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POSTERIOR FUSION OF THE LUMBOSACRAL SPINE

Evaluation of the Operative Results and the Factors Influencing Them

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The operative results of 79 patients subjected to posterior fusion of the lumbosacral spine were evaluated on the basis of a follow-up examination performed on average 5.4 years after operation. A method of evaluation was developed which measured the patients' subjective improvement and working capacity. The method proved appropriate for clinical use and gave a more correct picture of the operative result than methods relying on the patient's own opinion or the radiographic assessment as the only criterion. Sixty per cent of the patients were subjectively improved, 40 per cent had returned to their previous or a corresponding occupation and 24 per cent had a good operative result, assessed by the method applied.

A statistical analysis was performed in order to find the factors influencing the operative results. Age over 40 years, heavy or moderately heavy preoperative work and over 6 months' preoperative disability had a statistically significant, unfavourable effect on the results. In the case of labourers in heavy occupations, working capacity was seldom restored to a degree sufficient for return to their previous work.

The operative technique proved reliable with 91 per cent successful fusions, assessed from functional radiographs. Successful fusion did not imply a good operative result, although it did so more often than non-fusion.

On the basis of this study, operative fusion of the lumbosacral spine seems to be of relatively little value in the treatment of patients suffering from low back pain, and factors other than purely medical or surgical have a considerable influence on the operative results.

Key words: backache; lumbar vertebrae; lumbosacral region; non-fusion; operative results; spinal diseases; spinal fusion; spondylolisthesis; working capacity

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Operative fusion of the lumbosacral spine is used in the treatment of low back pain due to instability caused by anomalies and diseases of the lumbosacral spine. Fusion is accomplished by various operative techniques. The different methods have often been evaluated using the radiological success of the operation as the principal criterion (Thompson & Ralston 1949, Adkins 1955, Boucher 1959, Buck 1970). However, successful fusion does not necessarily imply that the patient is improved (Cleveland et al. 1948, Shaw & Taylor 1956, Stauffer & Coventry 1972, Morscher 1974, Samimi 1974, Weber & Peyer 1974).

The goal of the operation is to relieve the patient's backache and to bring about functional improvement of the back. Hence, the patient's subjective symptoms and working capacity must be considered in evaluating

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the results. Little is known about the effect of lumbosacral fusion on the patient's capacity for work.

An understanding of the factors influencing the operative results is a prerequisite for appropriate selection of patients for operation and avoidance of unnecessary operations. In previous series, purely medical and surgical aspects have been the main objects of investigation. Only exceptionally have the economic, social, occupational and psychological factors been considered in connection with operative fusion of the lumbosacral spine (Eriksen 1960, Rombold 1966, Stauffer & Coventry 1972, Kokan et al. 1974, Weber & Peyer 1974).

One purpose of the present investigation was to develop a clinically useful method for the evaluation of the operative results of lumbosacral fusion; another purpose was to detect factors influencing the results. In this paper, a method of evaluation considering the patients' subjective improvement and working capacity is described, and the follow-up results in 79 cases of lumbosacral fusion and the factors influencing these results are presented.

PATIENTS AND METHODS

Patients

The series consisted of 89 patients subjected to posterior fusion of the lumbosacral spine at the Central Hospital, Tampere, between 1968 and 1975.

The mean age of the patients was, at the time of operation, 36 years, range 16–59. Forty-three patients were female, 46 male. Eighty-four were labourers, five sedentary workers. The occupations represented fell into the category of heavy manual labour in 49 cases, moderately heavy in 24 and light in 11.

All patients had suffered from low back pain causing working disability or marked restriction of daily activities. The average duration of preoperative low back pain was 8 years and 8 months, ranging from 7 months to 28 years. The preoperative duration of disability was on average 10 months and 2 weeks, ranging from none to 11 years.

Almost all patients had been conservatively treated for low back pain. Rest was the best therapy and had brought relief in four-fifths of the cases. Previously, a total of 23 back operations had been performed on 15 of the patients.

The operative diagnosis was spondylolysis and spondylolisthesis in over half of the patients, and degeneration of the lumbosacral spine in less than one quarter (Table 1).

Operative technique and postoperative treatment

A straight longitudinal skin incision in the midline was made at the level of L2–S2.The lumbosacral fascia was split on both sides of the spinous processes. The muscles were detached beginning from the midline and turned aside. The spinous processes and laminae were freed from soft tissue and freshened. The same was done with the posterior surface of the sacrum if fusion was to be extended that far. The joints were crushed with a chisel.

A bone graft 2 cm in breadth and corresponding in length to the fusion area was detached from the iliac crest and split. The two bone grafts thus obtained were modelled to fit the fusion area and applied longitudinally on both sides of the spinous processes. The gaps remaining between the bone grafts and the freshened surfaces were filled with chips of cancellous bone taken from the iliac crest (Figure 1).

Table 1. Operative diagnoses of 89 patients

Diagnoses	Number of patients	
Spondylolysis and -olisthesis[1]	48	
Grade I		23
Grade II		23
Grade III		2
Grade IV		0
Degeneration of the lumbosacral spine	20	
Disc degeneration		14[2]
Disc herniation		6[3]
Lumbarization-sacralization	12	
Unsuccessful previous fusion	4	
Chronic lumbosacral insufficiency	2	
Lumbar scoliosis	2	
Sequela of fracture of L5	1	
Total	89	

[1] Meyerding's (1932) classification
[2] Six of these patients were previously operated on for a herniated disc
[3] Three of these were recurrent herniations

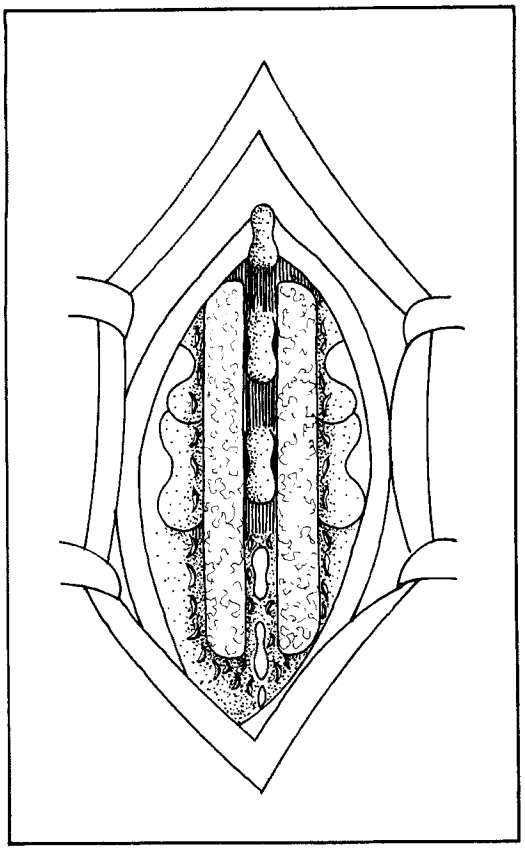

Figure 1. Operation area with the massive iliac bone grafts and cancellous bone chips.

Postoperatively the patient was nursed prone in the bed for 3 weeks, after which cautious turning was allowed. Getting out of bed was allowed after 6 weeks. Isometric exercises of the back muscles were started under the guidance of a physiotherapist on the day after operation. The lower extremities were bandaged with elastic dressings in order to avoid venous thrombosis. The patient was discharged in the seventh postoperative week and allowed to sit and to bend his back cautiously 3 to 4 months after the operation. No lumbosacral support was used. The patients were allowed to return to work between 4 and 6 months after operation, depending on the occupation.

Fusion was performed by the technique described above (a combination of Hibbs' (1911) and Albee's (1911) methods) in 82 cases, by other methods in seven. The fusion area was L4-sacrum in 70 cases (79 per cent), L3-sacrum in 14, L5-sacrum in three, L2-L5 in one case, and L3-L5 in one. Six operations included excision of a herniated disc.

The duration of operation was on average 2 hours and 5 minutes, the range being from 1 hour and 15 minutes to 3 hours and 10 minutes. The average peroperative bleeding was about 1000 g, range 200 to 4000 g. During operation or postoperatively 71 patients received an average of 1100 g blood.

Complications

Complications occurred in 18 patients (20 per cent) during their stay in hospital. Pulmonary embolism was diagnosed in two cases (one of these patients died on the eighth postoperative day), deep venous thrombosis of the lower limb in four, wound infection in two, urinary infection in seven, respiratory infection in three, an allergic skin reaction due to sulphonamide medication in one, and in one case a bedsore developed during the period of bed rest.

In eight patients (9 per cent) the following late complications developed: superficial wound infection in the back in two, superficial infection of the wound in the donor area in one, vertebral L4–5 block in two (in consequence of postoperative spondylitis), osteitis in the fused area in one and osteophytosis in the donor area in two cases.

Follow-up examination

Preliminary data were obtained from the patients' records, and additional information at the follow-up, including the results of clinical and radiological examinations. Invitation to follow-up was accepted by 79 patients (89 per cent). The follow-up period was on average 5 years and 5 months, ranging from 1 year and 3 months to 9 years.

Evaluation of the operative results

The operative result was assessed in the individual case by a score given on the criteria presented in Table 2. A score of 16–20 points represented a good result, a score of 9–15 points a fair result and a score of 0–8 points a poor result. The success of fusion was not taken into account in assessing the result of operation.

Radiological examination

The patients attending the follow-up were subjected to radiological examination of the lumbosacral spine, with the exception of two pregnant women. A radiographer took an anteroposterior

Table 2. Criteria for evaluation of operative results

Criteria for evaluation	Scores
Change of subjective symptoms	
Much better	5
Better	3
No change	1
Worse	0
Symptoms at follow-up (only the lowest score considered)	
No pain	5
Pain during heavy work	3
Pain after lengthy sitting	2
Pain during light work	1
Persistent pain	0
Working capacity	
Previous or a corresponding work	5
Lighter work owing to back pain	2
Lighter work for other reasons	*
Pensioned because of back pain	0
Pensioned for other reasons	*
Succeeds in work (pensioner in daily activities)	
Well	5
Fairly well	3
Poorly	0

* Same score as for "symptoms at follow-up".

view and two lateral views, one in extension, the other in flexion, with the patient recumbent. A radiologist completed the examination by taking pictures under fluoroscopic control with the patient standing in maximum extension and flexion.

Intervertebral movement in the fused area was considered a sign of non-fusion. A change by at least 2 mm in height of the anterior portion of the intervertebral space or a dislocation by at least 2 mm in the horizontal plane, measured on the extension and flexion views, were considered the criteria of movement.

As suggested by Meyerding (1932), spondylolisthesis was classified into four grades on the basis of the extent of dislocation.

Statistical and computational methods

The numerical data was processed by a universal digital computer (DGC Eclipse C/300). The data description was achieved by library programmes. The individual routines needed in the study were programmed. In testing statistical hypotheses the chi-square and t tests were used. The computation of the test scores was included in the programmes in order to avoid time-consuming manual calculations.

The groups were considered comparable when the null hypothesis was not refused on the level $\alpha = 0.1$ or the chi-square statistic computed from the fourfold table ($\gamma = 1$) was smaller than 2.706.

RESULTS

Clinical results

The clinical results were analysed in detail in those 63 patients, who had been subjected to their first fusion by the technique described above and had a radiologically successful fusion.

Subjective improvement. At follow-up, 38 patients (60 per cent) stated that their back was much better, and 17 that it was better than before operation. Four patients' symptoms were unchanged and four were of the opinion that their back was worse.

Working capacity. The duration of post-operative disability was under 5 months in four patients, from 5 to 7 months in 21, from 7 to 12 in 15 and over 12 months in 23.

At the time of follow-up 40 per cent of the patients worked in their previous or a corresponding occupation, while 25 per cent had shifted to lighter work (Table 3). Twenty patients (35 per cent) were unable to work because of the condition of their back. Of these, 16 had been constantly disabled post-operatively, while four had worked for at least 1 year and then become disabled.

Of those patients who considered themselves much improved, nearly one quarter had shifted to lighter work and more than one quarter were disabled owing to back pain (Table 3). The proportion of persons who succeeded well in their previous or a corresponding work was 14 per cent.

Factors influencing the postoperative working capacity. Working capacity at the time of follow-up was compared with age at the time of operation, the kind of preoperative work,

Table 3. Working capacity at follow-up compared with subjective improvement in 57 patients[1]

Subjective improvement	Number of patients	Previous or a corresponding work	Lighter work owing to the back pain	Pensioned because of back pain
Much better	34	17	8	9
Better	15	2	4	9
No change	4	3	1	0
Worse	4	1	1	2
Total	57	23	14	20

[1] From the table are omitted two patients who had shifted to lighter work and four who were disabled for some cause other than the back pain.

the duration of peroperative symptoms and disability, the benefit possibly derived from preoperative rest or the use of a lumbosacral corset and the number of previous back operations.

A statistically significantly more reduced postoperative working capacity was noted in

- patients over 40 years old compared with those under 40 ($P < 0.025$) (groups comparable with regard to kind of preoperative work and duration of disability),
- labourers doing heavy work compared with the remainder of the patients ($P < 0.0025$) (groups comparable with regard to age and duration of disability),
- patients preoperatively disabled for over 6 months compared with those disabled for less than 6 months ($P < 0.0125$) (groups comparable with regard to age and kind of preoperative work).

The number of previous back operations, the duration of preoperative symptoms and the benefit possibly derived from rest or the use of a lumbosacral corset had no effect on postoperative working capacity.

Operative results and factors influencing them. According to the criteria applied (Table 2), the operative result was good in 15 patients (24 per cent), fair in 29 (46 per cent) and poor in 19 (30 per cent). The mean score was 11.6.

The operative results were compared with age at the time of operation (Table 4), kind of preoperative work (Table 5) and duration of preoperative disability (Table 6). On the basis of the scores for the patients, the operative result was poorer to a statistically significant extent in

Table 4. Operative results compared with age at operation in 63 patients

Age (years)	Number of patients	Operative result			Mean score	
		Good	Fair	Poor		
⩽20	7	2	5	—	14.4	
21–30	14	2	7	5	11.9	12.4
31–40	20	6	8	6	12.1	
41–50	17	5	5	7	9.9	10.1
> 50	5	—	4	1	11.0	
Total	63	15	29	19	11.6	

Table 5. Operative results compared with type of preoperative work in 63 patients

Type of work	Number of patients	Operative result			Mean score
		Good	Fair	Poor	
Heavy manual labour	38	6 (16 %)	19	13	10.7
Moderately heavy manual labour	15	4 (27 %)	7	4	12.0
Light manual labour	5	4 (80 %)	1	0	16.4
Sedentary work	5	1	2	2	11.8
Total	63	15	29	19	11.6

Table 6. Operative results compared with preoperative duration of disability in 63 patients

Preoperative disability (months)	Number of patients	Operative result						Mean score	
		Good		Fair	Poor				
<1	15	7	(35 %)	5	3	(16 %)		14.5	13.5
1–6	22	6		13	3			12.8	
6–12	9	0	(8 %)	4	5	(50 %)		8.0	8.9
>12	17	2		7	8			9.3	
Total	63	15		29	19			11.6	

- patients over 40 years old compared with those under 40 ($P < 0.05$) (groups comparable with regard to kind of preoperative work and duration of disability),
- labourers doing heavy work compared with the remainder of the series ($P < 0.05$), labourers doing heavy or moderately heavy work compared with those doing light work ($P < 0.0125$) and labourers doing heavy work compared with those doing light work ($P < 0.01$) (groups comparable with regard to age and duration of preoperative disability),
- patients who had been disabled preoperatively for over 6 months compared with those disabled for less than 6 months ($P < 0.0005$) (groups comparable with regard to age and kind of preoperative work).

Patients with previous back surgery had slightly poorer results than those who had not previously undergone any back operations. This difference was statistically almost significant ($P < 0.1$), but it was explained by a greater number of patients over 40 years old in the first group.

On the other hand, the duration of preoperative symptoms, preoperative benefit of a lumbosacral support and the operative diagnosis had no statistically significant effect on the results of operation.

Patients with non-fusion. Radiological examination showed that fusion had failed to occur in six patients, three of whom had a fair and three a poor clinical result. Two of these patients stated that their back was much better than before operation, three that it was better, while one patient reported increased back pain.

The mean score for the patients with non-fusion was 8.2 and the operative results were

statistically significantly ($P < 0.05$) poorer in this group than in the group of successful fusions.

The group of patients with non-fusion was comparable with the successfully fused patients with regard to age and preoperative duration of disability, but their preoperative work was statistically significantly ($P < 0.05$) lighter in character.

Radiological results

Success of fusion. Of the patients subjected to their first fusion by the technique described above, 69 were radiologically examined as described in the foregoing. Fusion was established in 63 cases (91 per cent) and non-fusion in six (9 per cent). In two cases non-fusion was only noticed on the functional radiographs taken under fluoroscopic control with the patient standing.

The frequency of successful fusions was not influenced by the number of fused segments, the operative diagnosis, the degree of spondylolisthesis, the age or the sex of the patient.

Spinal stenosis. Radiologically, narrowing of the medullary canal was not observed in any patient, but plain radiographs of fused patients hardly permit any confident statement on this point.

DISCUSSION

The results of fusion of the lumbosacral spine have been extensively studied for the last 50 years. A wide variation noticeable in the results is obviously due to differences in the series and in the methods of assessment. In evaluating the operative results, the patient's subjective estimates and working capacity, and the success of fusion are the possible aspects to be considered. Furthermore, factors influencing the operative results and the value of operative fusion in the treatment of low back pain are essential objects of discussion.

The patient's subjective estimate

The patient's opinion of the operative result is an important criterion in evaluating the results of fusion, since the patient's subjective symptoms constitute the indication for operation. However, this approach to evaluation implies sources of error, since subjective improvement may be influenced also by factors not related to the operation.

In previous reports, complete relief of symptoms has been achieved by lumbosacral fusion in 0 per cent (Stauffer & Coventry 1972) to 97 per cent (Werlinich 1974). In general, at least a good subjective result has been achieved in 70–93 per cent of patients subjected to anterior interbody fusion (Harmon 1960, 1963, Sacks 1965, Hoover 1968, Freebody et al. 1971), in 65–96 per cent of those subjected to posterior interbody fusion (Cloward 1963, Wiltberger 1964), in 76–93 per cent of posterolateral fusion cases (Truchly & Thompson 1962, Rombold 1966, Enslin 1975, Saunders & Jacobs 1976), in 83–94 per cent of H-graft fusions (Bosworth et al. 1955, Barr et al. 1967, Langenskiöld 1967) and in 72–99 per cent of cases operated on by various methods of posterior fusion (Howorth 1964, Lettin 1967, Weber & Peyer 1974, Attenborough & Reynolds 1975). Although the series are not comparable with regard to indications for operation and principles of assessment, it appears that no definite differences can be demonstrated in the degree of subjective improvement achieved by the different operative methods.

Of the present patients, 60 per cent had a good subjective improvement (much better than before operation), which is a somewhat poorer result than those reported in previous series. However, since only 13 per cent were entirely symptom-free and only 14 per cent tackled their previous work successfully, subjective improvement alone must be considered an inadequate measure of the results of fusion.

Postoperative working capacity

Since the aim of lumbosacral fusion usually is to restore the patient's working capacity,

this is an important consideration in assessing the results. Furthermore, working capacity may be regarded as an essentially objective criterion, compared with the opinions of the patient or the doctor examining him, which are subjective criteria. The value of working capacity as a criterion is, however, reduced by the fact that it is in part influenced by factors other than medical: motivation for work, the job market and the advantages offered by the social security and insurance systems.

A comparison of previous investigations seems to indicate that postoperative working capacity is dependent on the operative diagnosis, but not on the operative method. In series of fusions principally connected with excision of a herniated disc, 79–98 per cent of the patients returned to their previous occupations (Cloward 1963, Harmon 1963, Barr et al. 1967, Thompson et al. 1974, Werlinich 1974). On the other hand, in series consisting for the most part of re-operations, a working capacity permitting return to previous work was attained by only 53–63 per cent (Truchly & Thompson 1962, Stauffer & Coventry 1972, Saunders & Jacobs 1976). Of patients with spondylolisthesis, 47–69 per cent are postoperatively found "free from trouble in all work" (Laurent 1958, Klenerman 1962).

Our results were somewhat poorer. Statistical analysis, performed to detect the sources of our poor results, showed that age over 40, a preoperative occupation implying heavy manual work and over half a year's preoperative disability were significant causes of reduced postoperative working capacity.

Methods of assessment

Friberg (1939) introduced a method of assessment combining the subjective (patient's own opinion) and objective (working capacity) results of operation. However, in analyses of the results of lumbosacral fusion, many authors have used subjective improvement as the only criterion (Cleveland et al. 1948, Bosworth et al. 1955, Harmon 1960, Howorth 1964, Sacks 1965, Rombold 1966, Lettin 1967, Hoover 1968, Freebody et al. 1971, Weber & Peyer 1974, Attenborough & Reynolds 1975, Enslin 1975).

The present investigation shows that an estimate of the operative results based exclusively on subjective evaluation is too favourable (Table 3). On the other hand, working capacity alone represents only one aspect of the total situation, since the patient's symptoms are not taken into account. A combination of these two criteria seemed reasonable, and the method of assessment was developed on this principle (Table 2). Using this method, a good operative result was noted in 24 per cent of patients, which is more realistic a result than 60 per cent good results based on subjective improvement alone.

Factors influencing the operative results

The low ratio of good results obtained in this series gave occasion for a statistical analysis aimed at detecting factors of prognostic value for the results of operation.

A statistically significant difference was observed between patients over and under 40 years old, the results for the former being poorer. Rombold (1966) and Weber & Peyer (1974) also reported more favourable results in younger than in older patients, whereas Stauffer & Coventry (1972) were not able to demonstrate any effect of age on the operative results.

A preoperative occupation implying heavy manual work impaired the results to a statistically significant extent. This is in agreement with Eriksen's (1960) observation that lumbosacral fusion is of no real benefit to workers in heavy occupations. On the other hand, Stauffer & Coventry (1972) and Kokan et al. (1974) noticed no effect of occupation on the results of fusion.

The results for those who had been disabled for over 6 months preoperatively were statistically significantly poorer than the

results for patients with a shorter duration of disability. In previous reports attention has not been paid to this factor, which the present authors regard as a very important one.

It has been shown that previous operations impair the results (Harmon 1963, Wiltberger 1964, Kokan et al. 1974, Thompson et al. 1974). A similar trend was noticed in this series.

We have previously believed that patients benefitting preoperatively from the use of a lumbosacral support would have good operative results. This assumption proved erroneous.

On the basis of this study, the factors influencing the operative results of lumbosacral fusion are not purely medical or surgical, but rather related to occupational and social aspects.

Assessment of the success of fusion

Although the aim of fusion is to alleviate the patient's back symptoms, there are two reasons why the technical success of fusion must also be considered:

1. A measurement of the technical reliability of various fusion methods is desirable.
2. To make it possible to assess the role of fusion in the patient's improvement, it is necessary to know whether fusion has occurred.

In this investigation two methods of functional radiography were used, one of which differed from the hospital routine: While checking the bendings with the aid of fluoroscopy, the radiologist took views with the patient standing. It was thus ascertained that the projections were entirely straight, that the radiographs were taken at the right level and that maximum extension and flexion were maintained. For the assessment of non-fusion this method proved superior to the ordinary functional examination performed by a radiographer.

In previous reports fusion of two segments performed by Hibbs' (1911) technique has been successful in 70–75 per cent (Thompson & Ralston 1949, Howorth 1964), by the H-graft technique in 64–83 per cent (Cleveland et al. 1948, Barr et al. 1967), while interbody two-segment fusions have been successful in 53–79 per cent (Wiltberger 1964, Stauffer & Coventry 1972) and posterolateral in 93–94 per cent (Truchly & Thompson 1962, Thompson et al. 1974). The high rate of successful fusions in the present series (91 per cent) may be attributable to the extensive operative technique and the long immobilization in bed. A comparable success rate for two-segment fusions has only been reported with the posterolateral technique.

Relationship between operative results and success of fusion

Many previous authors have reported that non-fusion did not impair the operative results (Eriksen 1960, Kelly 1962, Howorth 1964, Lettin 1967, Freebody et al. 1971, Turner & Bianco 1971, Morscher 1974, Samimi 1974, Rothman & Booth 1975), while others, in agreement with this study, have noticed more favourable results in connection with successful fusions (Cleveland et al. 1948, Bosworth et al. 1955, Laurent 1958, Stauffer & Coventry 1972, Thompson et al. 1974, Weber & Peyer 1974). In the light of these contradictory observations the value of lumbosacral fusion in the treatment of patients with low back pain seems doubtful.

Value of lumbosacral fusion

There has been a considerable difference of opinion concerning the value of lumbosacral fusion in the treatment of low back pain. Friberg (1954) believed that it is usually sufficient if the patient shifts over to lighter work. Nachemson (1976) also was of the opinion that fusion is hardly ever indicated in chronic cases of backache, except in young patients with spondylolisthesis and in cases of recurrent disc herniations. On the other hand, Cloward (1963) considered fusion the best therapy for low back pain, irrespective of the diagnosis.

It is beyond dispute that very favourable

results have been reported in some previous investigations, but the attitude to the principles of evaluation could have been more critical, and the best results have been obtained in series consisting mainly of disc herniations. Young et al. (1955) reported 20 per cent more satisfactory long-term results when excision of a disc was combined with fusion than when disc excision alone was performed. By contrast, Barr et al. (1967) and DePalma & Rothman (1969) observed no significant difference between the operative results in these two groups. Considering, in addition, that in many investigations no essential difference in improvement has been noted between the fusion and non-fusion groups, it may be stated that lumbosacral fusion is of relatively little value in the treatment of patients suffering from low back pain.

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