nervus sinuvertebralis and about the type of its fibres.

Our knowledge of the distribution of the ramus posterior of the spinal nerve is still incomplete. PEDERSEN, BLUNCK, and GARDNER (1956) found out through experiments with animals that besides the branches that the ramus posterior sends to the skin and muscles it also distributes fibres to the fasciae, ligaments, periosteum, and intervertebral joints. Adjacent divisions overlap in their area of supply. The interspinal ligaments receive their branches from the next cranial segment. The nervus sinuvertebralis supplies the longitudinal ligament, dura mater, periosteum, and blood vessels. It has intersegmental anastomoses which contain sensory fibres.

Due to our gradually increasing knowledge we are able to make a better distinction between the widely reflected pain, resembling the one in the subdeltoid bursitis, and that deep vertical pain which springs from a root compression (Luck, Steindler 1956).

One of the most interesting things in the pathology of the disc is the »concealed disc» described by DANDY in 1941. Of equal importance is the fact pointed out by KEY (1945) and by BURNS and YOUNG (1945, 1947) that the principal cause of low back pain is a degenerate disc even when not associated with sciatica.

The papers published in Finland have dealt with the disc prolapse problem chiefly from the neurological point of view. These reports have not discussed fusion operations in connection with disc lesions and lumbo-sacral disorders. The only survey of the problem of low back pain in its entirety is the one given by KALLIO in 1957, based both on the available literature and on his own valuable observation.

Reports published in Finland on low back disorders and sciatica show an increasing interest in these questions: LASSILA (1942), SNELLMAN (1944), WARIS (1948), HAGELSTAM (1949), VARA and WARIS (1952), AF BJÖRKESTEN (1954), BISTRÖM (1954), KALLIO (1955), VIITANEN (1955), KOSKINEN (1957), KALLIO (1957).

SOLONEN (1957) has investigated the part played by the sacroiliac joint in low back pain. He maintains that non-infectious lesions of the sacro-iliac joint comprised about 2.4 per cent of the disorders of the back.

II. INTERVERTEBRAL DISC AND ITS PATHOPHYSIOLOGY

The intervertebral discs, which number twenty-three in all, constitute one-fourth of the total length of the spinal column. In the lumbar region the discs are broader and relatively more mobile, too. About one-third of the pre-sacral spine is made up of the lumbar discs.

The physiological and the pathological phenomena of the intervertebral disc can be dealt with side by side. Developmental anomalies of the disc are also likely to play a significant part in low back diseases. Therefore, to understand the pathological states of the disc it is necessary to be familiar with its embryology.

KEYES and COMPERE (1932) have made an exhaustive study of the embryology of the vertebral bodies and intervertebral discs. According to them, in the early embryo the mesenchymal cells of the sclerotome migrate to surround the notochord.

The vertebral bodies are formed in such a way that the sclerotome is separated into segments by the intersegmental arteries which are direct branches of the aorta. The vertebral column can be distinguished even in a five week old embryo and each segment can be seen to consists of a light cranial and a dark caudal part. The cells close to the intersegmental arteries show rapid development and the dark caudal and the light cranial parts fuse to form the vertebral bodies. The upper portion of the dark mass receives least nutrition. It remains undifferentiated and forms the precursor of the annulus fibrosus. The corresponding part of the notochord in the middle remains and later forms the nucleus pulposus. The rest of the notochord is obliterated by advancing ossification. At birth the vertebral bodies are already supplied with cartilaginous end-plates which cover the corresponding intervertebral surfaces. As mentioned already, the peripheral part of the intervertebral disc is formed by cells from the cranial portion of the dark caudal mass.

The fibroblasts of the dark mass are arranged around the nucleus and, are closely attached to the cartilaginous vertebral bodies. The growth of the

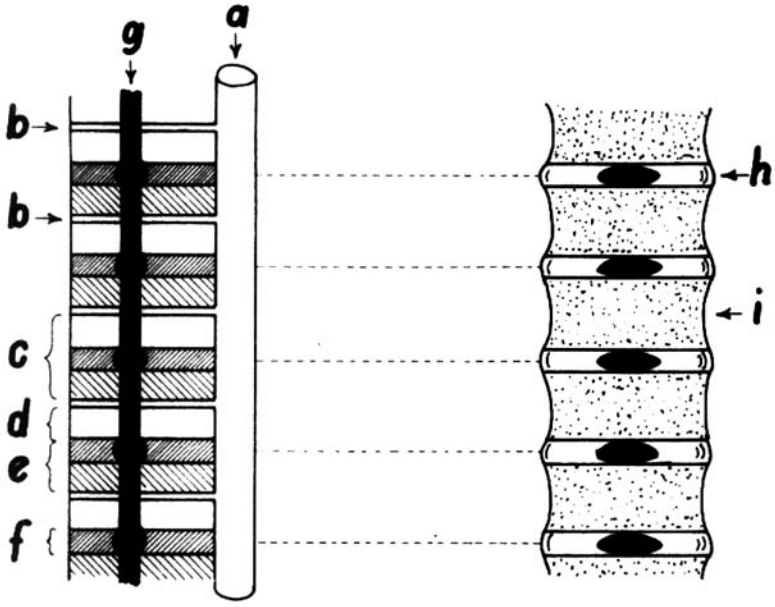


Fig. 1. — a) aorta, b) arteries separating mesenchymal cells and the notochord, c) precursor of vertebral body, d) light cranial part, e) dark caudal part, f) darker upper portion of the dark part or precursor of annulus fibrosus, g) notochord, h) fully developed intervertebral disc, i) fully developed vertebral body.

nucleus pulposus takes place by proliferation of the notochordal cells but later on also by the growing of the fibroplasts of the annulus fibrosus to the nucleus.

The later development of the nucleus pulposus is brought about by the proliferation of the fibroplasts.

In the twelve-year old disc the nucleus is made up of loose fibrocartilage with a gelatinous matrix.

At puberty secondary centres of ossification appear under the cartilaginous end-plates. From these centres ossification spreads to form a bony ring which is partially incomplete posteriorly. Centrally the end-plate is thus prominent, but marginally with the exception of the posterior surface it fades out into the annulus fibrosus, where the latter structure is attached to the elevated epiphyseal ring. Posteriorly the ring is incomplete and the cartilage plate reaches the posterior margin of the vertebral body (Eckert and Decker 1947). This bony plate fuses completely with the vertebral body. Centrally and posteriorly the cartilage end-plate remains unchanged. This cartilage plate covers the bony surface separating it from the nucleus pulposus and annulus fibrosus and gives attachment to their fibres, too.

The fully developed intervertebral disc thus consists of three parts. Firstly, the cartilage endplates enclosing the vertebral body above and below. The second part is the nucleus pulposus and the third the annulus fibrosus. The fibres of the annulus fibrosus are very intimately blended with the cartilage plates but also with the nucleus pulposus.

In the lumbar region the nucleus pulposus is situated rather behind the centre of the disc. The nucleus is plastic and obeys the law of fluids.

At the anterior and lateral margins of the vertebral body the annulus fibrosus is firmly attached to the epiphyseal ring and similarly to the anterior longitudinal ligament. Posteriorly, however, the peripheral attachment is not nearly so firm and, besides, the posterior longitudinal ligament is a relatively weak structure. (BEADLE 1931). The annulus lamellae, too, are less strongly developed posteriorly. This partly accounts for its tendency to posterior rupture. (GRANTHAM & SPURLIN 1953).

The mature intervertebral disc contains no true blood vessels. Its nourishment is effected by filtration of lymph through small channels (BÖHMIG 1930, KEYES & COMPERE 1932, COVENTRY, GHORMLY, and KERNSHAW 1945). It may be that this avascularity may contribute to the comparatively early degeneration of the intervertebral disc.

The first beginnings of degeneration can be distinguished in the regions of both the secondary curves, in the lower cervical and lower lumbar regions. These regions are also most exposed to traumatic movements. Degenerative changes are discernible so early, often before the 20th year of age, that degeneration of the intervertebral disc must be regarded as a more or less physiological phenomenon.

A degenerative disc may protrude in every direction. The experts have long been familiar with SCHMORL's nodules, which are due to a protrusion of nuclear parts into the spongiosa of the adjoining vertebra. Because of the anatomic factors the disc is more easily prolapsed posteriorly. A posterior protrusion is also of the greatest clinical importance due to the root compression attached to it. If, however, we have low back pain without any symptoms of sciatica, we have to take into consideration also prolapses towards the anterior longitudinal ligament. This ligament contains plenty of nerve endings which give sensations of posture (STEINDLER). An anterior protrusion has caused disability in a few cases, at least (CLOWARD 1952, KALLIO 1954).

The tendency to backward displacement of the disc is also due to the fact that the first degenerative changes take place in the posterior part of the nucleus pulposus. This begins to disintegrate into an increasing number of separate fragments which lie free in the semi-fluid material. At the same

time the posterior part of the annulus is vacuolated and softened. The final protrusion may then be precipitated by some small trauma or an inappropriate movement.

At first part of the annular ligament ruptures and the corresponding part of the posterior longitudinal ligament bulges towards the spine. A protrusion is formed. If again a greater or smaller portion of the nucleus pulposus is extruded straight under the posterior longitudinal ligament, a prolapsed or herniated disc results. Here the posterior longitudinal ligament remains unruptured. The last stage is marked by a rupture of the posterior longitudinal ligament and by a consequent extrusion of the nuclear tissue into the spinal canal. At a later age, the nuclear fragments may be ossified into bony deposits at the rims of the adjacent vertebral bodies. The prolapsed nuclear tissue may also be adhered very closely to the nerve root.

The development of this kind of herniated disc has been described by several investigators, among others by ARMSTRONG in 1952. In Finland such descriptions have been published by AF BJÖRKESTEN in 1954 and the most recent one by KOSKINEN in 1957. The classification suggested by KOSKINEN is as follows: 1) a typical nuclear prolapse, 2) a ruptured prolapse with a nuclear sequestrum bulging into the spinal canal, 3) a nuclear prolapse which adheres to one or two nerve roots and is often calcified.

This classification is similar to the one presented by DUNCAN and HOEN in 1942: 1) simple herniation, 2) the ruptured nuclear tissue is extruded into the epidural space, 3) fibrous fixation of the nuclear tissue and the nerve root. HYNDMAN (1946) speaks of a herniating and a herniated disc. This classification thus implies different stages of the same process which follow one another in a fairly regular chronological order.

One of the points that often attract the surgeon's attention is the greatly varying amount of degenerate mass to be removed during a disc prolapse operation. Sometimes this amount is extremely small, sometimes remarkably great. This may be explained by the fact that in the former case the annulus fibrosus has ruptured at a comparatively early stage of degeneration and the semi-fluid nuclear mass has been absorbed by the surrounding tissue. In the latter case the nucleus pulposus has undergone the entire degenerative process before the rupture. The nucleus pulposus undergoes progressive fibrous replacement until it becomes of the same consistency as the annulus.

Having once commenced, the fibrous degeneration of the intervertebral disc progresses steadily but the greatest changes take place during the fifth and the sixth decades of the patient's life (DEUCHER and LOVE 1939).

III. A CLINICAL PICTURE OF LUMBAR DISC LESIONS

The clinical picture presented by the degeneration of a lumbar disc varies widely between individual patients. Most patients complain of attacks of low back pain, usually called »lumbago». The first attack is followed by a relatively quick recovery. These pains are very often characterized by their periodic nature and by the increasingly slower recovery after the following exacerbations. BURNS and YOUNG (1947) found that backache was the first symptom in 68 per cent., ALEXANDER (1947) in 52 per cent., ARMSTRONG (1952) in 67 per cent., and the author in 72 per cent. of the patients.

The radicular nature of the disease becomes apparent sooner or later and begins to be the predominant feature in the clinical picture. This very often appears as an aggravating pain when coughing or sneezing. The main cause of this may be a rise in the liquor pressure which makes root compression more feasible. It may also be possible that the reflectory involuntary muscle spasm is simultaneously strengthened in the muscles of the back and abdomen thus narrowing the intervertebral space and increasing the involved root compression. Besides being due to a root compression this position, in the author's opinion, must be considered to be an initial symptom of primary low back insufficiency.

An aggravating sensation of pain is also often produced by percussion of the corresponding processus spinosus or the space between the corresponding arches.

When the really radicular symptoms begin to dominate the clinical picture, the straight leg raising test, first described by FORST in 1881, is the most pathognomonic. In Finland this test is attributed to Lasègue though the Lasègue test proper ist not equally applicable. When carrying out the latter, with the patient supine, the leg is raised by flexing both the hip and the knee to 90 degrees. The knee is then slowly extended. A highly limited range of

extension — to about 20 degrees — is an almost regular indication of root compression between SI and LV. Also in the following intervertebral space the Lasègue is mostly positive but usually less clearly so.

The rest of the clinical local diagnostics is based on peripheral irritation of the nerve roots involved.

It is also important to remember that the spinal root, which caudally passes under the vertebral body, corresponds to this body. Thus, between the bodies L IV and L V there runs the fourth lumbar root.

In the clinical niveau diagnosis four points must be observed: localisation of the sites of radiated pain, sensory disturbances, motor disturbances, and reflex changes.

When speaking of radiated pain we distinguish between two types of pain. Deep pain is of a dull, aching character, and it is felt deep within the leg. It is also difficult to locate and constant in character. This pain increases gradually with advancing degeneration of the disc, but does not radiate to the skin. Deep pain gives indications of the different stages of disc degeneration and, accordingly, of secondary low back insufficiency, too.

Superficial pain is liable to sudden and sharp variations. It originates in the skin and subcutaneous tissues and is chiefly due to a direct root compression (ARMSTRONG 1952).

By careful anamnesis it is possible for the investigator to draw the right conclusions concerning the pain discussed above. The patients are able, almost without exception, to localise their pain sensations with great accuracy.

If a patient suffering from sciatica is made to lie down supine and asked to cough while his leg is being raised, the usual sensation of radiated pain is generally produced more clearly. Thus in the L IV syndrome pain is felt in the antero-medial aspect of the leg as far as the knee; in the L V syndrome in the antero-lateral aspect of the leg below the knee down to the dorsum of the foot and to the region of the hallux; in the S I syndrome pain extends down to the peroneal region, the lateral malleolus, the lateral side of the foot, the heel, and the sole.

Sensory disturbances are typical of the L V and S I syndromes. These facilitate the location of the disc lesion. The L IV syndrome is characterised by disturbances in the metatarsus and the hallux. The S I syndrome shows disturbances in the sole, the heel, and the peroneal region.

In the L IV syndrome there are sensory disturbances mainly in the anterior aspect of the leg below the knee. They are not, however, so characteristic as between L V—S I. In the cases where the roots above L IV are

involved the wide overlap of adjacent dermatomes seems to make the diagnosis more difficult (FOERSTER 1933, KEEGAN 1943, AF BJÖRKESTEN 1954, etc.).

The motor fibres of the root seem to be less affected than the sensory ones. Thus muscle weakness and wasting is less severe than sensory disturbances and pain (ARMSTRONG 1952).

The motor fibres of the second lumbar root supply only the hip joint, as far as the leg is concerned. It has a distribution to the flexors, adductors, and internal rotators of the hip.

The third lumbar nerve is concerned with the same muscles as the second but also with the quadriceps muscle. Its disturbance is consequently reflected in deficient extension of the knee.

The fourth lumbar root has a wide distribution to the muscles of the buttock. It supplies the gluteus medius, gluteus minimus, quadratus femoris, and the inferior gemellus muscles. It is involved in the extension, external rotation, and abduction of the hip joint; in the extension of the knee joint, in the dorsiflexion of the ankle joint and the toes, and in the inversion of the foot.

The branches of the fourth and the fifth lumbar roots may easily be confused. The most notable difference is that the fourth root is concerned with the extension of the knee and the inversion of the foot, whereas the fifth root supplies the muscles which perform the opposing movements: flexion of the knee and eversion of the foot.

The fifth lumbar root has a wide distribution to the muscles of the buttock through both the gluteal nerves. It is concerned with the extension, external rotation, and abduction of the hip, the flexion of the knee, the dorsiflexion of the ankle and the toes, and the eversion of the foot.

The fifth lumbar and the first sacral roots are both concerned with the flexion of the knee and the eversion of the foot. The main differentiation between these two is that the fifth root is concerned with the dorsiflexion of the foot and toes whereas the first sacral root supplies the plantarflexors of the ankle and toes. The first sacral root has no effect on hip movement, either. A noteworthy point in the L V syndrome, mentioned *e.g.* by AF BJÖRKESTEN in 1954, is that on examination extension of the toes may seem to be fairly similar in each leg. If, however, attention is paid to the function of the extensor digitorum previs muscle, it will be observed that on the affected side the muscle is softer and consequently weaker. Total retropulsion of a prolapsed disc is extremely dangerous. This may occur *e.g.* during delivery as a compression between the lower discs. The sensory disturbances are here of the same type as in L V and S I. The legs become

TABLE I. — *The Clinical Symptoms of a Lumbar Disc Prolapse*

Root	Site of Pain	Sensory Changes	Motor Changes in Hip	Reflex Changes		Ankle and Toes	Foot
				Knee Jerk	Ankle Jerk		
2nd L	Low back	Not typical	Flexion Internal rotation Adduction	Normal	Normal	Normal	Normal
3rd L	Low back	Not typical	Flexion Internal rotation Adduction	Usually weakened	Normal	Normal	Normal
4th L	Antero-medial aspect of the leg above the knee	Anterior aspect of the leg below the knee, sometimes down to the ankle	Extension Ext. rotation Abduction Tenderness on percussion in the medial aspect of the leg above the knee	Diminution or loss	Normal	Diminution in the dorsiflexion of the ankle and toes	Diminution in the inversion of the foot
5th L	Posterior aspect of the leg. Often dorsum of the foot and the hallux	Dorsum of the foot and the hallux	Extension Ext. rotation Abduction	Normal	Normal	Diminution or loss in the dorsiflexion of the ankle and toes	Diminution in the evertion of the foot
1st S	Posterior aspect of the thigh and calf. The region of mall. lat. The lateral aspect of the foot; the heel and the sole	Lateral aspect of the foot. Sometimes the small toes	Nil	Normal	Diminution or loss	Diminution or loss in the plantarflexion of the ankle and toes	Diminution in the eversion of the foot

paretic. This symptom is accompanied by a sensory disturbance of all the lower sacral roots supplying the rectal region, and the posteromedial aspects of the upper legs, associated with bladder and rectal symptoms. This cauda equina syndrome calls for prompt and adequate operative treatment.

The previous symptoms are accompanied by reflex changes which must be observed in the location of the level of root disturbance. The knee jerk is never lost completely in a lumbar disc prolapse (ARMSTRONG 1952). A weakened knee jerk is an indication of compression of the third or fourth lumbar root, whereas this reflex is not at all affected by change of function of the L V and S I roots. The ankle jerk is disturbed by a compression of the first and second sacral roots. Diminution or loss of the ankle jerk has to be considered a comparatively positive indication of a L V—S I disc prolapse.

Table I shows a combination of the clinical symptoms which are associated with the second lumbar root and the first sacral root, and the corresponding spaces.

BRIGGS and KEATS (1947) have described an interesting »tap test», which may be of some significance when the fifth lumbar root has been compressed in the foramen by a lateral herniation of the fifth lumbar disc. By tapping the fifth inferior articular process during the operation a painful contraction is produced in the gluteal muscles of the corresponding side. The test is also positive if, due to insufficiency, the articular facet presses the nerve root against the anterior bone wall.

IV. QUESTIONS TO BE DISCUSSED ON THE GROUNDS OF THE MATERIAL AVAILABLE

1. What does this investigation tell us of the symptoms of low back pain and sciatica?
2. What is the relation between low back pain and sciatica?
3. Is operative treatment justified in low back pain without any signs of sciatica?
4. What is the treatment of secondary low back insufficiency?
5. How to stabilise an aching low back?
6. What are the final results of the whole investigation?

V. GENERAL ASPECTS OF THE CASES INVESTIGATED

This investigation is based on the patients operated for sciatica or low back pain at the General Hospital of Tampere in the years 1944—56. Our patients come from an area inhabited by some 300,000 people. The total number of these patients is 359. Table II shows the number of patients operated each year.

TABLE II. — *The Number of Patients Operated for Sciatica and Low Back Pain in the Years 1944—56*

Year	Number of Patients	Year	Number of Patients
1944	15	1951	18
1945	8	1952	10
1946	9	1953	28
1947	17	1954	20
1948	19	1955	74
1949	8	1956	116
1950	17		
	93		266
			Total 359

It appears from Table II that the number of patients has remained relatively low up to the year 1953 when there was a distinct rise. This is due to the fact that our hospital has been compelled to admit an increasing number of patients suffering from sciatica and low back pain. In earlier years a large number of patients travelled to Helsinki for operative treatment. Year by year this possibility of transferring patients has been reduced. Secondly, from the proper disc prolapse cases our attention has been increasingly turned also to other causes of low back pain, *e.g.* low back insufficiency etc. All this has contributed to the increasing number of patients operated here.

All the 359 patients were sent a questionnaire in which special attention was paid to the duration of the symptoms and to their eventual changes

during the pain. Particular inquiries were also made about the patient's working ability, his profession, and the possible inconveniences and changes. Questions like these were put: Has the patient later found it necessary to use a corset and of what kind? Has the patient suffered from pain at night as an indication of secondary insufficiency? Has the patient been operated again somewhere else?, etc. And it was found that the information thus obtained and later information gathered from personal investigation correlated extremely well.

314 operated patients or 84.4 per cent of the total have been personally re-examined by the author himself. Since such a considerable number of the patients operated have undergone personal re-examination, which moreover has been supplemented by x-ray examinations including flexion and extension, the information gathered from there has been considered sufficient for tabulation of the observations.

185 of the patients thus re-examined were male and 129 female.

TABLE III. — *The Number of Disc Prolapse Operations in Proportion to other Low Back Operations*

	Number of Patients	%
Disc operations	242	77
Other low back operations	72	23
	Total 314	100

Table III shows the number of ordinary disc prolapse patients and the number of other low back operations. In certain parts this material will be dealt with as one unity because it will thus give a clearer picture of low back disorders. On the other hand, the pure fusion operations have also been discussed separately so as to illustrate more effectively their share in therapy.

The operations have been performed by five surgeons in all. Since the year 1953 the author himself has done all the low back operations (238), which makes 75.4 per cent. of the whole. All the arthrodeses have been performed by the author.

The follow-up period of the cases has been 2—13 years.

Almost all the patients have first undergone conservative treatment at the General Hospital of Tampere or at other local hospitals. Several patients have been given conservative treatment also under the guidance of neighbouring district physicians. Owing to the conditions prevailing but also to deep-rooted prejudice the history of many a patient's preoperative suffering was one of invalidity, often of many years' duration.

VI. RADIOGRAPHY

On the grounds of neurological observation it is very often possible to diagnose the symptoms of root compression. The nature and level of the compression, on the other hand, remain obscure. Radiography and its ancillary methods myelography and discography enable us, in very many cases, to localize the exact site of the compression. The greatest importance of an ordinary x-ray investigation in the lumbar region seems to lie in its power to reveal and exclude other pathological conditions and eventual developmental anomalies simulating a disc prolapse. The conditions revealed by ordinary x-ray investigation are listed below:

I. Spondylolisthesis.
II. Transitional vertebrae.
III. Hypoplasy of the pedicles in the sacro-lumbar region.
IV. Unilateral or bilateral sacralised and lumbarised transverse process with pseudarthrosis.
V. Osteoarthritis of lumbar spine.
VI. Spondylitis ankylopoetica.
VII. Paget's disease.
VIII. Metastatic tumours.
IX. Osteomyelitic abscess.
X. Tuberculous abscess.

There are, of course, some radiological changes which are, to some extent, typical of a disc lesion. They may also, with other clinical evidence, be such as to confirm the diagnosis. If *e.g.* neurological signs clearly point to a certain intervertebral space and x-ray examination reveals a narrowing of the corresponding disc, the diagnosis may be regarded as fairly certain.

There is often some difficulty in drawing definite conclusions from the relative narrowing of different discs. The L V—S I disc is originally narrower than the L IV—L V disc, and the discs above the L IV— LV interspace show gradual narrowing again.

Although intervertebral narrowing is a valuable sign of the presence of a disc lesion, it cannot be considered to be of very great importance. For instance, GILLESPIE reports (1946) that in 160 disc prolapse cases narrowing was only present in 31.2 per cent.

An interesting phenomenon is also the apparent posterior displacement of the L V vertebra. The cause of this phenomenon is shown in Fig. 2.

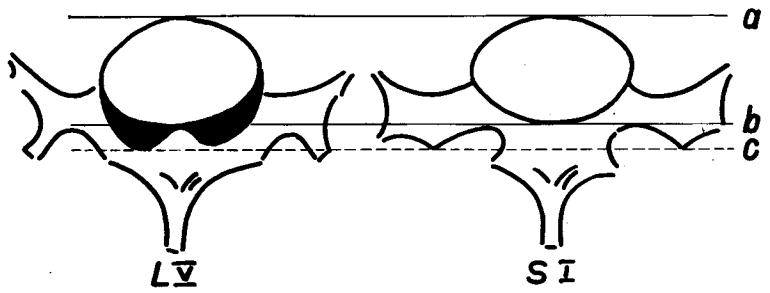


Fig. 2. — The inferior facet of the fifth lumbar vertebra is kidney-shaped. The adjoining surface of the sacrum is oval. The side projection of the fifth lumbar vertebra is marked a—c. The corresponding upper surface of the sacrum is marked by the side projection a—b.

The explanation here is that the inferior facet of the fifth lumbar vertebra is kidney-shaped while the adjoining surface of the sacrum is oval. The antero-posterior diameter of the surface of the sacrum corresponds to that of the hilus-part of the kidney-shaped inferior facet of the fifth lumbar vertebra. A lateral x-ray plate can thus show an apparent posterior displacement of the fifth lumbar vertebra.

There also occurs true posterior displacement of the fifth lumbar vertebra (FLETCHER, 1947) when the lumbo-sacral interspace is narrowed. If the posterior articular facets of the sacrum are oblique in relation to the vertical plane, narrowing of the disc will be associated with some posterior shift of the fifth lumbar vertebra. Mere backward displacement does not produce any clinical symptoms (HAGELSTAM, 1949). In the author's view this posterior displacement is often to be regarded as an early symptom of insufficiency of the lumbo-sacral region. This, again, almost without fail leads to slighter or severer low back pain.

According to different authors it has been proved that one of the key structures in the surgical anatomy at the fifth lumbar-disc level, apart from the disc itself, is the articular process of the sacrum. This is especially due to the fact that there is a very close relationship between the articular process of the sacrum, the fifth lumbar nerve, and the first sacral nerve.

A narrowing of the disc at a very early stage of insufficiency may lead to compression of these nerve roots by the articular processes without any appearance of protrusion. Consequently, in this case, exploration of the disc and removal of the nucleus does not relieve the patient from sciatic pain. This is only achieved by a facetectomy or, in the case of insufficiency, by fusion. The site of compression is a lateral bony recess in the spinal canal at the fifth lumbar-disc level. This recess is bounded in front by the fifth lumbar disc and vertebral body and behind by the medial portion of the articular process of the sacrum.

Facetectomy was first described by PUTTI in 1927. Afterwards reports on series of facetectomies have been published *e.g.* by BADGLEY 1941, BRIGGS and KRAUSE 1945, HYNDMAN 1946, GRAY 1947, HIRSCH 1948, CRAWFORD 1949, SCHLESINGER 1955, 1957.

Thus we may say that an x-ray examination revealing true posterior displacement of a vertebra, best distinguishable in lateral plates with flexion and extension, provides the surgeon with indications suggestive of such a compression.

Myelography is a valuable addition to x-ray investigation. The contrast mediums used originally were exclusively oil-soluble (e.g. lipiodol, jodipin). Their chief asset is that they produce a good contrast but, on the other hand, they have serious disadvantages like the irritations they cause and their irresorbability. Meningism, headache, collapse, and other complications like these are always troublesome even if not everyday phenomena when dealing with large material. In fact, several papers have been published warning against the use of oil-soluble mediums in myelograms (OLIVER-CRONA, LINDBLOM, etc.). The contrast mediums which are in common use like myodil and pantopaque ought to be resorbable. There are, however, reported cases in which some amount of pantopaque has appeared to remain in the spinal canal as long as one and a half years after the injection (AF BJÖRKESTEN 1954). The use of water-soluble contrast mediums has also been followed by complications though they have not been so severe as those due to oil-saluble contrast mediums. In 10 myelographies out of 1000 FRIBERG and HULT (1951) found temporary cramp.

Air and oxygen are valuable mediums in spinal diagnosis especially because they enable the investigator to examine almost the whole canal without difficulty. *E.g.* a caudal tumour situated at the Th XII—L I level may produce typical S I symptoms. This level is not quite within reach of other contrast mediums but by means of oxygen the level diagnosis can be done. At our hospital this method has not been employed at all because of

our oldfashioned x-ray equipment. Air or oxygen produce a weaker contrast and this puts higher demands on the x-ray apparatus. This state of things has lately been improved and thus we can widen our field of research in this respect, too.

In all the myelograms take of these cases the Conturex contrast medium of 20 per cent concentration (natrium monojodmethansulfonat, Lundbeck & Co) was used. It is water-soluble and quickly resorbable. This medium seems to produce comparatively few complications. Some patients have complained of headache of a few hours' duration, some of transitory, rather severe pain in the legs. In one case after a myelogram a partial peroneal paresis was found but this was totally cured in six months. At operation, however, a large prolapse was discovered which may have bulged deeper into the spinal canal because of the effect of the anaesthetic and change in muscle tension due to myelogram, and thus may have increased the pressure on the corresponding nerve root.

As a rule the operation has been performed five or six days after the myelography. Experience proves that even a tiny puncture may lead to a troublesome liquor leakage if the patient is operated immediately after myelography. If the patient's position is not critical, it is advisable to wait five or six days before performing the operation.

The following principles have been followed in interpreting the myelographies:

I Total compression, in which the spinal canal is completely blocked at some level. This is a rare phenomenon in disc prolapse cases, even with total prolapse. This kind of myelogram is mostly suggestive of a tumour.

II Typical mid-line prolapse. It would seem natural that an hour-glass shaped myelogram would indicate a bilateral prolapse. This is not, however, the case but this shape appears in mid-line prolapses. It is described by Begg, Falconer, and McGeorge (1946) as follows, »The mid-line protrusion forces the intradural nerve roots at that level to each side.»

III Asymmetry in root pockets. One of the pockets may be missing altogether. In these cases even a slight defect may be suggestive of a considerable prolapse.

IV Streakiness close to the border of a root sheath. This phenomenon is discovered when the nerve itself in the dura sack is edematous. Such a change in a myelogram has proved a fairly reliable sign of a prolapse. Above all, this holds true as to the upper parts of the lumbar spine where the neurological symptoms are more obscure.

V A notch to be seen in a side picture is often suggestive of a prolapse but

gives no hint of its size. Quite often a large prolapse produces a comparatively small notch. The same phenomenon may, by the way, be caused by a thickening of the ligamentum flavum probably due to instability. In a lateral picture a large mid-line protrusion is not necessarily visible at all. A small posterior displacement, too, is often simulative of a prolapse which does not really exist.

At the S I—L V level the spinal canal is comparatively wide and leaves some empty space and thus the contrast medium may often cover the whole region. Here a myelogram is not necessarily suggestive of any protrusion though there might exist a large prolapse. Accordingly, if the myelogram is negative but the clinical investigation indicates a prolapse, the prolapse is, practically in every case, to be found in the S I—L V interspace (INMAN and SAUNDERS, 1942). According to our experience it is in this region that the myelogram seems to be most unreliable. Even at higher levels it does not reveal a very lateral prolapse which bulges into the spinal canal. Here, on the other hand, the neurological symptoms are more distinct. In a narrow space even a small protrusion produces a heavy compression. The operator must not forget to examine the root canal, otherwise the symptoms persist unchanged.

TABLE IV

Author	Number of Cases	Percentage of Positive Results
FORD and KEY	206	72.3
SCOVILLE, MORETZ, and HANKINS	196	67
CAMP	203	92.3
SOULE, GROSS, and IRVING	77	81.5
BEGG, FALCORNER, and MCGEORGE	95	85
LEIKKONEN	60	78.4

In Table IV are tabulated some series of myelograms the positive results of which the investigators have been able to verify at operation. The figures as such are not quite comparable because all of them do not include a more detailed analysis of the margin of error. Figure 78.4 implies complete conformity of the positive myelogram and the corresponding operative discovery.

Plate I shows a myelogram of a man aged 44 who had had low back pain for five years. During the last four months there had been radiated pain in the left leg. Lasègue on the left 70 degrees. No other neurological particulars worth mentioning. From the middle of L III down to the lower edge of L IV the myelogram reveals a fairly distinct defect the lower end of

which is a little blurred. At operation ten days after the myelogram the L III—L IV interspace was opened dextrally. Some blood coagula were found in the region but no prolapse. The L IV—L V disc was then exposed and a typical prolapse was found. This kind of myelogram is mostly suggestive of a tumour. A hematoma, somehow due to the myelogram, has given a misleading picture.

In the following two cases the exact diagnosis was made possible only through myelograms. These patients had undergone several neurological investigations at many hospitals.

Plate I. — The myelogram reveals a fairly distinct defect which extends from the middle of L III down to the distal end of L IV.

Case 1. Plate II. A farmer's wife aged 40, who had suffered from back ache for10 years. Pain in the left leg during the last year. Before coming to hospital the patient had been confined to bed for three months. Neurological indications: Lasègue negative l.a. (lat. amb.). Right ankle jerk ++, Left +. Hallux extension normal. Dorsiflexion in the ankle l.a. normal. Knee jerk l.a. normal. An atrophy of 1.5 cm in the left thigh and in the left calf. No sensory changes. The radiogram shows some narrowing between L IV and L V. The myelogram reveals a notch on the left in the L IV—L V interspace. In the antero-posterior picture the root sheath is missing in the same region to the left. At operation a prolapse the size of a finger-tip was removed from the left L IV—L V interspace. The patient went back to work after one month.

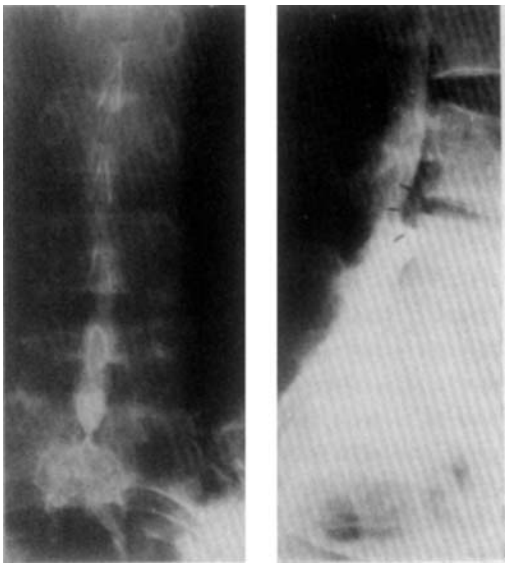


Plate II. — Case I. Antero-posterior myelogram and a lateral one. In the L IV—L V interspace on the left the root sheath is missing and in the lateral picture a notch is seen at the corresponding level.

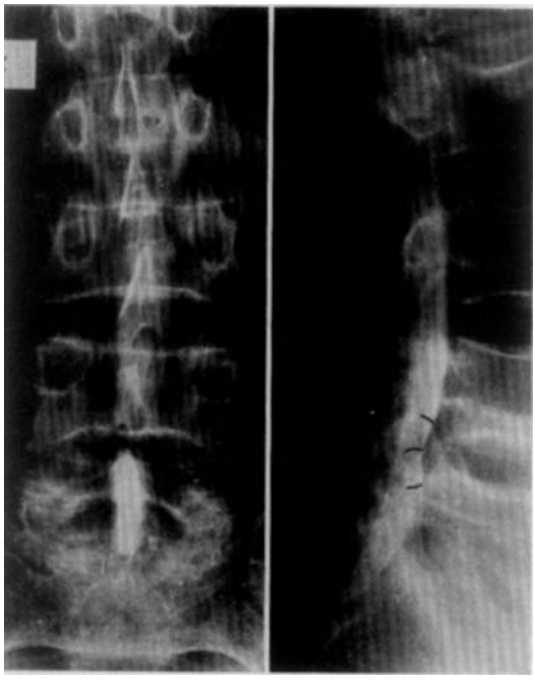


Plate III. — Antero-posterior myelogram is narrowed in the L IV—LV interspace. The lateral picture reveals a defect at the same level.

Case 2. Plate III. A carpenter aged 40. The patient had suffered from back ache for five years. For seven months before coming to hospital he had been entirely unable to work.

Neurological indications: Lasègue negative l.a. Right ankle jerk ++, Left +. Extension of the right hallux ++, of the left +. Ankle dorsiflexion l.a. normal. Knee-jerk l.a. normal. The left thigh showed an atrophy of 1 cm. No sensory changes. The radiograph revealed nothing abnormal. In the myelogram the contrast medium showed considerable narrowing at the L IV—L V level. The root sheaths were missing at the same level. The lateral picture revealed a remarkable defect on the left in the L IV—L V interspace.

At operation a total prolapse was removed medially from the left. The patient resumed his former occupation after one and a half months.

An essential part in the technique of x-ray examination is discography. Every surgeon who works on disc problems will very soon find out that the picture given by clinical neurology and myelography together is not sufficient. The myelogram is not clear enough to reveal prolapses deeper in the root canal or anterior protrusions under the anterior longitudinal ligament.

Thus, we have greeted with joy a new method introduced by a Swede, K. LINDBLOM in 1948. He injected watersoluble, quickly absorbable contrast medium straight into the disc. 15 discs were thus examined. In 1952 LINDBLOM published the results of 52 injections. His method became well-known in the United States after he had demonstrated it at several clinics. GARDNER, WISE, HUGHES, O'CONNELL, and WEIFORD (1952) reported on 169 punctures. ERLACHER in Vienna began his post-mortem experiments with the nucleus. He injected contrast medium into the disc (potasium iodide of 30 per cent concentration) and thus made the disc also radiographic. These investigations will be discussed later. WALK (1953) reported on 98 discograms, etc.

In Finland discography is known to be rather an infrequently used method. In few cases only the author has employed it to clear up a pathological state. The literature, however, fairly well assures the usefulness of this method.

The technique of the discogram is as follows: The patient is lying in a prone position with a cushion under his stomach to eliminate the lumbar lordosis. A measuring rod is put up on the vertebral body. A lateral radiogram is taken. The film shows the best point for the puncture and also enables the operator to estimate the depth of the nucleus pulposus. A double needle is used when making the puncture. After skin anaesthesia the puncture needle is inserted 8 mm laterally from the mid-line and aimed a little upwards in the direction of the posterior wall of the spinal canal so that the point of the needle will touch upon the lower part of the arch concerned. The disc lies straight under the arch. The point of the needle is turned downwards till no more resistance is felt, and a new radiogram is taken. The operator assures himself of the position of the needle. The diameter of the inner needle is 0.5 mm and the length 10—12 cm. The inner needle is pushed into the nucleus. A mixture consisting of 2 ccm of a 35 per cent solution of iodopyracet (diodrast) and of 0.5 ccm of a 5 per cent procaine hydrochloride solution is used. The amount of the injection varies between 1.5 and 2 ccm. Immediately after the injection an antero-posterior and a lateral picture are taken. Anaesthesia is not necessary for the injection (GARDNER).

A normal disc gives a biconcave shadow, because the contrast medium surrounds an undamaged nucleus bilocularly from above and below. This is not the case with a protrusion. The more degenerate the disc, the more broken is the shadow of the nucleus. In the presence of a rupture contrast medium flows through the opening into the spinal canal. Pain occurring during the injection is also a diagnostic hint. In a prolapse case this pain is typically sciatic. In the presence of a prolapse sciatic pain is felt in two

thirds of the cases (GARDNER 1952). In one third of the cases contrast medium is seen in the epidural space. This is not, however, a pathognomonic sign and is of importance only if a protrusion is also detected. This spreading of the contrast medium can be prevented by not removing the needle before the x-ray picture is taken (CHAMBERLAIN 1952).

ERLACHER (1952) classifies the morphology of the nucleus as follows:

1. Globular nucleus. Occurs in young persons without a prolapse.
2. Lobed nucleus. Usually found in adult persons, not typical of a prolapse.
3. Simple branched nucleus. A central shadow and few branches. Predisposes to a prolapse.
4. Multibranched nucleus with a small central shadow. This is a transitory form of degeneration in which a prolapse is probable.
5. Broadened nucleus. No central shadow at all, only branches. Also narrowing of the intervertebral space. Herniation must no longer be expected.

Thus, a solid foundation has been laid for the morphology of discography. The literature concerning discography infers that this method will hold a permanent position in the diagnostics of disc degeneration.

One of the drawbacks of discography is that this method is not free from complications (GARDNER, WISE, HUGHES, O'CONNELL, WEIFORD). It also requires considerable experience both to employ this method and to interpret the results. It may miss a caudal tumour which may be revealed by myelography. Gardner suggests that a lumbar puncture should be done before a discogram so that the caudal tumour can be excluded.

On the other hand, it has to be borne in mind that by discography we are able to detect diseases of which myelography gives no indication and which are such as to disable the patient to a marked degree.

Among these diseases are *e.g.* DANDY's »concealed disc» and anterior herniation. Disc herniation under the anterior ligament may also produce pain and lasting disability.

At a meeting of the Finnish Orthopaedic Association K. E. KALLIO reported on a case in which, some years before, he had ventrally removed an anteriorly prolapsed disc hernia. It had been diagnosed by an ordinary x-ray examination. According to the author's report the patient has been completely free from back pain ever since.

In the year 1952 there was a case reported by CLOWARD of a man aged 42 who, while playing volleyball, jumped high and fell down on straight legs. He at once felt severe pain in his back. Lasègue l.a.––. Ankle jerk l.a.+. Analgesia in the left calf and periodically in the posterior aspect of the left thigh, too. A discogram indicated a large anterior hernia in the S I—L V

interspace. The disc was removed by an operation and a spondylodesis was also done. The patient recovered and returned to work three months after the operation.

The anterior longitudinal ligament has been found to contain nerve endings. This is not surprising since it supplies posture sensation (STEINDLER 1947). The causality of back pain is thus quite easily understood also in the pathological conditions originating in the front part of the spine.

CLOWARD (1952) has written convincing words in favour of discography: »It has proved beyond the question of a doubt to fulfil all the qualifications which for many years we had hoped to find in a diagnostic procedure, to determine unmistakeably the presence of a ruptured intervertebral disc without objective signs. With only the patient's subjective symptoms of intermittant low back pain, the presence or absence of a lesion which can be treated surgically can now be definitely determined. It is not necessary to »guess» that the patient has a »concealed disc» as Dandy did.»

CLOWARD works in the field of industry and makes a frequent use of discography in cases characterised by severe low back pain but not by sciatic pain in the legs. Then, from the point of view of objective judgment, it is useful to see the disc itself.

An interesting method of investigation has been introduced by NAKAMOTO, UNEMOTO, YTAKA, WAKITA, and KATAYAMA (1955) from Japan. By means of CATHELIN's method they injected through the hiatus sacralis 15 ccm of novocaine solution mixed with gelatin- and iodopyraceton C. The x-ray photographs were immediately taken antero-posteriorly and obliquely. This kind of extradural examination was performed on forty patients. It was discovered that in this way it is easy to investigate the dura mater and the nerve roots in a far-reaching area. It also made visible the course of the nerve roots in the region of the intervertebral foramina.

This method has also enabled the investigator to clear up phenomena not to be seen in an intradural myelogram at all. Thus, e.g. the upward shift of the spinal chord discernible with a forward bend is a positive sign of a protrusion. When, again, it is observed in connection with a backward bend, this phenomenon is suggestive of hypertrophy of the ligamentum flavum due to low back insufficiency.

There are still different lines in the diagnostics of the disc which have their own supporters. At some clinics they do a great number of myelograms, at others again they prefer discograms. There are even those who confine themselves mainly to defining the neurological symptoms and as far as possible try to avoid using the intralumbar methods of examination. GARD-

NER, WISE, HUGHES, O'CONNELL, and WEIFORD have collected reports on 58 cases in which some damage has been caused in connection with lumbar punctures. Thirty-seven of these were cases in which lumbar punctures had been performed on patients suffering from meningitis. These disorders were, however, cured chiefly through rest.

On the whole, considering the great number of lumbar punctures these injuries are extremely rare. Hardly is it possible for modern disc diagnostics to dispense with any of these methods.

When compared with the extensive disc literature, comparatively little attention has been called to the share of the supraspinal and interspinal ligaments in low back insufficiency. The clinical and pathological significance of these structures has been discussed by BAASTRUP (1933), KELLGREN (1939), MAGNUSSON (1944), NEWMAN (1952), and others. In Finland this side of the picture has been particularly pointed out by Professor KALLIO. On his initiative, KÖHLER, chief radiologist of his clinic, developed (1958) a method by means of which the ruptures of the interspinal ligaments can radiologically be revealed with great accuracy. He injected contrast medium into the spinous process of the affected side. The contrast medium then forced its way through the hole of the ruptured ligament to the opposite side. Later on he developed this method by injecting contrast medium into each side of the corresponding ligament. KÖHLER introduced his method at the meeting of the Finnish Orthopaedic Association 26th April 1958 and published it in Acta Radiologica in 1959. On the grounds of clinical observation it seems to be certain already that this method will prove a valuable contribution to the radiological diagnostics of low back insufficiency.

VII. ON INDICATIONS AND OPERATIVE TECHNIQUE

The symptomatology of sciatic and low back pain is essentially connected with the pathology of the disc. It has to be remembered that the anatomy of the disc and its degenerative changes were fairly well known long before operative treatment was introduced. This state of things was no doubt responsible for the fact that the beginnings of operative treatment were almost exclusively determined by the pathology of the disc. It is obvious that this kind of one-sided attitude could not bring satisfactory results. Consequently, in spite of plain discoveries, there was in many quarters a growing tendency to fall back on the conservative line. McFARLAND said in 1951 that there was too much talk in favour of operative treatment when the conservative treatment generally sufficed if skilfully carried out. Besides, it must be borne in mind that a sciatic operation, whatever the indications then may be, is always a comparatively lengthy procedure. In no case should the patient's condition be worse than before the operation and it is, of course, even more regrettable if the patient is lost.

The indications of sciatica and low back disorders are always such as to require sufficiently great experience to be correctly interpreted. When a disorder is of longer duration, the symptoms usually become less severe but still they invalidate the patient to a considerable degree. In an older person the symptoms essentially change in character. The patient's condition begins to be influenced by secondary arthritic changes. Old age itself must be regarded as a contraindication.

Local progressive changes in the disc itself are naturally of primary importance. The secondary effects of local changes are almost equally important from the clinical point of view. In other words, in the surrounding tissue the pathological disc calls forth adhesions, reactive arthrosis, etc. These are such as to characterise the clinical picture.

Only by experience are we able to distinguish between normal and pathological discs and between the different stages of the latter, as well as judge

how much the patient's condition is influenced by the pathological disc. It would take several explorations to learn the different variations of a normal disc and even more to clear up the whole cycle of a pathological disc. This is by no means an easy thing even if the surgeon masters his technique fairly well. It is comparatively difficult to expose the discs in the lumbar region and even in the very best case only a small portion of the annulus fibrosus can be denuded and made directly visible. The surgeon's working field is at the bottom of a small and deep incision where visibility is often hampered by bleeding. The operator is often compelled to rely on palpation to determine whether the disc must be removed or not. Therefore it is not to be wondered at if under these circumstances the operator sometimes fails to arrive at a completely successful result.

Consequently, even at large clinics the treatment of sciatica and low back pain ought to be concentrated in the hands of few specialists, preferably of neurosurgeons and orthopaedists. O'CONNELL says that in his first twenty-five disc operations he found the degenerate disc only in one half of the cases, later on the proportion of failures was one to forty. It is also obvious that reports based on limited experience do not give an adequate picture of this disease, particularly if the investigator is not sufficiently acquainted with the problem in its entirety including its clinical and operative sides.

The technique adopted in these operations has gradually changed in course of years. At first, quite a large laminectomy was performed which included the lowest two lumbar vertebrae, at least. Fairly soon the technique was changed so that generally a hemilaminectomy was performed on the lowest lumbar vertebra, and the processus spinosus of the fifth vertebra removed. The muscles were drawn aside on each side of the spinous processes. With such a process it was often necessary also to gouge the lower part of the arch of the fourth lumbar vertebra on the affected side. Since the year 1953 the muscles have been opened only at the spinous processes on the affected side and some bone has been removed only from the sacrum and from the arch of the fifth vertebra, and respectively from the corresponding arches in the fourth interspace. Thus the disc was exposed without disturbing the statics of the vertebral column.

This was the procedure in ordinary disc operations. It was different if the position and size of the disc caused difficulty in the removal of the disc. Then we thought it better to sacrifice more bone tissue in order to save important nerves from undue stretching. In connection with primary fusions too, a more radical exposure was employed because then there was no danger of risking the statics.

For fusion the following three methods have been used:

A one-sided tibial graft developed by ALBEE (1911). At the same time, however, plenty of bone chips which were taken mainly from the wing of the ilium were used. Later on, for one-sided arthrodesis there was a growing tendency to use firm grafts taken from the ilium. They proved easier to mould into a suitable shape. Their fusing capacity also proved very good.

The second method employed was a double graft. One graft was taken from the anterior surface of the tibia during the main operation. The other graft was excised from the wing of the ilium.

The grafts were planted on each side of the spinous processes over the sacrum and the corresponding arches. Bone chips were also used at these operations. In most cases no fixation was used for the grafts.

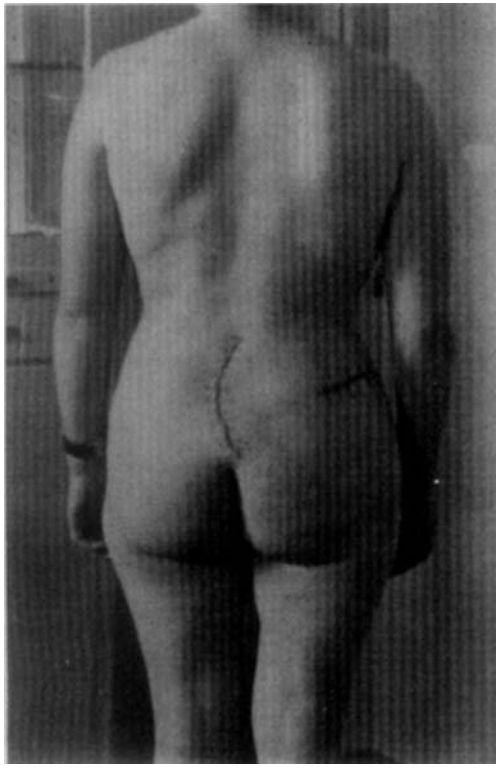


Fig. 3. — A case illustrating an arthrodesis with double grafts due to unilateral sacralisation. A skin incision is seen over the right iliac bone. A tibial graft has been taken from the right leg.

The third method was the »self-locking clothespin graft» described by GIBSON in 1931. It was also called a »fish-tail graft» by GIBSON. He usually took a graft from the upper end of the tibia rather than from the wing of the ilium. The H-graft was thus invented by him, though this method was later developed by BOSWORTH and called by the latter name in literature. In this method an H-shaped bone graft is placed between the sacrum and the spinous process of the lumbar vertebra concerned, with the patient's back in full flexion. When lumbar lordosis is restored, the graft is fixed in its place automatically.

All the operations were performed with the patients lying prone. Care was taken to avoid pressure on the intestinal blood vessels of the patient during the operation. A slight Trendelenburg position was also adopted at some stage in the operation.

Figure 3 shows a curved incision used in fusion operations. A separate incision has been made at the wing of the ilium.

Before the year 1954 local anaesthesia was employed for all the disc operations. Since then it has been totally displaced by general anaesthesia controlled by an anaesthetist. No complications have occurred in connection with narcosis.

VIII. INSTABILITY IN THE LUMBAR AND LUMBO-SACRAL REGION AND ITS TREATMENT

In course of time there has been established the opinion that the removal of a disc does not always eliminate low back pain. If we want to enter into the subject more deeply, we shall have to classify the different causes of low back pain. Only in this way can we find an effective treatment for each case. If, *e.g.* we speak of primary instability (MORGAN and KING 1957) we are mainly concerned with those insufficiency symptoms which were established by KNUTSSON (1944) when he spoke about a routine x-ray examination of the lumbar vertebrae in full flexion and extension in standing position. Their anatomical and pathological principles have been worked out through x-ray investigations and several necropsies by FRIBERG and HIRSCH (1949), LINDBLOM (1948), and HARRIS and MACNAB (1954).

In primary insufficiency a peculiar form of disc degeneration is to be seen the cause of which might be attributed to small traumata. Between the lamellae of the disc there can be detected cracks and fissures as well as incomplete radial or transverse tears in the periphery of the disc. On an x-ray plate these appear as small olisthetic phenomena. It was these very phenomena for which JUNGHANNS in 1930—32 coined the word »pseudo-spondylolisthesis» because they did not imply any arch defect. From the clinical point of view, this may produce acute, sometimes even severe back pain worse than sciatica. As a rule, the pains are, however, less severe than in disc degeneration or in secondary lumbo-sacral insufficiency.

The so-called secondary insufficiency is, of course, caused by the same factors as the primary one. The only difference is one of degree, the degenerative changes having progressed further in the latter. Here one can already distinguish osteoarthritic changes, narrowing of the discs, sclerosis of the epiphyseal ring, marginal osteophytes, etc. Instability due to secondary insufficiency might be extended to include also the sequelae of spondylolisthesis, those of unilateral lumbarisations and sacralisations, the transitional

vertebrae, the hypoplastic vertebral joints, and other states like these which comparatively soon lead to the changes mentioned above. They may further include low back insufficiency due to a disc operation.

Such an instability calls forth permanent insufficiency which tends to increase, as a rule. The treatment aims at decreasing the instability and offers two alternatives, either the conservative or the operative treatment. The conservative methods mainly consist in bed-rest or the use of various supporting corsets, by means of which the movements of the lumbo-sacral region can be reduced. The operative treatment, on the other hand, consists of fusion operations. In this way the vertebral column is strengthened by constructing an inward bony support which is not, like the use of a corset, accompanied by the threat of chronic muscle atrophy. Muscle atrophy is a very harmful phenomenon because it contributes to the weakening of the natural defense mechanism of the vertebral column and is bound to lead to an increase of pain. Thus, corset therapy may tend to give a result quite opposite to the one originally aimed at. Recent investigations have, indeed, revealed rather surprising facts about the immobilisation problems connected with the use of a corset. X-ray examinations of the movements of the lumbar spine have shown that the use of a corset has increased, and not decreased these movements (NORTON and BROWN, etc. 1957).

This is easy to understand if we think of a very long corset which immobilises the whole thoraco-lumbar spine. The point of support of such a corset lies between the thoracic and the lumbar regions. The part of the body above this level is comparatively well supported and not particularly mobile by nature. The compensatory powers of motion then inevitably concentrate further down accumulating in an increased movement of the sacrolumbar region.

According to this view the lumbosacral region is best immobilised with a comparatively low corset. It should extend from a little above the thoracolumbar level down to the middle of the sacrum. It should actually cover the hip joints, too, but this would make walking too difficult.

Very valuable, on the other hand, is the soothing support supplied by the corset against the irritating jerks of the intestinal organs. Thus a corset is an effective »shock absorber» against sympathetic pain sensations.

For the above reasons a plaster corset is of no noteworthy importance in the immobilisation of the lumbosacral region. It can rather be considered to have a negative effect. The treatment of low back pain exclusively by means of a plaster corset might already be regarded as an historical method.

In a forward bend of the body there are considerable interindividual

differences in the mobility of the lumbosacral region. (TANZI. 1953). With some persons this bend mainly takes place in the lumbosacral region, with others in the region of the hip joints.

A phenomenon which may be of some importance in the pathology of low back pain is the widening of the L V—S I interspace often observed with a forward bend of 10—15 degrees. This may be due to the position of the articular facets and may be of importance when estimating primary instability. This phenomenon requires, however, closer investigation.

The most essential movement in a forward bend takes place in the lumbosacral region at the initial stage of the movement. This fact is of importance also when constructing a corset. Another significant point here is that the most essential part of the lumbosacral movement has already taken place when a person is sitting in an upright position.

Sitting in itself thus increases lumbosacral stress. The growing number of low back lesions may partly be due to the modern age of motoring and to too comfortable seats in offices. The stress on the lumbosacral region is not eliminated by the back of a low chair nor by a low support for the back, however comfortable it may be. The essential point here is the height of the legs of the chair.

When a person bends his body forward in a standing position the greatest movement of the lumbar spine usually takes place in the lumbosacral region. In a sitting position the fourth and the fifth interspace seem to have quite an equal share in the range of the movement. When fusing the lumbosacral part this is good to remember in order to prevent a possible pseudoarthrosis and also when considering the patient's occupation.

Apparently on the border between physiological and pathological states there are a considerable number of phenomena which must be cleared up for the completely correct indications of fusion operations in the lumbosacral region. This state of things is a good justification for further research and for publication of new reports.

Primary instability, a pathological state in itself, may after all be the commonest cause of low back pain. It is certainly the basic problem when the difficult tangle of low back disorders is unravelled. This must be the way to find more satisfactory indications for secondary insufficiency of the back and for its treatment by fusion operations.

This research includes 68 cases in which fusion operations have been performed because of lumbosacral instability. The basic cause of these may chiefly have been a degenerate disc which, due to an injury or, in most cases, to a constructive anomaly, has led to and hastened the progress of secondary

lumbosacral insufficiency with attending chronic pain. In eight cases an arthrodesis was done in connection with a re-operation. In two cases when exploring the disc the spinal region was found to be edematous. The specimens were taken at exploration and later examination revealed tuberculosis in each case. The transplanted bone grafts were, however, quite normally fused in their places. In these two cases instability was thus due to tuberculous spondylitis and consequently the appropriate chemotherapy was applied. Both streptomycin and penicillin were used for antibiotic treatment in all the operations.

In two cases (2 and 66) instability was caused by a traumatic rupture of the ligaments. Case 2 will be discussed later in Table VII.

TABLE V. — *Results of Sixty-eight Fusions*

Type of Operation	Excellent	Per Cent.	Good	Per Cent.	Improved	Per Cent.	Not Cured	Per Cent.	Number of Cases	Per Cent.
Bosworth	15	58	3	11	7	27	1	4	26	38
Double grafts	15	83	3	17	—	—	—	—	18	27
Albee	18	75	3	11	2	10	1	4	24	35
								Total	68	100

Table V shows the results of the sixty-eight fusions included in this investigation. In twenty-six cases fusion was done using an H-shaped bone graft developed by Bosworth. The graft was taken from the wing of the ilium or from the anterior aspect of the tibia. The other eighteen fusions were performed by means of double grafts. One graft was taken from the iliac bone, the other from the tibia at the same operation. All the grafts have been autotransplants and none of them has been resorbed. A certain advantage is being gained by transplanting two grafts simultaneously. The fusion is firmer from the very beginning provided the grafts are imbedded quite accurately. Plenty of bone chips are also left over for the operator's disposal. If the soft tissues are carefully sutured so as to cover the grafts from the sides and above, there is no fear of a dislocation of the transplants. A disadvantage is the prolonged duration of the operation and consequently the patient's increased tendency to shock.

In the remaining twenty-four fusions only one graft was employed, adopting Albee's method, but plenty of bone chips were also used.

Among the fusion operations there was one exitus. This is not included in

the tabulated material but will be discussed together with the other exitus cases as a separate group.

In Table V we can also compare the results of different methods of arthrodesis. Since the number of cases is small, the conclusions must be drawn with due reserve. The percentage differences themselves are so great as to give clear indications of the relative success of the different methods adopted.

When adopting Bosworth's method an excellent result was obtained in 58 per cent. of the cases. The double grafts and the Albee method, however, have given considerably higher percentages in the same group: the former 83 per cent. and the latter 75 per cent. The author suggests that the figures would still speak for the double grafts if the material were large enough.

Yet, it has to be taken into consideration that in earlier cases Bosworth's clothespin graft was inserted without bone chips. It was clearly found that in these cases the ossification took a longer time and was more incomplete than with bone chips. This observation has also been pointed out by BOSWORTH himself. We must also remember as it has been shown by UNANDER SCHAREN (1950) that firm bony union between a graft and the spinous processes alone is not enough to immobilise the vertebral bodies and sacrum completely. With plenty of bone chips it is easier to achieve bony union between the corresponding laminae, too. In the later operations, accordingly, the surrounding periosteum was carefully denuded and filled with plenty of bone chips.

When using an H-shaped graft the contact surfaces of the upper fork are ossified more slowly. If the patient leaves bed too early, some kind of bone defects and formations resembling pseudoarthrosis are easily formed between those surfaces. If the strain on the back is decreased, this phenomenon generally disappears and ossification goes on normally in those parts, too. It is also here that the patient last complains of pain.

In one case spondylolysis developed immediately above the H-graft but as yet it has not caused the patient any pain worth speaking of. In one case the lower fork of the H-graft was broken because the patient left bed too early. After that the patient lay in a plaster bed for seven weeks and recovered. This is Case 25 in Table VII.

Highly interesting is Case 2 in Table VII. This is a clear proof of the fact that a ligament rupture may cause permanent inability until it is cured.The case is as follows:

The patient was a lumberer of 27. He had always been well and before this accident he had never had back pain of any kind. He had been carrying a log on his shoulder with his body bent forward a little when by accident he stepped into a pit

one foot deep. He felt severe pain in his low back and was quite unable to walk after that. The patient stayed in bed for two months, was then partly on his feet but the low back pain did not subside. The insurance company sent him to hospital for examination 7 months after the accident. On examination Lasègue was found to be positive l.a. at 60 degrees. The patient complained of low back pain and though it had lately abated a little, it was still incapacitating. The ankle jerk l.a. similar and symmetrical. The dorsiflexion of the halluces normal and strong l.a. The dorsiflexion of the ankles strong l.a. The knee jerk l.a. symmetrical and normal. No sensory changes or muscle atrophies were found. Palpation revealed acute tenderness in the S I—L V interspace. A forward bend showed a notch in the same space. A lateral x-ray plate with flexion and extension revealed some displacement in the above interspace.

At operation scar tissue was found in the S I—L V interspace. The interspinal ligament as well as the ligaments between the articular processes were ruptured. The movement of the space was quite pathological. The case was thus a primary traumatic instability connected with persistent insufficiency. In spite of rest there was no improvement. An H-formed tibial graft was placed between the fifth lumbar

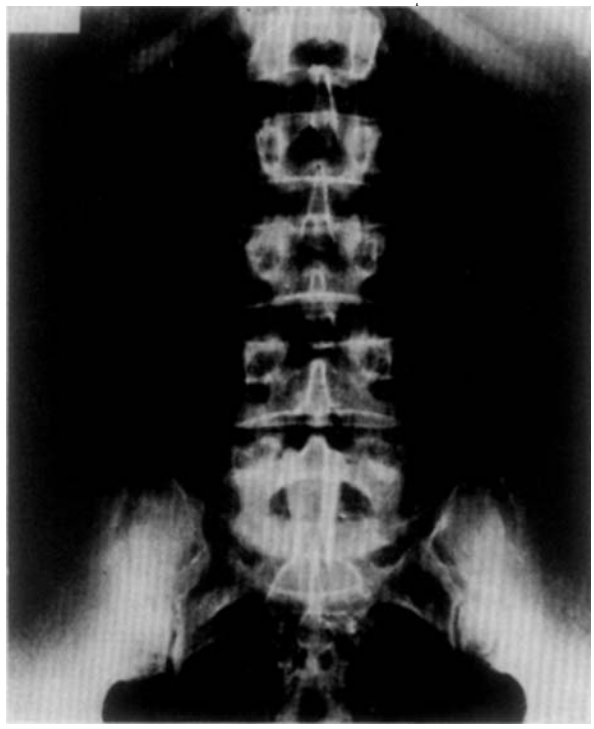


Plate IV. — Case 2. **A traumatic case, repaired with an H-graft.** A lumberer of 27. An H-shaped bone **graft well planted and ossified. No arthritic changes** or reactive phenomena **to be found.**

vertebra and the processus spinosus of the sacrum with the spine in full flexion. The edge of the upper fork of the H was softened a little to make the graft fit closely in its bed so that the arch of the L V was not abnormally lifted. The patient made an uneventful recovery. After five months he went back to his former work. In spite of strenuous lumbering his back has remained quite well for three years.

The case mentioned above belongs to a group of low back lesions which has lately begun to attract increasing attention and which was named »sprung back» by NEWMAN in 1952. It may be quite a common cause of low back pain. It is due to a rupture of the posterior ligaments of the spine. Sometimes the rupture is so deep that even the annulus fibrosus is damaged.

A new method of reconstructing ruptured interspinal ligaments has been introduced in Finland by KALLIO (1957). He takes a band of skin from the margin of a skin incision, disepithelizing it. This band is about 10 cm in length and 6 mm in breadth. The patient is lying prone in a lordotic position. The operator then conducts the band of cutis through a drilled hole in the processus spinosus thus bridging the ruptured interspinous space. The results look very promising.

By this method it is not possible to eliminate all the sensations of pain, especially those originating in the region of the sinus vertebralis nerve. It is obvious, however, that those pains, too, considerably abate. A remarkable advantage of this method is the fact that it can be carried out easily and quickly in connection with a disc operation. Furthermore, it does not hinder later measures as KALLIO says himself: »The primary reconstruction of the interspinosus ligament by cutis graft does not prevent a fusion if later necessary.» The use of a skin graft as a replacement of tendon and ligament defects has been experimentally studied by JOKINEN (1958) at KALLIO's clinic.

In unilateral lumbarisation or sacralisation BOSWORTH's method was used five times, in cases 1, 4, 5, 12, and 25 (Table VII). The same method was employed in case 17 which is an incomplete symmetrical lumbarisation. Here the transverse processes of the S I have formed a very mobile joint with the sacrum causing painful insufficiency in the space concerned.

An example of unilateral lumbarisation is Case 5 (Plate V) (Plate VI) and of unilateral sacralisation Case 4 (Plate VII, Plate VIII).

The patient is a shop assistant aged 36 who has always had a weak back. For the last four years very severe low back pain which has made the patient sleep very poorly. Now she can hardly lift anything without feeling severe pain in her back. Lasègue l.a. 90. Dorsiflexion of the halluces normal. Dorsiflexion of the ankles strong. Ankle jerk very active but bilateral and symmetrical. Knee jerk bilateral, symmetrical, and active.

Plate V. — Case 5. Anterior-posterior picture of the result. In the middle of a tibial graft a hole has been drilled for the processus spinosus of the lumbarised vertebra.

Plate VI. — Case 5. Lateral picture of the result. The tibial graft has been ossified between the L V and the sacrum.

At operation both the sides were opened. Pathological instability was found in the low back. The periosteum was denuded in the operative region. A tibial graft was placed according to Bosworth's method and a hole drilled in the middle of the graft for the spinous process of the lumbarised vertebra. An ample supply of bone chips was taken from the ilium. The patient made a good recovery. Ten days after operation she was allowed to stand up. She was then allowed to walk freely but not to sit down. Four weeks after operation she could sit on a high chair. For the greater part of the day, however, she still stayed in bed. After four and a half months she resumed her earlier work. Now, three years after operation her back is still stabile and painless. Plates with flexion and extension show no movement in the sacrolumbar region.

Case 4. — (Plates VII and VIII) is a waitress aged 32. She told that she had always had a weak back and during the last two years it had been very difficult for her to carry on her work. Walking numbed her back and caused severe pain in the evening. Sleep was disturbed by pain. Lasègue 90 l.a. Dorsiflexion of the halluces strong. Dorsiflexion of the ankles strong. Ankle jerk sharp l.a. No sensory changes or muscle

Plate VII. — Case 4. **A back stabilised with an H-graft. Anterior-posterior** picture of the result. **In the low back lateral displacement and rotation.**

Plate VIII. — Case 4. **Lateral picture of the result. A Bosworth graft** well ossified in its place. **The upper interspaces are sound.**

atrophy in the legs. Low back sensitive on palpation. X-ray revealed narrowing in the lowest interspace and lateral displacement of the vertebral bodies. At operation both sides were opened. An iliac graft was placed according to Bosworth's method with a hole in the middle for the proc. spinosus of the sacralised vertebra. Plenty of bone chips were spread round the graft. The patient was allowed to walk 14 days after operation, but she was not allowed to sit down or bend her back. Not till 6 weeks after operation was she allowed to sit on a high chair. Most of her time, however, she spent in bed. After 5 months she went back to her former work. She has now been quite symptomless for three and a half years. X-ray control shows complete stability in the low back.

Case 8 (Plates IX and X) is here to illustrate how a root compression with subsequent secondary insufficiency due to a disc prolapse can be repaired by means of BOSWORTH's plastics also at a higher vertebral level.

The patient is a farmlabourer aged 40 who felt sudden pain in his back when lifting a log five years ago. After that he felt periodic, more or less severe pain in his back

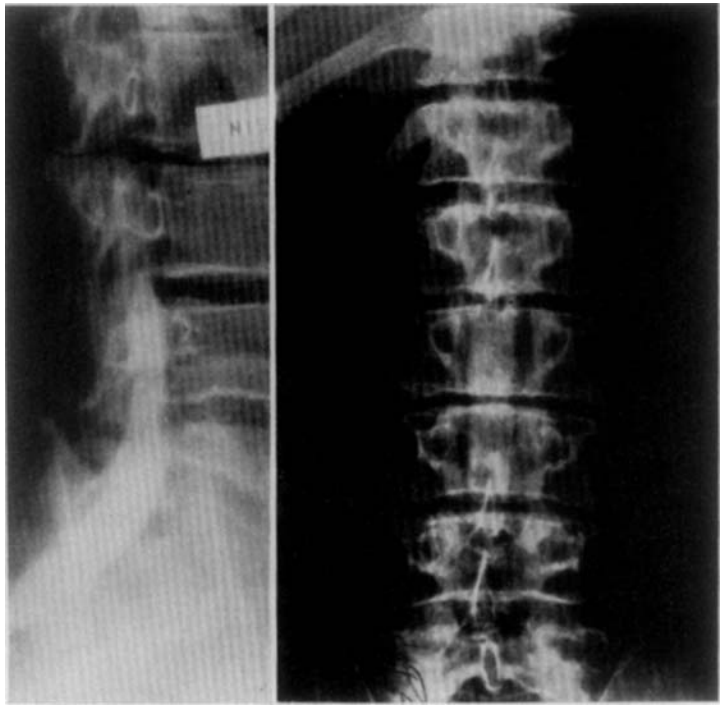


Plate IX. Plate X.

Plate IX. — Case 8. Lateral picture of myelogram. Disc prolapse between L II and L III.
Plate X. — Case 8. Final result. Degenerate disc has been removed and two vertebrae fused according to Bosworth's method.

until eight months before operation he became quite unable to work and had to spend most of his time in bed. Persistent pain had made walking difficult. Lasègue 50 l.a. Dorsiflexion of the halluces normal. Dorsiflexion of both the ankles strong. Ankle jerk l.a. extremely active. Knee jerk extremely active and bilaterally symmetrical. Pain on palpation at the L II. Myelogram reveals contrast medium defect between L II and L III. Ten days after myelogram an operation with full laminectomy was performed because a total prolapse was found the removal of which proved otherwise impossible. This produced severe insufficiency in the region. The state was repaired by planting a tibial graft between the spinous processes of L II—L III according to Bosworth's method. After operation the patient remained at hospital for 21 days. Twelve days after operation he was allowed to stand up with his back erect. After 18 days he was also allowed to sit because at so high a lumbar level an H-graft stays well in its bed if the patient moves with some care. For several months, however, the patient had to rest and be kept under policlinical observation. After six months postoperatively he went back to his normal work. For three and a half years after the operation he has now been fully capable of work and free from back pain.

This study is too small to give sufficient elucidation of the strong or the weak points of the H-plastics in low back insufficiency. The author has, however, made continual use of this method so that his present experience of it is considerably wider than these facts imply. This method seems to have certain weak points, though, on the other hand, many advantages, too. Some analysis of these may be justifiable here. To begin with, the ridge of the sacrum is very often poorly developed. Thus it does not afford enough support to the lower fork of the H-graft and firm stabilisation remains uncertain. In a congenital developmental anomaly like spina bifida occulta it cannot be employed at all. If the lower fork gives way the upper fork of the graft, of course, becomes insufficient, too, and ossification between the spinous processus and the bone graft remains incomplete. At the middle bar the bony contact easily remains too weak. This, however, is no great disadvantage because a sufficient amount of bone chips can be laid over the H-graft even when the spinal theca has been exposed through a larger laminectomy.

When an H-graft is being planted in its bed the back is in full flexion. It is very difficult to give a correct estimate of the pressure which should be created between the bones when the back is brought to normal extension again. If the tension grows too great, there arises the risk of the disc above the H-graft being subjected to excessive stress and reacting accordingly, or of the relations in the root canals being changed.

To prevent this the author has, using a thin circular saw, cut vertical parallel fissures into the bottom of the upper fork of the H-graft thus

making it comblike and elastic enough to give way when extension is restored, yet strong enough to give the support required. If the graft has been taken from the iliac bone this softening can be done with a biting instrument, too.

In cases with spondylolisthesis it is not always advisable to remove the loose arch because its spinous process may be wedged between the upper and the lower spinous processes (BOSWORTH, FIELDING, DEMAREST, and BONAQUIST 1955). This prevents further displacement of the vertebral bodies. The removal of the wedged processus spinosus essentially weakens the supporting apparatus and then especial firmness is required of the H-graft. It seems to the author that particular care ought to be taken when using H-plastics in spondylolisthesis.

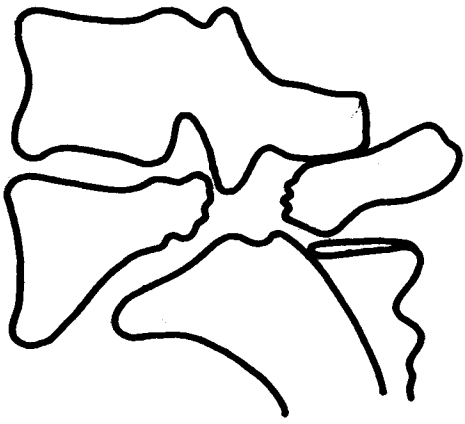


Fig. 4. — At the final stage of spodylolisthesis the proc. spinosus of the olisthetic vertebra is often turned upwards and wedged between the corresponding parts of the adjoining vertebrae.

As mentioned above, the processus spinosus of the displaced vertebra is wedged between the spinous processes of the upper and the lower vertebrae thus stabilising the position (Fig. 4). Further displacement is then mostly impossible. If this defence mechanism is removed, the graft replacing it must be firm enough. If the symptoms of root irritation disappear through rest, the author does not consider it necessary to remove any bone structures but rather to increase the capacity of the back by adding new bone material. If, again, the arch must be removed, double grafts seem to be the strongest bone plastics, at least in theory.

A very great advantage of the H-plastics is that — if the case admits — the patient need hardly stay in bed at all without causing any noteworthy damage to the graft.

Table VII shows the cases (27—44) fused by means of double grafts. There has been a general tendency to employ this method in spondylolisthesis or in difficult low back insufficiency due to some anomaly in which it is necessary to create a firm and reliable fusion.

Thus, there are ten spondylolistheses among the cases fused with double grafts. Unilateral sacralisation has been performed in four cases, for one of which a disc exploration had been done earlier at another hospital. At that operation the arches of the L V—L III vertebrae had been removed through a large laminectomy. After the operation the patient was able to walk only few steps with difficulty. The case will be dealt with in more detail later in this chapter. In three cases there was difficult back insufficiency due to a degenerate disc and in one case a unilateral congenital hypoplasy of the L V articular facet.

BOSWORTH's arthrodesis was employed in three spondylolisthesis cases. One of these patients has improved, in the other two the result has been excellent. As mentioned above, ten spondylolisthesis cases have been treated with double grafts. In eight cases the result was excellent, in two cases good. ALBEE's modified arthrodesis was performed on three patients suffering from the same disease. In two cases the result was excellent, in one fair.

In the double graft operations one of the grafts was taken from the anterior aspect the tibia and the other graft in its full thickness from the wing of the ilium. The length of the graft was determined by the length of the region to be immobilised. The patient's fluid balance, need of electrolytes, and possible need of blood were attended to during the operation. By means of a circular saw the cutting of a graft from the anterior surface of the tibia prolongs the operation time by only 10—15 minutes and thus has no essential influence on the duration of the operation. It is also a comparatively little traumatising procedure provided the outer periosteum of the tibia is carefully sutured in its place again. In spite of the excision of a tibial graft the patient was able to walk freely three and a half weeks after operation, and there have been no complications. Only in three cases was the graft fastened with metal wire in its bed. Pains have always been taken to shape the graft so well for its bed that it is firmly kept there by the pressure of the soft parts only. It takes a little longer time to shape the graft more exactly but technical improvements have made it much easier than before. The upper end of the tibial graft is made to rest against the base of the arch of the corresponding spinous process and the lower end against a notch cut in the sacrum. Endeavour has been made to shape the iliac graft to coincide with the lumbar curve and to have as wide a bone contact with its bed as possible. If there has been

an ample supply of bone chips they have been packed round the graft so carefully that there has been no danger of pressure on the spinal cord.

Post-operative treatment has been based on the following main points: For the first ten days the patient has been kept prone in bed if possible. After the removal of the sutures the patient has been allowed to lie in a supine position, in a hard bed with a well fitted cushion under the lumbar region to maintain lumbar lordosis. After three or three and a half weeks the patient has been allowed to stand up keeping his back straight and go for a short walk, after which he has gone immediately to bed again. These walking periods have been increased weekly. Sitting, on the other hand, has been avoided during the initial phase of consolidation. If in exceptional circumstances the patient has been allowed to sit down, the seat was at a higher level, *e.g.* the edge of a table. One of the patients (Case 25) has been compelled to lie in a plaster bed because one of the branches of the graft broke at the sacrum when the patient was standing up. In the author's view a plaster jacket, however well fitted, does not create sufficient immobilisation where the lumbosacral region is concerned. The range of movement can be limited but not eliminated by the use of a plaster jacket. Because the upper region of the spine is fairly well immobilised by means of a plaster jacket, there are consequently created detrimental pathological turn moments which become much stronger in the sacrolumbar region, than without a plaster jacket. It is more important to teach the patient to behave properly without a corset after operation. This saves the patient from typical muscle atrophy. It is quite obvious that strong muscles are of great importance for the progress of consolidation. Thus, post-operative treatment has been based on the principles referred to at the beginning of this chapter.

TABLE VI. — *Average Duration of Pain Before the Operation and Average Length of Convalescence*

Type of Arthrodesis	Number of Cases	Duration of Symptoms in Years	Length of Convalescence
Bosworth	26	6.2	5.6
One or two grafts	42	6.6	5.6

Table VI shows that most of the patients have begun to seek help after the symptoms have persisted for six or six and a half years. In this respect there is no noteworthy difference between BOSWORTH's operation and the other types of arthrodesis. This is a hint of the fact that in spite of a great variety

of original causes a degenerative insufficiency of the back takes a little over six years to deteriorate so as to become sufficiently incapacitating. The table shows, too, that the length of average postoperative rest is the same after all the methods employed here. Thus, complete fusion takes the same time irrespective of the type of arthrodesis employed. Bosworth's method has a seeming handicap only. An early strain may cause a bone defect on the upper fork, but this quickly disappears during the rest period and gives way to complete consolidation. At the same time the local pains felt at the corresponding level vanish.

If disc degeneration and consequent secondary insufficiency of the back are due to a congenital anomaly like unilateral sacralisation or spina bifida occulta, no permanent improvement can be attained except by arthrodesis (SMITH-PETERSEN 1951). Unilateral sacralisation creates an abnormal lateral stress and the statics of the back can be corrected only by fusion. This can be seen even more clearly if the statics of the low back are or have weakened through an operation. An example of this is Case 35.

The patient is a dressmaker of 43 who had felt slowly increasing low back pain two years before she went to hospital. There was also some radiated pain in both her legs. Because of these pains she was taken into another hospital 2nd Nov. 1955. The status was then as follows: Ankle jerk positive l.a. but the left one weaker. Extension of the halluces normal. l.a. Knee jerk normal l.a. Lasègue on the right 45, on the left 30 degrees. The attending physician diagnosed disc prolapse in the presacral interspace. At operation the arches of the L V and L IV were totally removed. The exploration of the discs remained negative. The patient left hospital on 29th Nov.—55 but her condition had not improved. She was unable to work and her gait grew more and more difficult. When she was taken into our hospital she was unable to walk because of grave low back insufficiency.

The other symptoms were as follows: In the low back a strong convex scoliosis to the left. The back muscles overstrained. Ankle jerk on the right +, on the left —. Extension of the right hallux +, of the left —. Knee jerk very sharp l.a. and bilaterally symmetrical. Lasègue l.a. 70 degrees. No sensory changes or muscle atrophy in the legs. The x-ray shows that the arches of the L V and L IV had

Plate XI. — Case 35. Anterior-posterior picture of the patient after the first operation.

been totally removed, unilateral sacralisation on the right, and some scoliosis, too. The patient was nursed in bed at hospital for two weeks. All the reflexes were gradually revived but the Lasègue remained below normal.

A new operation was performed on 1st Nov. 1956. Through a skin incision all the old scar tissue was removed from above the spine. No narrowing or compression was found round the two lowest pairs of roots. The bone surfaces were carefully denuded. A thick iliac graft 13 cm in length was planted on the right side. The graft was shaped so as to fully coincide with the curve of the spine. A straight tibial graft of the same length was placed on the left side. Accordingly, this graft remained straight but good contact surfaces were shaped at both ends. Besides, the grafts were packed with bone chips so that there was no danger of pressure on the spinal chord. The wound was carefully sutured. The patient was confined to bed for three and a half weeks. After that her postoperative treatment followed the principles presented above. The patient went back to work five months after operation and has continuously been able to work. Her gait is normal, she feels no pain in her low back or legs.

Plate XII. **Plate XIII.**

Plate XII. — **Case 35. Anterior-posterior picture of the patient eight months after operation. The patient has been at work for three months already.**

Plate XIII. — **Case 35. Lateral picture of the patient eight months after operation.**

In cases 45—68 the lumbosacral region was stabilised according to Albee's method by means of one graft which was taken either from the wing of the ilium or from the anterior aspect of the tibia. In all these cases plenty of bone chips were used in addition.

In four cases (47, 51, 52, 64) arthrodesis was performed during the re-operation. In two cases (50 and 58) the pedicular part was exposed comparatively widely and therefore an immediate arthrodesis was done. In three cases there has been spondylolisthesis (54, 56, 57), in one case (45) unilateral lumbarisation, and in one (68) unilateral sacralisation. Spina bifida occulta caused a disc degeneration with consequent insufficiency in case 60. All the other cases were insufficiencies due to degenerate discs in which stabilisation proved necessary at operation.

When employing one graft care was taken to make the graft firm enough and an ample supply of bone chips was used. With regard to the final result this method has no noteworthy advantage over the double graft method.

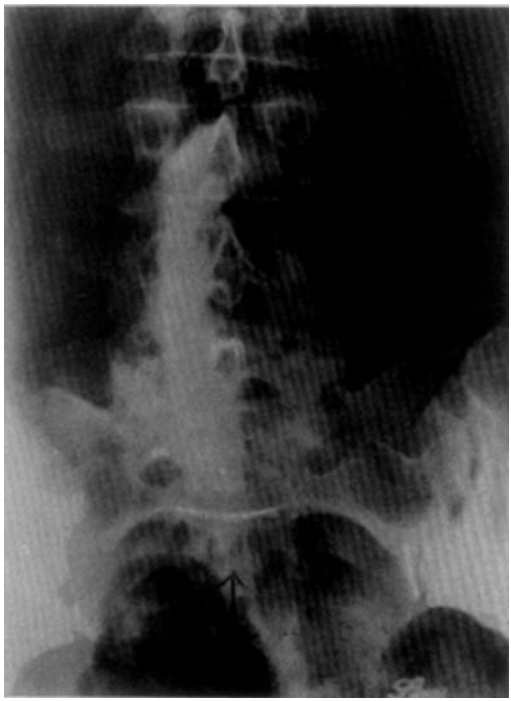


Plate XIV. — Case 46. **Anterior-posterior picture one and a half** years after operation. Note **the strongly incorporated graft of Albee's** type.

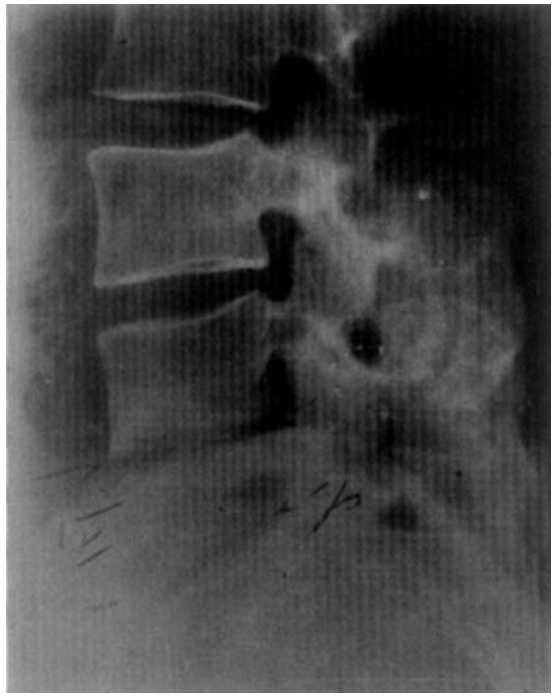


Plate XV. — Case 46. Simultaneous lateral radiograph showing strong fusion round the spinous processes.

It has to be borne in mind, however, that during the convalescence a patient with a double-graft arthrodesis need not be equally careful because the primary strength of his back is greater.

The following two cases are here to illustrate difficult back insufficiencies stabilised by arthrodesis of Albee's type.

Case 46 is a houswife aged 30 who had been suffering from increasing back pain for two years. Shortly before coming to hospital there had appeared almost symmetrical pain in the legs. Lasègue l.a. 20 degrees. Ankle jerk sharp and bilaterally symmetrical. Extension of the halluces normal. Dorsiflexion of the ankles normal and strong l.a. Knee jerk sharp, almost multiple l.a. X-ray showed narrowing in the presacral interspace. Flexion-extension plates revealed strong insufficiency in the same interspace.

At operation the lumbosacral region was exposed only on one side of the spinous processes. A firm tibial graft was placed between the L III and the sacrum. Some additional bone chips were also taken from the wing of the ilium. After operation the patient was kept in bed for three and a half weeks. After that she was allowed to get up but most of the following four months she spent in bed. After six and a half months

the patient was considered to have fully recovered. Re-examination after one and a half years showed that she was entirely well and able to work. Cf. the plates XIV and XV.

Case 60 (Plate XVI) is an example of secondary insufficiency due to a difficult congenital anomaly (spina bifida occulta) with accompanying disc degeneration, which was repaired with a single graft.

The patient is a farmer's daughter of 46 years. Her low back pain grew worse during the war because of continous hard work on the farm, the men being in service at the front. The patient suffered from periodic, sometimes severe pain for the last twelve years. Later on she felt temporary lameness in her right leg. On examination the state was found to be as follows: Lasègue negative l.a. Ankle jerk l.a. sharp and multiple. Dorsiflexion of the halluces normal. l.a. Knee jerk very sharp l.a. No atrophy or sensory changes in the legs. The patient complained of periodic severe pain both in the low back and simultaneously in the anterior aspect of the right shin. X-ray findings

Plate XVI.

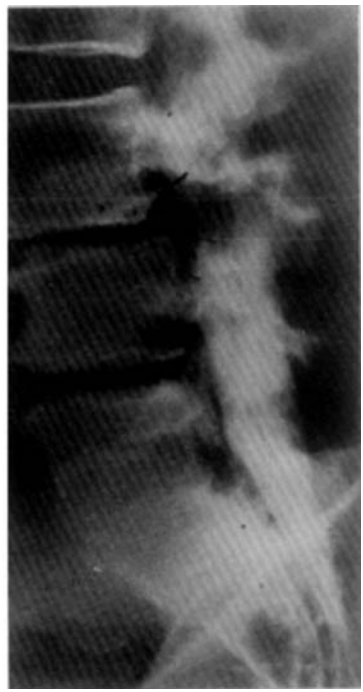


Plate XVII.

Plate XVI. — Case 60. The arch of the fifth vertebra and part of the upper sacrum open. Pedicles on one side arthrotic and collapsed. Scoliosis.

Plate XVII. — Case 60. Myelogram reveals quite a large prolapse in the L III—L IV interspace. The lower spaces narrowed. The L II—L III space is sound.

(Plate XVI): total lumbarisation of the S I, spina bifida occulta, scoliosis. Narrowing of the discs and much osteophytic formation in the region of the three lowest lumbar vertebrae. Myelogram (Plate XVII) revealed a remarkable prolapse in the L III—L IV interspace. The prolapse extended across the mid-line but lay mostly on the right side.

At operation the right side was opened. Between L III and L IV a total prolapse was found which lay entirely loose in the spinal canal causing considerable narrowing in the canal. The prolapse was removed without difficulty. The L III—L IV interspace greatly insufficient. The same defect was detected in the two lower interspaces. A firm tibial graft 14 cm in length was planed to immobilise the three lowest lumbar vertebrae. The graft was packed with plenty of bone chips taken from the iliac bone. The wound was sutured in the usual way.

Three weeks after the operation the patient was allowed to stand up and walk a few steps but not sit down. After 35 days she left hospital but at home, too, she stayed up only as little as necessary. The process of fusion was examined every six weeks. After four and a half months the patient was allowed to walk more freely. After seven and a half months she was fully capable of carrying on her former work. Re-examination

Plate XVIII.

Plate XIX.

Plate XVIII. — Case 60. Anterior-posterior radiograph three years after operation.

Plate XIX. — Case 60. Lateral radiograph three years after operation. Note the strong fusion.

three years after the operation showed the patient's low back to be quite painless. (Plates XVIII and XIX). Lasègue negative l.a. All the leg reflexes normal. No symptoms suggestive of spinal compression to be found.

In the author's view, none of the above fusion methods can be given distinct precedence. Each individual case must be considered separately. When assessing the indications the following main points ought to be considered:

1. The patient's general state is the decisive factor as to the scope of the operation.
2. One of the essential points is also the number of the vertebrae to be stabilised. This can also be called the extent of insufficiency.
3. Intensity of insufficiency.
4. Duration of insufficiency and the seriousness of secondary changes (border formations, osteophytes, etc.).
5. All the discs left above the bone block should be fairly sound.
6. Static position of the lowest mobile interspace must also be taken into consideration.

Bosworth's method might seem to be suitable for fusing short parts. As the upper fork of the graft will be subjected to considerable strain, an ample supply of bone chips has to be provided for this region. If one long graft is used, there is always the danger of its breaking up and of pseudoarthrosis forming particularly at the lower end of the graft. The use of double grafts practically eliminates this danger but, of course, it widens the scope of the operation.

TABLE VII

Low-Back Fusions with H-Graft (1—26)

Low-Back Fusions with Double Grafts (27—44)

Low-Back Fusions with Single Graft (45—68)

TABLE

Case Number	Occupation	Sex Age	Duration of Pain	Back Ache Sciatica	Radiographic Findings	Neurological Signs
						Low-Back Fusions
1	Farmer's daughter	♀ 27	5 years	Back ache	Unilateral lumbarisation dx.	None
2	Lumberer	♂ 27	7 months	Back ache	Interspinal ligament ruptured at S I—L V level	None
3	Clerk	♂ 31	4 years, (3 months) very bad)	Back ache	S I—L V interspace narrowed	Lasègue 80 dx. Lasègue — sin. Other reflexes sharp
4	Waitress	♂ 32	2 years. Back always weak	Back ache. Numbness of legs	Unilateral sacralisation	None. Reflexes sharp
5	Shop assistant	♀ 36	4 years. Back always weak	Back ache	Unilateral lumbarisation	None. Reflexes sharp
6	Housewife	♀ 37	6 years. Very bad	Back ache. Sciatica in the left leg	Spondylolysis in the arch of L V. In the body incipient olisthesis	Lasègue 70 dx. Left hallux extension weak
7	Factory worker	♀ 40	4 years. Severe for 2 years	Back ache. Sciatica in the right leg	Two lowest interspaces narrowed	Right ankle jerk negative
8	Farmworker	♂ 40	5 years. Absent from work 8 months	Back ache. Pain in both the calves and soles	Considerable narrowing in the L I-L II—L III interspaces	Lasègue 50 l.a. Reflexes sharp
9	Housewife	♀ 40	3 months	Back ache. Sciatica in the right leg	None	Lasègue 25 dx. Right hallux extension weak
10	Bricklayer	♂ 40	5 years	Back ache. Sciatica in the left leg	Operated in 1947. L V arch absent	Lasègue 70 sin. Left hallux extension weak
11	Lorry-driver	♂ 40	7 months	Sciatica in the left leg	Six lumbar vertebrae;the lowest weakly developed. L IV arch defective Spondylolisthesis	Lasègue 70 sin. Hallux extension and ankle jerk weak on the left
12	Dressmaker	♀ 41	3 years	Back ache	Unilateral lumbarisation	None
13	Charwoman	♀ 45	10 years	Back ache. Lameness in both legs	L V—L V insufficient	Ankle jerk weak l.a.
14	Factory worker	♂ 45	2 years	Traumatic back ache	The arch of L V forms a rudimentary transitional vertebra	Lasègue 45 sin.

VII.

Operative Findings	Type of Fusion	Convalescence in Months	Result	Remarks
with H-Graft				
S I very mobile. Its spinal process is removed	Bosworth S II—L V	6	Not cured	Bosworth graft not fused with the lumbarised S I
Ligaments ruptured	Bosworth S I—L V	5	Excellent	Damaged when lifting a heavy weight
Lower nerve roots very oedematous	Bosworth S I—L IV	6	Good	Histological examination revealed tuberculosis. Cured
L V vertebral body twisted	Bosworth S I—L IV	5	Excellent	Iliac graft with plenty of bone chips
Pathological movement between S I and L V	Bosworth S II—L V	4.5	Excellent	Tibial graft. A hole drilled for the spinous process
Small disc prolapse in L IV—L V interspace	Bosworth S I—L IV	6	Improved	Iliac graft, whose lower end not consolidated by re-examination
Disc prolapse on the right betw. S I and L V. Insufficiency	Bosworth S I—L IV	5	Excellent	Iliac graft with plenty of bone chips
Total prolapse in L II—L III interspace. Insufficiency	Bosworth L II—L III	6	Excellent	Tibial graft
Disc prolapse in S I—L V. Insufficiency	Bosworth S I—L V	4.5	Excellent	Tibial graft
In S I—L V, left, a broken facet fragment presses the nerve. Insufficiency	Bosworth S I—L V	6.5	Improved	After reoperation a nephritic calculus attack
Insufficiency	Bosworth S I—L III	6.5	Excellent	Olisthesis only 5 mm. Iliac graft
S I—L V interspace insufficient	Bosworth S II—L IV	4.5	Excellent	Iliac graft with plenty of bone chips
Pathological movement between L IV and L V. Interspinal ligament ruptured	Bosworth S I—L IV	4.5	Excellent	Iliac graft with a hole for the spinous process of L V. Plenty of bone chips
Insufficiency in S I—L V	Bosworth S I—L IV	9	Excellent	Iliac graft with an ample amount of bone chips

Continued

Case Number	Occupation	Sex Age	Duration of Pain	Back Ache Sciatica	Radiographic Findings	Neurological Signs
15	Factory worker	♂ 45	7 years	Back ache. Pain in the left leg	The arches of L V and L IV are missing	Lasègue 30 sin. Symptoms of irritation. (Reflexes sharp)
16	Farmer	♂ 47	1 year	Back ache. Sciatica in both legs. Caudal symtoms	Considerable narrowing in the S I-L V—L IV interspaces	Lasègue 60 l.a. Rectum slack. Genitals insensitive
17	Mechanic	♂ 47	14 years	Back ache. Slight sciatica in the right leg	S I partly lumbarised. Its big transv. processes are jointed to the sacrum	Symptoms of irritation. (Reflexes sharp)
18	Foreman	♂ 48	5 years. 6 months very bad	Back ache. Pain in the medial aspect of thighs	Border formations in L III—L II interspace	Lasègue 45 l.a. Symptoms of irritation. (Reflexes sharp)
19	Factory worker	♂ 50	3 years	Back ache	L V arch and L IV spinous process are missing	Symptoms of irritation. (Reflexes sharp)
20	Workman	♂ 50	10 years	Back ache. Sciatica symptoms in the left leg	L V arch and spinous process weakly developed	Symptoms of irritation. (Reflexes sharp)
21	Workman	♂ 51	16 years	Back ache	Strong lumbar lordosis	None
22	Farmer	♂ 51	3 years	Back ache	Spondylolisthesis L IV. Scoliosis	Ankle jerk negative l.a. Atrophy in the right thigh and calf
23	Factory worker	♂ 53	6 years	Back ache. Pain in the thighs	Spondylarthrosis	Ankle jerk negative l.a.
24	Mechanic	♂ 55	20 years	Back ache	Strong narrowing in S I—L V interspace	Lasègue 70 dx. Ankle jerk negative on the right
25	Housewife	♀ 56	15 years	Back ache. Sciatica in the left leg	Unilateral sacralisation	Lasègue 30 dx.
26	Housewife	♀ 58	18 years	Back ache. Incipient lameness in the left leg	Myelogram reveals a prolapse in L V—L IV interspace	Lasègue 80 dx. Hallux extension and ankle jerk negative on the right
						Low-Back Fusions
27	Mechanic	♂ 22	2 years	Back ache. Sciatica in the left leg	None	Lasègue 45 sin. Left hallux extension negative

Operative Findings	Type of Fusion	Convalescence in Months	Result	Remarks
Medial disc prolapse in L V—L IV interspace. Insufficiency	Bosworth S I—L III	7	Improved	Iliac graft with plenty of bone chips. Disc operation in 1948
Medial total prolapse in the L V—L IV interspace. Insufficiency	Bosworth S I—L III	7	Good	Iliac graft with pseudoarthrosis at the upper end. Patient's weight 115 kg
Instability in S I—L V. Insufficiency	Bosworth S I—L IV	6.5	Excellent	Iliac graft with bone chips. Strong arthrosis of pedicles in S I—L V interspace on the right
Medial prolapse in L III — L II interspace. Insufficiency	Bosworth L III—L II	3.5	Excellent	Iliac graft
Insufficiency	Bosworth S I—L IV	6	Good	Iliac graft. Patient's weight 100 kg. Disc operation 7 months ago
Medial total prolapse in S I—L V interspace. Insufficiency	Bosworth S I—L IV	6	Excellent	
Insufficiency	Bosworth S I—L IV	8	Improved	Mentally difficult patient who escapes work
Insufficiency	Bosworth S I—L III	4.5	Excellent	
Pathological movement in S I—L V interspace. Insufficiency	Bosworth S I—L IV	6.5	Excellent	Iliac graft with plenty of bone chips. Disc operation 5 years ago
Plenty of adhesions in S I—L V interspace. Insufficiency	Bosworth S I—L IV	4.5	Improved	
In L V—L IV interspace the lig. flavum turns in. Insufficiency	Bosworth S I—L IV	5	Improved	Lower end of the tibial graft was broken when the patient got up
Large medial prolapse in L V—L IV interspace	Bosworth S I—L IV	4.5	Improved	Large amount of bone removed with the prolapse necessitated fusion
with Double Grafts				
Disc prolapse in L V—L IV. Insufficiency	Double grafts	6	Excellent	

Continued

Case Number	Occupation	Sex Age	Duration of Pain	Back Ache Sciatica	Radiographic Findings	Neurological Signs
28	Housewife	♀ 22	7 years	Back ache. Radiated pain in the legs	Severe presacral spondylolisthesis	Knee jerk sharp l.a. Ankle jerk negative l.a.
29	Factory worker	♂ 32	12 years	Back ache	Presacral spondylolisthesis	None
30	Lumberer	♂ 33	2 years	Back ache	In S I—L V interspace the left pedicle hypoplastic	None
31	Housewife	♀ 36	2 years	Back ache. Weakness in the legs	Spondylolisthesis of 1.5 cm in L IV	Symptoms of irritation
32	Housewife	♀ 36	6 years	Back ache. Is able to walk only 100 m.	Spondylolisthesis of 1.5 cm in L IV	Symptoms of irritation
33	Factory worker	♀ 38	7 years	Back ache. Walking difficult	Grave spondylolisthesis in L V	Symptoms of irritation. Rectum insensitive
34	Plumber	♂ 39	7 years. Severe for 6 months	Back ache	Unilateral sacralisation dx.	Symptoms of irritation
35	Dressmaker	♀ 43	2 years	Back ache. Pain in the legs	LV—LIV—LIII arches missing. Unilateral sacralisation	Lasègue 70 l.a. Left ankle jerk and left hallux extension negative
36	Joiner	♂ 45	10 years	Back ache. Pain in the right hip	Spondylolisthesis of 1 cm in L V	None
37	Housemaid	♀ 46	6 years	Back ache. Sciatica in the left leg	Unilateral sacralisation l. sin. Degenerate disc in S I—L V	Left ankle jerk negative
38	Factory worker	♀ 46	2 years	Back ache. Pain in the legs, too	Spondylolisthesis of 1.5 cm in L IV	Symptoms of irritation. (Reflexes sharp)
39	Mechanic	♂ 48	6 years	Back ache. Incapacitated by weakness of legs	Spondylolisthesis of 1.5 cm in L V. Spina bifida	Ankle jerk negative l.a.
40	Charwoman	♀ 51	10 years	Back ache	Unilateral sacralisation	Symptoms of irritation
41	Factory worker	♂ 52	10 years	Back ache. Weakness in the legs	Spondylolisthesis of 1 cm in L IV	Symptoms of irritation
42	Workman	♂ 54	4 years	Back ache	Degenerate disc in L IV—L V	Lasègue 70 l.a. Right hallux extension weak

Operative Findings	Type of Fusion	Convalescence in Months	Result	Remarks
Loose arch of L V is removed	Double grafts	6	Excellent	The patient's low back was hurt in a bicycle accident at the age of 10
L V arch partly loose	Double grafts	6	Excellent	
Insufficiency	Dduble grafts	5.5	Excellent	Patient incapacitated 2 years before coming to hospital
Insufficiency	Double grafts	5	Excellent	Patient has two children. Pain appeared after the second delivery
Insufficiency	Double grafts	5	Excellent	Patient has six children. Legs weakened after the last delivery 6 years ago
Insufficiency	Double grafts	6	Good	At 4 patient fell from a roof and broke her femoral, too
Insufficiency	Double grafts	5	Excellent	
Grave insufficiency	Double grafts	5	Excellent	Patient operated at another hospital a year ago. Exposure too extensive. Obs! Sacralisation!
Insufficiency	Double grafts	5	Excellent	
Disc prolapse S I—L V sin. Insufficiency	Double grafts	4.5	Excellent	
Insufficiency. L IV arch broken	Double grafts	6	Excellent	L IV arch not removed at operation
Insufficiency. L V arch broken	Double grafts	4.5	Excellent	L V arch not removed at operation
Insufficiency	Double grafts	5.5	Excellent	Before operation patient had used corset for 5 years
Insufficiency. L IV arch broken	Double grafts	6	Excellent	Before operation patient was able to walk 100 m
Pathological movement in L III—L IV	Double grafts	5	Excellent	Fell from a car on his back 4 years ago

Continued

Case Number	Occupation	Sex Age	Duration of Pain	Back Ache Sciatica	Radiographic Findings	Neurological Signs
43	Housewfie	♀ 56	36 years	Back ache. Sciatica in the left leg	6 lumbar vertebrae. Strong scoliosis, convex to left. Myelogram reveals disc prolapse in L V-LIV	Lasègue 70 sin. Left hallux extension weak
44	Manager	♂ 56	3 years	Back ache. Pain in the lower abdomen	Spondylolisthesis of 1 cm in L IV	Symptoms of irritation
						Low-Back Fusions
45	Factory worker	♀ 22	1 year	Back ache	Unilateral lumbarisation l. sin.	No scoliosis
46	Housewife	♀ 30	2 years	Back ache	Narrowing in presacral interspace	Lasègue 20 l.a. Symptoms of irritation
47	Post official	♀ 33	4 years	Back ache. Sciatica in the left leg	Narrowing in S I-L V—L IV interspaces	Lasègue 80 sin. Left ankle jerk negative
48	Workman	♂ 35	5 years	Back ache	L IV—L V interspace insufficient	Symptoms of irritation
49	Shop assistant	♀ 37	1 year	Back ache. Sciatica in the right leg	Insufficiency	None
50	Housewife	♀ 38	12 years	Back ache. Sciatica in the right leg	Insufficiency. Narrowing in L V—L IV interspace	Lasègue 45 dx. Ankle jerk and hallux extension negative on the right
51	Painter	♂ 39	8 years	Back ache	L V—L IV space narrowed. Myelogram positive	Lasègue 45 sin. Symptoms of irritation
52	Post official	♂ 46	8 years	Back ache. Sciatica in the right leg	Myelogram positive in L V—LIV	Lasègue 30 dx. Ankle and knee jerk negative on the right
53	Insurance inspector	♂ 41	4 months	Back ache. Sciatica in the left leg	LV—LIV arches operatively removed	Lasègue 25 sin. Ankle jerk negative. Left hallux extension weak
54	Workman	♂ 43	2 years	Back ache. Weakness in legs	Spondylolisthesis of 1.5 cm in L V	Severe symptoms of irritation
55	Workman	♂ 44	2 years	Back ache. Walking produces pain in the left leg	Narrowing in SI-L V—L IV interspaces	Lasègue 60 sin. Left ankle jerk weak

Operative Findings	Type of Fusion	Convalescence in Months	Result	Remarks
Disc prolapse in L V—L IV. Insufficiency	Double grafts	6.5	Good	At 20 patient fell from a swing. Since then pain in the back
Insufficiency	Double grafts	8	Good	
with Single Graft				
Pathological movement in L V—L IV interspace	Single graft	5	Excellent	
S I—L V interspace very mobile. Insufficiency	Single graft	6.5	Excellent	
Re-operation. Prolapse in S I—L V interspace. Insufficiency	Single graft	6.5	Excellent	Disc operation in 1953, reoperated for insufficiency
Fracture, apparently old, in L IV arch. Insufficiency	Single graft	5.5	Excellent	Fell from a train in 1950
Pathological movement in S I—L V space. Articular facet presses the nerve	Single graft	4.5	Excellent	
Disc prolapse in L V—L IV. Pedicle damaged at operation	Single graft	4	Excellent	
Prolapse in L V—L IV. Insufficiency	Single graft	5	Excellent	Disc operation in 1949. At reoperation half of the disc left
Prolapse in L V—L IV. Articular process damaged	Single graft	5.5	Good	Disc L V—L IV removed in 1947
Single iliac graft to be removed due to suppuration	Single Graft	4	Not cured	Insufficiency still remains
Mobile L V arch removed. Decompression of nerve roots	Single graft	6.5	Excellent	
Pathological movement in S I—L V—L IV interspaces. Insufficiency	Single graft	5	Good	

Continued

Case Number	Occupation	Sex Age	Duration of Pain	Back Ache Sciatica	Radiographic Findings	Neurological Signs
56	Housemaid	♀ 45	6 years	Low back pain. Weakness of legs	Spondylolisthesis of 1.5 cm in L IV	Knee jerks very sharp
57	Plater	♂ 45	3 years	Back ache. Pain in the legs	Spondylolisthesis of 1 cm in L V	Lasègue 80 l.a. Symptoms of irritation
58	Factory worker	♂ 45	8 years	Back ache. Pain in the legs	Lordosis straightened	Lasègue 80 l.a. Ankle jerk negative l.a.
59	Housewife	♀ 45	4 years	Back ache. Sciatica in the left leg	Myelogram reveales a prolapse in L III—L IV	Lasègue 60 sin. Left hallux ext. and knee jerk weak. Femoral. pain on the left
60	Farmer	♀ 46	12 years	Back ache. Weakness of legs	Spina bifida. Myelogram positive in L III—L IV	Symptoms of irritation. (Reflexes sharp)
61	Shop assistant	♀ 47	1 year	Back ache. Sciatica in the left leg	Degenerate disc in S I—L V interspace	Lasègue 70 sin. Ankle jerk negative on the left
62	Farmer	♂ 49	3 months	Back ache. Sciatica in the left leg	Myelogram positive in L III—L IV	Lasègue 70 sin. Left hallux ext. weak and ankle jerk negative. Atrophy of the thigh
63	Nurse	♀ 51	4 years	Back ache. Sciatica in the left leg	Narrowing in the presacral interspace	Lasègue 70 sin. Ankle jerk negative
64	Railway guard	♀ 53	5 years	Back ache. Sciatica in the left leg	Myelogram positive in LIV—LV space	Symptoms of irritation
65	Housewife	♀ 55	7 years	Back ache. Radiated pain in the legs	Lateral displacement in LV-LIV interspace	Symptoms of irritation. Left hallux extension weak
66	Housewife	♀ 55	19 years	Back ache	Insufficiency in S I—L IV	Lasègue 110 dx. Right ankle jerk negative
67	Housewife	♀ 55	17 years	Back ache	Severe arthrosis in S I—L III	Left ankle jerk negative
68	Housewife	♀ 61	15 years	Back ache. Unable to walk for 7 months	Unilateral sacralisation dx Scoliosis	Ankle jerk negative l.a.

Operative Findings	Type of Fusion	Convalescence in Months	Result	Remarks
L IV arch loose	Single graft	6	Improved	Painless but unable to work with her back bent
L V arch broken. Decompression of nerve roots	Single graft	6	Excellent	
L V—L IV disc degenerate. No typical prolapse. Insufficiency	Single graft	6	Improved	Articular facet is opened largely at operation
Disc prolapse in L III—L IV. Insufficiency	Single graft	6	Excellent	
Disc prolapse in L IV—L III. Insufficiency	Single graft	8	Excellent	Severe arthrosis in S I—L III region
Ossified disc fragment removed from under LV nerve root	Single graft	7	Excellent	At operation the joint is opened largely and spondylodesis is indicated
Big prolapse in L IV—L III interspace	Single graft	5	Excellent	Severe back ache 15 years ago. At operation the joint is opened widely. Spondylodesis is done
Disc prolapse in S I—L V. Insufficiency	Single graft	6	Excellent	
Insufficiency	Single graft	7	Excellent	Hurt his back at 16. Total prolapse in S I—L V. Re-operation and fusion due to recurrent pain. Psychosis which was cured
Insufficiency	Single graft	6	Excellent	
Pathological movement in LV—L IV	Single graft	5.5	Excellent	Persistent pain after hurting her back 19 years ago
L V—L IV very mobile	Single graft	5	Good	
Disc prolapse in L IV—L V. Pathological movement in S I—L IV	Single graft	4.5	Excellent	

IX. ANALYSIS OF THE CASES

The patients personally examined by the author numbered 314, 185 of which were male and 129 female. It has been stated with fairly great conformity that the majority of patients involved in disc operations are male. The following table (Table VIII) has been compiled from four considerably extensive reports on disc operations with the author's own material underneath. Those collected by LENHARD (1947), LOVE (1947), WARIS (1948), and O'CONNELL (1951) consist of disc cases only.

TABLE VIII

Investigator	Year	Number of Patients	Percentage of Male Patients
LENHARD	1947	843	67
LOVE	1947	1217	70
WARIS	1948	374	72
O'CONNELL	1951	500	66
LEIKKONEN	1956	314	59

The high percentage of men is, however, reduced if we consider other factors which contribute to instability, such as spondylolisthesis, unilateral lumbarisation and sacralisation, spina bifida occulta, hypoplasy of the pedicles, transitional vertebrae, arthroses, sequilae of infections, etc. The author's figures in Table VIII are a clear proof of this fact, the percentage of men being only 59.

In 1945 WAHREN reported on a twelve year old patient with a disc prolapse. The youngest patient in this investigation was 16 years old. Because so young persons rather seldom appear in such investigations, the case is reported here in its entirety.

The anamnesis revealed that one year before the operation the patient had fallen into a sitting position when ice-skating. The lower part of her back was hurt but the pain soon disappeared. Two months after this accident her back began to ache again. After a time the patient was obliged to give up her ballet dancing lessons and after a few months her apprenticeship at a laboratory, too. In the radiograph the lumbar lordosis was completely missing. On the left the transverse process of the L V was jointed to the sacrum (unilateral sacralisation) but on the right the processus transversus was free. No special narrowing of the spaces was to be seen. No myelogram was done. The flexion and extension plates revealed some instability between L IV and L V. Lasègue on the right positive at 45, on the left at 15 degrees. Ankle jerk positive in the right but negative in the left leg. Extension of both the halluces good. Knee jerk normal on both sides. No sensory changes or atrophy.

At operation 29th March 1956 the two lowest interspaces were exposed through a small incision on the left. Below the L V root a prolapse the size of the tip of the little finger was found, which pressed heavily on the nerve. The interspace was emptied of the typically degenerate nuclear disc mass. Her recovery took place without any complications and ten days after the operation the patient was able to be taken home. She went back to her work at the laboratory one month after the operation.

In this case disc degeneration was obviously due to a trauma with consequent instability. An aggravating factor here has most likely been unilateral sacralisation, which may trouble the patient later on. Since the patient was so young, no fusion was performed.

The oldest patient was a bricklayer of 68 years. He had been suffering from low back pain for only two years before operation. Two months before his coming to hospital pain had spread into the left leg. After that the patient had been almost unable to walk. Only lying in a certain position had made him feel a little more comfortable. Sleep had been badly disturbed by pain.

The radiograph revealed strong border formations in the lumbar vertebrae. Nerve status: Lasègue on the right negative, on the left 80 degrees. Ankle jerk positive on the right but weak on the left. Knee jerk symmetrical and similar. In the peroneal region of the left leg sensibility clearly decreased. No myelography was done.

At operation the S I—L V interspace was opened on the left. Immediately beside the nerve root there was a big disc prolapse the size of a thumb end, which was easily removed. No noticeable bleeding. No complications during the recovery. The patient stayed in hospital for only 20 days in all. In spite of his age he went back to his former work 3 months after operation. He is still at work and has no pain in his back.

Before, operations have not usually been performed on so old persons because there has prevailed the opinion that the sciatic symptoms are apt to disappear with age. And, as a rule, this is so. Severe arthrosis and the increasing number of degenerate discs put certain limits on the possibility

of making a diagnosis. If the patient has severe pain, however, and the level can be localised with some certainty, there is no reason why an operation should not be done. An age limit is not justifiable where this operation is concerned if the symptoms are otherwise quite clear. Moreover, osteoporosis, typical of old age, makes the operation easier.

Here in Finland there has been published (BISTRÖM 1954) a series of 151 cases most of which have revealed considerable radiographic changes in the spine with osteophytes, Schmorl's nodules, and other symptoms of disc degeneration. These patients never had any low back pain. With age there was to be seen proportional increase in these changes. It is then to be understood that when several discs begin to degenerate simultaneously, similar degenerative changes in the corresponding nerve endings take place, particularly in those endings branching off the sinus vertebralis nerves, and thus the sensation of pain disappears together with the increasing degenerative changes. Furthermore, at the same time there is gradual immobilisation of several discs so that there is no local accumulation of secondary insufficiency. For the same reason there are no prolapses causing root compression. The fact that osteophytes do not usually gain ground in the root region may be explained by the fact that the disc area is of nothochondral origin where ossification is possible only under exceptional circumstances.

TABLE IX. *Level of a Disc Prolapse Discovered at Operation*

Interspace	Number of Cases	Per Cent
S I—L V dx.	72	62.7
S I—L V sin.	80	
L V—L IV dx.	34	33.4
L V—L IV sin.	47	
L IV—L III dx.	4	1.6
L IV—L III sin.	3	1.6
L III—L II	2	0.7
	Total 242	100.0

Two of these cases were double prolapses, both of them in the S I—L V and L V—L IV interspaces. In the table each of these has been marked as a S I—L V prolapse only so that the figures in the table might correspond with the actual number of patients.

TABLE X

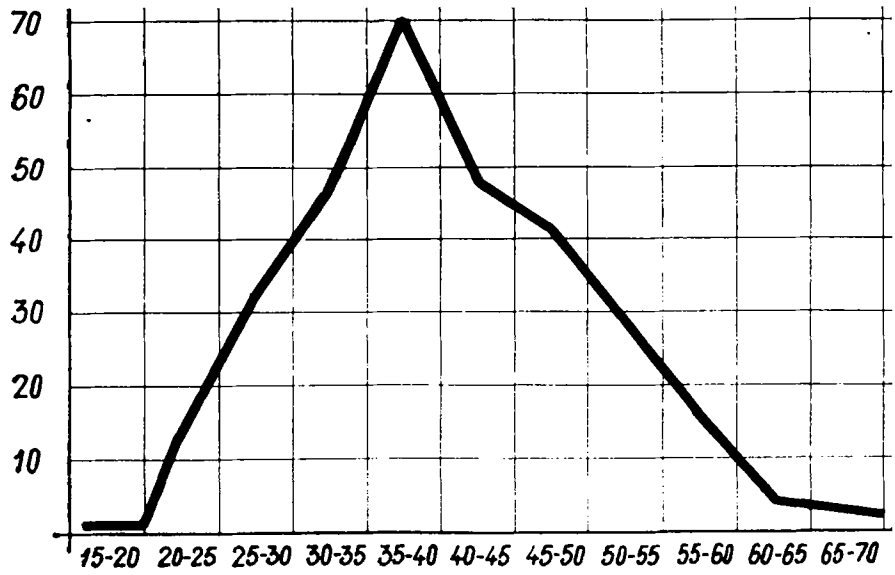
Other indications for the operations performed by the author. On 68 patients out of the total number of 72 were performed fusion operations explained in the text.

Indication	Number of Cases
Insufficiency	35
Spondylolisthesis	13
Unilateral sacralisation	7
Unilateral lumbarisation	4
Varicosis	4
Hypoplasy	3
Rupture of ligaments	2
Compression due to fracture	2
Hemangioma	1
Fibrolipoma	1
Total	72

The hypoplasy group contains two spina bifida occulta cases in which the lower end of the spine was extremely badly developed. In the third case one of the articulars in the S I—L V interspace was congenitally hypoplastic.

Table XI is a diagrammatic representation of the patients' operative ages. The vertical line denotes the number of cases, the horizontal one the patient's ages in five years.

TABLE XI



Diagrammatic representation of the number of operations on patients at different ages. The vertical line indicates the number of patients, the horizontal one the patients' ages in five years.

Here we see that the greatest number of the operations have been performed on patients between 35 and 40 years. Fusion raises the percentage of older patients.

TABLE XII. — *The Cases Classified According to Occupation*

Occupation	Number of Cases	Per Cent
Heavy work.....	135	43
Light work	63	20.4
Housekeeping	54	17.2
Factory work	28	8.9
Intellectual work	34	10.5
	Total 314	100

It is very difficult to estimate the heaviness of some work. Among the factory workers there are sure to be persons whose work ought to be regarded as heavy. Similarly, many housewives have to work comparatively hard from morning till night. Most of them are also mothers who have given birth to several children. The percentage of purely intellectual workers is only 10.5. These figures are remarkably different from *e.g.* the ones given by Waris in 1948. In this report the corresponding percentage is 22. Here the basis of estimation is, however, so decisive a factor that this table is, in fact, of no greater importance. Yet, it is of some value in casting light on the following table which shows the grouping of the final results.

At closer study of Table XIII the reader's attention is first drawn to points 1 and 6: no symptoms of a disc lesion 182, and cured 189. The corresponding percentages are 59.6 and 60.2. The figures under the first heading have been arrived at through an exact objective investigation, while those under the sixth heading are based on the patients' subjective statements. Both these figures are almost consistent. They fall within the limits of the same medial error so that their validity may be relied upon.

If we then pay attention to heading eleven, we find out that the patient's working capacity has been fully restored in 266 cases or in 84.6 per cent. These patients have been able to return to their former occupations. Their number is over 20 per cent. higher than that of completely recovered patients. This implies that in spite of remaining pain several patients have been willing to resume their former occupations. In fact, to learn a new profes-

TABLE XIII. — *Final Results of 314 Operations*

	Number		Per cent.
1. No further symptoms of disc lesion		182	59.6
2. No radiated pain in the legs		244	77.7
3. Radiated pain in the legs			
— weak and transitory	51		
— severe and transitory	10	70	22.3
— persistent	9		
4. No low back pain		184	58.6
5. Low back pain			
— slight symptoms at work	99		
— severe symptoms at work	7	130	41.4
— persistent	24		
Subjective results:			
6. Cured		189	60.2
7. Remarkably better		33	10.6
8. Better		61	19.4
9. Unchanged		24	7.6
10. Recurrent		7	2.2
	Total	314	100
Working capacity:			
11. Restored		266	84.6
12. Reduced		39	12.4
13. Very poor or none		9	3
	Total	314	100

sion is often so difficult for a middle-aged person that he prefers to continue his former work if it is at all possible. Here we come across a social problem of great moment pointed out by KALLIO (1955) here in Finland. This problem is that in our country as well as in other countries occupational guidance, also from the medical point of view, ought to be applied even more than before. The use derived from this would later be seen, probably quite clearly, in reduced social expenses.

The author also agrees with KOSKINEN (1957) in his statement that the patients who have carried on an independent occupation — *e.g.* farmers — prefer going back to their heavy back-straining work. This may be due to the fact that it is easier for an independent person to get help for very heavy work than for an employee.

When Table XIII is studied further — points 2, 3, 4, and 5 —, the following facts can be stated: Purely sciatic pain has disappeared in 244 cases or in 77.5 per cent. Low back pain, on the other hand, has disappeared only in 184 cases or in 58.6 per cent. In connection with strain sciatic pain appears

in 70 cases or in 22.3 per cent., low back pain respectively in 130 cases or in 41.4 per cent. This is a clear proof of the fact that a low back disorder cannot always be completely cured only by removing the disc though it can be considerably improved.

These figures apply to all the 314 patients, the 68 fusions included. As seen in the tables above, the latter group improves the figures as regards the low pack pain but it cannot exercise a more remarkable influence on the total results because the percentage of fusions is only 21.6. This becomes apparent, too, if we compare the following disc cases, three of which series have been investigated in Finland.

TABLE XIV. — *Operative Results of some Disc Cases*

Investigator	Number of Cases	Cured	Improved	Unchanged or Worse
		Given as a Percentage		
SENNING and SJÖQUIST (1946)	403	55.7	35.5	8.7
LOVE (1947)	987	53.7	36.6	9.6
WARIS (1948)	347	41.0	50.0	9.0
VIITANEN (1955)	168	55.0	38.0	11.0
KOSKINEN (1957)	104	41.0	45.0	14.0
The author (1959)	314	60.2	30.0	9.8

The figures given in the above table are very comparable with the author's results. If we take the average number of cases cured by the earlier investigators, we get 48.2 per cent. The percentage of fusions in the author's own cases is 21.6 or about one fifth. Their improving influence upon the results would thus be some 12 per cent. Here we can clearly see the contribution of fusions to the final results.

Table XIII has been made up according to O'CONNELL's pattern (1951) to make it possible to compare two sets of results: the disc operations performed by O'CONNELL in which only a protrusion was removed, and the operations done by the author which also include immediate arthrodesis on 68 patients.

TABLE XV. — *Comparison of two Sets of Results*

Investigator	Number of cases	No Symptoms Referable to Disc Lesions	Cured	Full Capacity for Work
		Given as a Percentage		
O'CONNELL	443	46.5	60.7	92.8
LEIKKONEN	314	59.6	60.2	84.6

As mentioned above, the share of fusions in the author's material is about one fifth of the total amount. The improving influence on the results, if there is any, should be about 10 per cent. In this table the figures 46.5 (O'CONNELL) and 59.6 (LEIKKONEN) are the ones in which the difference ought to be detected.

On the other hand, the figures indicating capacity for work are quite reverse in the above table: 92.8 (O'CONNELL) and 84.6 (LEIKKONEN). When we analyse such a factor as capacity for work our basis of estimation is influenced by so many constituents that it is difficult to compare two different sets of results in this respect.

TABLE XVI. — *Number of Attacks of Pain Before Operation*

Number of Attacks	Number of Cases	Per Cent.
One attack only	60	19.1
Two attacks	78	24.8
Several attacks	176	56.1

Table XIV shows that more than half the patients had several attacks before operative treatment.

TABLE XVII. — *Duration of Pain*

Duration	Number of Cases	Per Cent.
One to six months	60	19.1
Six months to one year..	62	19.5
One to several years	192	61.4

Table XVII shows that more than half the patients (61.4 per cent.) had suffered from pain due to disc lesion for one year or more before the operative treatment was begun.

TABLE XVIII. — *Distribution of Pain*

Distribution	Number of Cases	Per Cent.
Lumbar spine and lower limbs.....	240	76.2
Lumbar spine only	38	12.3
Lower limbs only	36	11.5

Table XVIII indicates that in most of the cases (76.2 per cent.) pain was felt both in the low back and the legs.

TABLE XIX. — *Reflex Disturbances and the Lasègue Test*

Reflex Disturbances	Number of Cases	Per Cent.	Lasègue Positive	Per Cent.
S I—L V protrusions			115	75.8
Reflexes normal	21	13.8		
Ankle jerk reduced or absent	131	86.2		
Knee jerk reduced	2	1.3		
L V—L IV protrusions			58	71.6
Reflexes normal	50	61.7		
Ankle jerk reduced or absent	31	38.3		
Knee jerk reduced	2	2.5		
LII—LIII and LIII—LIV				
Reflexes normal	5			
Ankle jerk reduced or absent	2			
Knee jerk reduced	3			
Reflexes normal	76	24.2		
abnormal	238	75.8		

Weakness in Big Toe	Number of cases	Per Cent.
S I—L V protrusions	26	17.1
L V—L IV »	55	60.5
L IV—L III »	2	

Table XIX shows that the most pathognomonic symptom in the S I—L V interspace is a reduced or absent ankle jerk (in 86.2 per cent. of the cases). In the same interspace the Lasègue test is positive in 75.8 per cent. In the L V—L IV interspace the reflexes are not as important as in the above. The Lasègue, however, appears to be positive in 71.6 per cent. of the cases. Weakness is found in the big toe in 60.5 per cent. and this symptom must be regarded as a comparatively pathognomonic one to the L V—L IV interspace.

As we can conclude from the text above there are many unmapped regions and much uncertainty in the diagnostics of disc lesions. On the other hand, there may often be innumerable small details of great help in making a diagnosis but impossible to present as a consistent series. Command of them is obtained only through experience in course of time and, so to speak, through the tactile sense.

An interesting method for treating low back and sciatic pain was reported by FEFFER in 1956. Together with contrast medium he injected hydrocortison into the space round the disc concerned. In 37 cases out of 55 cases, in which a myelogram had revealed a pathological disc (67 per cent.) all the pain symptoms disappeared a few hours after the injection. In 18 cases (33 per cent.), the symptoms remained unchanged.

This material also includes a patient whose low back pain had been treated with a hydrocortison injection at another hospital. As this case may be of certain interest in this connection it is described here more closely:

Case 244 is a housewife of 50 years. For seven monhts she had been suffering from low back pain which periodically was so severe that she had to stay in bed. No radiated pain in the legs worth mentioning. Because of pain she was given a cortison injection the technique of which is not known. A few hours afterwards the patient was allowed to leave the hospital. In course of the following twelve hours she began to feel severe pain in her right leg. Radiated pain extended as far as the heel and the toes. The patient felt lameness in her legs and was unable to walk. On examination the ankle jerk was absent from both sides. Lasèque 75 on the right, 90 degrees on the left. Peroneal paresis on the right. Hallux extension absent from the right.

Peroneal region insensitive on the right. Knee jerk bilaterally symmetrical. No radiographic findings. At operation S I was exposed on the right. Nerve root excessively swollen. No prolapse in the S I—L V interspace. The L V root heavily strained. On its medial side a prolapse the size of a pea was found. Because the root was still blocked the root canal was oponed. In it there was discovered a soft narrow strip of prolapse 15 mm in length, which was clogging the canal. The L V—L IV interspace was emptied. Many prolapse fragments were found floating in a milky mass. Not until four weeks after the operation was the patient able to walk. After six months she was quite symptomfree and able to walk without pain though her back was still a little stiff. Ankle jerk on the right weak. Peroneal paresis had disappeared but the ankle was still little weak. Re-examination one and a half years after the operation proved the patient to be symptomless.

On the grounds of one case it is impossible to draw any conclusions. It seems, however, that the above procedure (Feffer's method) implies a considerable risk of complications.

Out of the total number of three hundred and fifty-nine cases five patients were lost. They are the following:

A female patient of 23 was operated in 1944 and died three days after the operation of Streptococcus meningitis. At operation a disc prolapse was revealed in the S I—L V interspace and removed. At that time, because of the war, we had not sufficient antibiotics at our disposal.

In the same year a male patient of 25 was lost, who also had a disc prolapse in the

S I—L V interspace. He died suddenly on the day after the operation. No autopsy was done.

In 1951 a male patient aged 37 was lost. At operation a disc prolapse was removed from the S I—L V interspace. The patient died four hours after the operation without recovering consciousness.

In 1952 a female patient of 35 was lost. It appears from the case history that in the operative region there were found large varicose veins. A wide opening had to be made and because of this a liquor fistula occurred. On the following day the patient had several attacks of cramp and died during one of them.

In 1955 a female patient aged 44 was lost. This is the only exitus case among the patients on whom a fusion operation was performed. Because of severe low back pain she had been incapable of work for one year. The last few months before operation she had spent in bed. At operation the nerve roots were found to be free but the S I—L V interspace very severely insufficient. A fusion operation was performed according to Albee's modified method. The graft was taken from the iliac bone. The patient was considerably stout and the ilium was covered with a comparatively thick layer of fat. She made a normal recovery after the operative shock but died suddenly of fat embolus on the third day after the operation.

X. DISCUSSION

The most essential cause of low back disorders centres on the pathophysiology of the disc. Whatever the original cause may be, congenital anomaly, developmental abnormality, or attaining static factors, etc., the disc factor becomes increasingly essential with the progress of the disease. In the end it often culminates in radiated sciatic pain due to a compression which gradually grows so severe as to invalidate the patient.

Again and again the good results of exclusively conservative treatment are being discussed. Again and again many physicians interested in these problems try to find a solution in the use of a lighter or heavier corset.

In the operative line extensive laminectomies have already been abandoned if the maintenance of sufficient static support is not simultaneously secured. There has also been prolonged discussion about the problem of whether to remove the whole disc or only the prolapsed portion of it. Nowadays most authors seem to be inclined to recommend total removal because it obviously reduces the possibility of recurrences. LOVE at Mayo Clinic, however, — based on 1217 cases — has not been in favour of total removal, in general (1947). LENHARD (1947) proved through a series of 843 patients that the final result is not dependent on the fact of whether the disc is removed in its entirety or only partially. Out of 147 cases LENHARD had 20 re-operations, most of which were after total removal. On the other hand, there is heated controversy as to whether to perform an immediate fusion or only a simple removal of a disc, with which to relieve, temporarily at least, the most incapacitating pain.

Unless we take into consideration the whole pathophysiological background of the extensive low back syndrome, it is quite futile to discuss the exclusive superiority of this or that operative method. We ought rather to pay attention to the definite facts that have been found out and may justify the application of a certain method.

In the low back syndrome the results of even more extensive investigations must necessarily remain vague because as yet we have no means of

stopping the continuous progress of the pathological cycle. Here we approach the pathological background which is common to several human diseases and combines with the general problem of ageing.

The low back and sciatic syndrome mostly begins with recurrent attacks of low back pain. The duration of these attacks is generally lengthened in course of time but, on the other hand, their intensity subsides. This, accordingly, is the main argument to justify conservative treatment in certain cases. Its anatomical and pathological background will be discussed later on.

Here we first ought to find out whether this sensation of pain could be related back to the disc itself. ROOF (1940) discovered nerve fibres deep in the posterior longitudinal ligament and in the disc itself, in the annulus fibrosus. He could not, however, discover their origin and course. EHRENHAFT (1943) also revealed nerve endings in the annulus fibrosus. It is also generally known that beside the anterior longitudinal ligament there branch off a great number of fine nerve fibres which accompany the blood vessels of the periosteum as far as the annulus fibrosus (JUNG and BRUNSCHWIG 1932). WIBERG (1949), too, saw nerve fibres in the posterior longitudinal ligament.

The disc itself seems to be rather devoid of sensory nerve fibres while in the surrounding tissue there is an ample supply of them. The sensory nerve system of the posterior aspect of the vertebrae is mainly based on the sinus vertebralis nerve. This is a recurrent branch of the spinal nerve, first described by LUSCHKA in the 1850's. It deviates from the posterior root of the spinal nerve postganglionically. After that it returns through the vertebral foramen recurrently and supplies all the ligament structures, capsules, posterior longitudinal ligament, and periosteum. It also sends sensory fibres to the posterior parts of the annulus fibrosus. The branching point of the nerve is always two segments lower than the real origin of the nerve, according to ROOF.

Since the sinus vertebralis nerve is a branch of the spinal nerve, it is quite understandable that it sends pain sensations to the gluteal region, too, and perhaps to the upper end of the thigh. Yet, it cannot transmit sciatic radiation.

PEDERSEN, BLUNK and GARDNER (1956) have shown through animal experiments that painful irritation of joints and ligaments in the lumbosacral region produces reflex spasm of the dorsal and hamstring muscles. WIBERG (1949) points out that the sinus vertebralis nerve divides into an upper branch and a lower branch after it has recurred postganglionically in the intervertebral foramen. In the same region there also appears bilateral anastomosis.

In several cases LERICH and JUNG (1930) caused the pain to subside and also the disc space to increase by injecting novocain round the vertebrae. They concluded that the pain originated in the ligaments round the disc causing contraction and narrowing of the interspace. They did not consider the possibility that the compression might come from the reflexes through the muscles.

Besides through anatomical investigations valuable information can of course be gathered during the operation itself through pain sensations. This can be done provided local anesthesia has been employed, which has no primary influence on the nerve root itself. This can be proved by touching the nerve root which always produces compression pain if not anesthetised. The palpation of the intervertebral disc regularly produces a pain sensation, too, (SPURLING and GRANTHAM 1940, WIBERG 1949). The ligamentum flavum, on the other hand, is insensitive. It may be operated without anesthesia. If the nerve root is anesthetised, pain sensation is produced through palpation of the disc. In this case the pain sensation must come either from the region of another root through the sinus vertebralis nerve or then through anastomosis of the sinus vertebralis from the opposite side. If two successive roots are anesthetised, the pain sensation still remains. This seems to be a proof of ROOF's statement that the distribution of the sinus vertebralis nerve may be even two segments downwards, or then the sensation is transmitted through contralateral anastomosis as mentioned above. The vertebral body itself is not sensitive, not that side, either, which faces the disc. It seems most likely as WIBERG says that a change in the relative positions of the vertebral bodies causes pain in the intervertebral disc.

Consequently, if the disc is intact, it cannot in all probability send any sensations of pain. The disc portion of the vertebral column is a notochordal joint, which has the same relation to pain sensations as the other joints. The joint itself produces no pain but its surroundings do: capsule, ligaments, muscle attachments etc. It is probable that acute lumbar attacks might well be due to the beginnings of insufficiency caused by a degenerative disc. There are other explanations, too, *e.g.* ANDERSEN (1943) suggests that pain might be caused by hemorrhage due to a rupture in the annulus fibrosus. WALDENSTRÖM (1944) maintains that when the nuclear tissue of the disc is extruded through a rupture in the annulus fibrosus, it first comes into contact with the peripheral root fibres and lumbago is a result of the ensuing irritation. If the rupture is larger there arises a real root compression. WIBERG (1949) suggests that the ligaments might be strained by the nuclear fragments at the rupture and the pain sensation transmitted by the nerves of the liga-

ments. True sciatic pain is produced by a prolapse compression on the nerve root.

The spinal column itself is subjected to continuous stress which is balanced when all the structures are sound. Physiological disstress is brought about *e.g.* by bending the back. The sacrospinal muscles, the quadratus lumborum, and the low back muscles in general take over the weight and also convey sensory impulses. If the disstress continues, the weight is distributed more heavily on the unyielding tissues, *i.e.* the ligaments. These are: lig. interspinale, lig. flavum, lig. intertransversale, capsular einforment, and lastly lig. supraspinatus. Consequently, if the supraspinal ligament is ruptured, it is fairly certain that other ruptures have already occurred in other ligaments. This opinion is also strengthened by the clinical findings the author has observed during operations.

The nucleus pulposus contains so much liquid — 80 per cent. — that it is not elastic in itself. It is incompressible and obeys the law of Pascal in this respect. The elasticity of the spine is due to the surrounding tissue, annulus fibrosus, lig. flavum, etc.

With the progress of degeneration the disc loses in height and elasticity and is no longer able to act as a buffer. The surrounding bones are subjected to pathological, traumatising stress, and this is perceived as hypertrophic arthritis with the development of spurs and bridges. The result is relaxation, the degree of which determines the corresponding extent of the prevailing insufficiency. The insufficiency begins to produce back pain. STEINDLER says in 1947, »A degenerated disc can and does produce the inclination to periodic attacks of soft-tissue strain in the lumbosacral junction or above, without necessarily being herniated.«

It has also to be borne in mind that due to relaxation and stress the pedicles, too, are pressed closer to each other. Narrowing of the intervertebral foramina takes place and with it also root compression may become manifest.

Here, too, as well as in other parts of the human body compression is sure to call forth stasis and edema. Edema, again, aggravates the pain. If a root sheath is not distinguishable in the myelogram and at operation no prolapse is found at the corresponding level, the operator has to be especially careful as to a possible compression of the root canal.

It remains uncertain whether the widening of the root canal will be the final solution because possible secondary changes in the bone structure have to be taken into consideration. In the author's opinion absolute immobilisation through fusion is the best means to do away with edema and with it also the patient's pain due to compression. This has been considered to be

one of the most important fusion indications in the relaxed low back even though the seeming insufficiency were slight.

Edemisation of the prolapsed disc in the region concerned already seems to be a significant factor in the rise of compression pain (STEINDLER, DEUCHEN, and LOVE, etc.).

The disc is able to expand many times its own size but with old people this capacity is weakened due to fibrosis. This is why a protrusion does not necessarily produce pain at that age.

The greatest anatomical and pathological changes as well as the contraction of the disc take place during the fourth and fifth decade of the patient's life (ECKERT and DECKER 1947). With age the compressing influence of the disc on the nerves is weakened.

These changes and the instability of the disc in relation to the nerve root forms the anatomical and pathological background which justifies the conservative treatment of this disease. Otherwise it would hardly be well-grounded.

Absolute rest always mitigates the edema in a prolapsed disc and with it there also disappears the root compression with the radiated pain in the lower extremities.

»Sciatic» scoliosis due to severe low back pain, of which *e.g.* ARMSTRONG (1952) has given a diagnostic description, is also done away with when the nerve root is relieved from compression.

From the diagnostic point of view it is good to bear in mind that if a disc prolapse is situated laterally in relation to the root, the tilt is to the opposite side. Due to scoliosis the nerve moves farther away from the disc.

If the operative treatment of low back pain and sciatica were examined against this background, the author would be willing to draw the conclusion that only through an immediate fusion can final cure be obtained. Thus, insufficiency and instability following the removal of a disc prolapse is best repaired by immediate fusion, too.

Yet, another thing is how this can be clinically carried out. It is also another thing how greatly the risk involving the patient increases with the widening scope of the operation, etc. These questions can only be answered through statistic investigations.

It has also to be considered that the first mobile disc above the fused region will be subjected to greater strain than before the fusion. This, again, may cause damage to this disc. FRIBERG reported in 1954 that in 8 per cent. of the cases investigated the disc above the bone graft revealed new degeneration. On the other hand, the disc at the sacrolumbar junction is in the

most difficult static position, and the burden received by the upper disc after fusion is not at all so heavy from the static point of view.

BARR mentions (1940) that 91 per cent. of the patients on whom fusion had been done in connection with a laminectomy were freed from sciatica, 73 per cent. from low back pain. Among those patients who had been treated without fusion, 69 per cent. were relieved from sciatica and 52 per cent. from low back pain. The total number of the patients is, however, as small as 94. The results without fusion are often claimed to be good by neurosurgeons. BARR says, »It seems probable that these men have been so impressed by the obvious relief of the patient's acute sciatic pain that they have failed to look carefully for later evidence of a mechanically unsound back.» In 1947 BARR re-examined 234 cases 102 of which had been done with fusion and 132 without fusion. The results were, on an average, 15—20 per cent. better in the former group. DAVIS (1947) reports his opinion to be that recurrence of pain and the danger of instability is greatest in the two lowest interspaces. Therefore the best thing in most if not in all cases would be immediate arthrodesis. Approximately 150 have been treated in this manner, and recurrences have practically been eliminated.

There are certain indications for bone graft operations. If there are no contraindications they can be carried out but not always (LOVE 1947). At Mayo Clinic, where LOVE gathered information from 1217 cases, they had performed a combined operation on 148 cases, *i.e.* on 12.2 per cent of the patients. In his conclusion LOVE mentions that the results are not so good as one might have expected though they are satisfactory. It is only continuous experience that teaches us how to decide which of the patients are in need of operative treatment.

GHORMLEY, LOVE, and YOUNG reported on 77 patients with protrused discs. On these there was performed a combined operation, laminectomy and fusion. The result was good in 64 per cent., fair in 25 per cent., and poor only in 11 per cent. of the cases.

STEINDLER says in 1947, »Fusion should be done in all cases in which instability of the lumbosacral junction has manifested itself by prolonged and repeated attacks of backache. This is a strictly local disturbance, and it is not taken care of by the removal of the disc.»

Instability may occur at the lumbosacral level though the disc might seemingly be intact. Examples of this are to be found in the cases for which PUTTI (1927) was the first to recommend a facetectomy as mentioned earlier in this book in Chapter VI. For the diagnosis of this state SCHLESINGER (1957) gives the following indications: The nerve root is edematous, scarred,

or enlarged. The nerve root is adherent, angulated, or tensed, or its retractibility is reduced. A contracted lateral recess, that is, the upward projecting articular process approximating the anterior structures.

It still remains uncertain if the facetectomy, after all, is the method to bring any final cure in these cases. Lasting insufficiency persists after the removal of compression and an increase of this insufficiency may lead to another compression. By fusion it is, at least, possible to prevent neoformations and to eliminate the part played by the sinus vertebralis nerve in causing pain.

A very interesting series of 100 fusion operations has been reported by STINCHFIELD and SINTON (1952) from New York. Their indications follow quite the same lines as this work. In 44 cases fusion was done for a mechanical defect, in 32 for instability, in 8 for spondylolisthesis. In the remaining 16 cases fusion was decided upon during the operation. Only the affected interspace was fused, as a rule. The number of S I—L V cases was 45, S I—L IV cases 45, L III—L V cases 2, L IV—LV cases 6, L III—S I cases 1, and Th IX—XI cases 1.

The youngest patient to be operated was 15 years, the oldest 57 years old. The routine method eployed was the H-graft (94 cases).

The fusion technique has been described in detail. The bone transplant was taken from the posterior aspect of the ilium. No pain was felt at this site after operation as is often the case when the transplant is taken from the anterior part of the ilium. Among these cases residual back pain was felt by 13 patients only, and seven of these resumed their former work. The frequence of pseudoarthrosis was 6 per cent.

Thus, one cannot help being fairly convinced that a fusion operation is a good method for repairing instability due to various factors. Quite opposite opinions are, however, also presented. In 1948 CALDWELL and SHEPPARD reported on cases treated, with fairly good results in 82.6 per cent., without fusion. The value of this material is, however, small because the results are based on only 75 re-examined cases. LENHARD (1948) reports on 515 cases operated by a neurosurgeon without fusion. Good results were achieved in 64 per cent. but 20 per cent. of the cases were so poor that the patients had at times to absent themselves from their work due to severe pain. LENHARD concludes that a combined operation may, after all, be more justifiable in selected cases.

LOGUE (1953) objects to primary fusion on the grounds of the following arguments: »Only few patients have back pain after operation severe enough to incapacitate them. — — It is impossible to recognize this small group

pre-operatively either on clinical or radiological grounds. — — The (combined) operation is more serious and carries a higher risk. — — Fusion necessitates the patient staying in bed between 6 to 12 weeks.»

A very well known record of 500 disc operations was published by O'CONNELL in 1951. These were performed without primary fusion and 92 per cent. of the patients have either been cured or remarkably improved. Some of them, however, have later been fused by an orthopedist because of persistent backache.

The literature makes one convinced that most of the patients to be operated for sciatic and low back pain can be permanently aided through a simple disc operation. Primary fusion is necessary only in certain selected cases. The case is quite different, however, if the operator is concerned with congenital anomalies or large ligament ruptures, spondylolisthesis, or, in general, so great a secondary instability that it is sure to cause persistent pain if left unrepaired.

In the author's material primary fusion has been carried out in 68 cases with excellent results in 70.7 per cent., good in 13.3 per cent., improved in 13.3 per cent., and poor in 2.9 per cent., *i.e.* either excellent or good results in 83.8 per cent. Pseudoarthrosis in 6 per cent.

The subjective results of the total are as follows: Completely cured 60.2 per cent., completely cured or considerably improved 70.8 per cent., improved 19.4 per cent., poor 9.8 per cent.

These figures are not quite comparable but they are clearly indicative of the usefulness of fusion operations.

The most difficult and certainly the most exacting surgical problem within the low back and sciatica syndrom consists of the spondylolisthesis cases. These conditions are of greater importance, and their incidences as a cause of low back pain with or without sciatica are higher than many realize. When examining 4200 skeletons ROCHE and ROWE (1952) discovered a tendency to olisthesis or an incidence of defects in the neural arch in 4.2 per cent. The cause of spondylolisthesis was long held to be of congenital origin. Yet *e.g.* the observations by HADLEY (1955) bear strong evidence to its traumatic origin. The masses bulging towards the spinal canal resemble callus formations typical of fractures. GILL, MANNING, and WHITE discovered considerable amounts of fibrocartilaginous tissue in the affected parts of the neural arch. The latter investigators have also recommended an operative method in which the loose portion of the arch in its entirety is removed as far as the articular facet of the sacrum. Thus the masses compressing the nerve

roots can be got rid of altogether. No fusion operations have been performed in connection with this method. The results in more than twenty cases have been promising.

HARRIS (1955), again, is a keen supporter of fusion. He defends his opinion on the grounds of over 200 spondylolisthesis cases treated by himself.

It seems very probable that in spondylolisthesis as well as in other low back disorders the pain issues from two sources: low back pain from the unstable vertebral body, and sciatica from nerve-root pressure.

HARRIS says, »It has not been emphasized sufficiently that movement is an important factor in the production of pain in spondylolisthesis, — not only pain due to the instability of the vertebral body but also that due to nerve-root pressure. The elimination of movement by a successful lumbo-sacral fusion is sufficient to relieve the patient of his symptoms.«

BOSWORTH's experiences also support this conclusion. His results from a series of cases were as follows: After the initial operation solidity of the fusion was achieved in sixty-two patients out of seventy-three (in 85 per cent.). Pseudoarthrosis developed in eleven cases (15 per cent.). Repair was attempted in five and fusion resulted in four cases. Thus, solid fusion was ultimately obtained in sixty-six patients (90 per cent.).

It seems that there are good grounds for adopting this line in the treatment of spondylolisthesis.

The use of fusion in the treatment of other conditions leading to secondary back insufficiency chiefly depends on the graveness of the condition and makes also great demands on the operator.

XI. CONCLUSIONS

I. No symptom or a complex of symptoms is distinctly pathognomonic in sciatica and/or low back disorders. The diagnosis is always based on a syndrome in which each factor points in a clearly different direction.

II. Pain is usually first felt in the low back and it gradually develops into sciatica radiating down into one or both of the legs. With persistent symptoms the disc factor begins to appear more distinctly.

III. If a secondary low back insufficiency has progressed too far the patient cannot be freed from his symptoms without an operation whatever the causes then may be. Here a combined fusion operation gives the best results.

IV. The best and most reliable treatment of secondary insufficiency is a fusion operation.

V. Fusions of Albee's, Bosworth's, and the double-graft type are equally successful provided an ample amount of bone chips is applied. The author has no experience in intercorporal fusions but because of the segmental character of the spinal column their lasting firmness may be doubted. A corset is not necessary for the aftercare of fused patients.

VI. The subjective results of the total survey are as follows: 60.2 per cent. completely cured, 70.8 per cent. completely cured or remarkably improved, 19.4 per cent. improved, 9.8 per cent. not cured.

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