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Treatment of Cervical Disc Disease Using Cloward's Technique
I. General Results, Effect of Different Operative Methods and Complications in 1,106 Patients*

By

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With 7 Figures

Summary

During the period from April, 1965, to October, 1979, 1,106 patients with symptoms or signs of cervical disc disease were operated on using Cloward's technique. 94% of the patients alive filled in a questionnaire forwarded on October, 1980. The study revealed that 81% experienced an immediate effect of the operation, and 63% were in a better condition than preoperatively at the time of the questionnaire. It appeared that the effect of the operation 1 year postoperatively was independent of age and observation time, but the functional result and postoperative working capacity were very significantly better in young patients, but still independent of observation time. The result was independent of the number of primarily inserted grafts, cutting of the posterior spinal ligament or the finding of a free herniated disc. Use of calfbone grafts resulted in more reoperations.

Primary complications were registered in 13% of the patients, reduced to 5% after 3 months. 3 patients developed a severe tetraplegia, and 6 patients died within 3 months of the operation.

Keywords: Cervical disc disease; anterior cervical fusion; Cloward's operation; observation time; outcome; complications.

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Introduction

That the treatment of cervical spondylosis and disc herniation (cervical disc disease) remains a controversial issue is indicated by the different surgical techniques proposed[1]. Throughout the past decade a trend towards the anterior surgical approach has become increasingly obvious, however[2].

The results of many studies are confusing, considering the clinical symptoms[11,13], in some studies, however, this may be prevented by larger samples of patients. Furthermore different methods of anterior disc surgery have been advocated on the basis of clinical material, including 26 to 52 patients collected over a period of 5 years[8,11]. The results achieved have often been incomparable mainly owing to differences in the selection of patients and in the indications for surgery[20].

The purpose of presenting this relatively large series is to provide a more reliable information about the role of clinical, radiological, and surgical findings and strategy in order to achieve the best result for the patient.

In this survey the general long-term results—which were identical in the groups of patients operated for discogenic symptoms[5], radicular phenomena and spinal cord symptoms, respectively—are presented, as well as the results from different operative strategies and the complications. Also, the specific role of symptoms, clinical syndromes and radiological features will be presented.

Material

Since 1965 Cloward's operation[3] has been the treatment of choice for cervical disc disease at the Department of Neurosurgery, the University Hospital, Aarhus, and during the period from April, 1965 to October 1979, 1,356 patients were operated on. This study comprises 1,106 patients who underwent surgery for treatment of cervical disc disease. The following groups of patients are not included:

1. 81 patients who had previously undergone surgery of the cervical column, brachial plexus or a peripheral nerve at the upper extremities.

2. 109 patients with other neurological diseases, *e.g.*, cerebrovascular diseases, multiple sclerosis, primary lateral sclerosis, and tumours related to the spinal canal.

3. 76 patients with acute cervical fractures.

Due to overlap a total of 250 were excluded. All remaining 1,106 patients had symptoms and/or signs indicating cervical disc disease. 70, 77, and 15% presented with cervical, radicular and/or spinal cord symptoms respectively. Prior to surgery conservative therapy of varying extent and duration was carried out. Preoperative

myelography was performed in 91% of the cases. All operations were performed as described by Cloward[3]. Postoperatively the patients wore a stiff collar for 2–3 months until 1973. After that a soft collar was used for 6 weeks.

Methods

The clinical symptoms and signs, radiological and operative findings, complications, postoperative course, and the patient's condition at the first follow-up examination were registered retrospectively. At the time of the follow-up examination, which was on average performed 3.8 months after surgery (range 2 weeks to 6 months), 1,100 were alive and 1,027 patients (93%) completed the examination. By November 1980 all patients who were still alive (988) received a questionnaire of which 94% were returned. Mean observation time was 7 years (range 1–15 years).

All parameters were stored and calculations were made in a Data General Eclipse s 250 computer. Table 1 shows the number of registered and calculated parameters.

Based on actual symptoms of pain (in head, neck, extremities), sensibility loss and paresis, a functionally good result was obtained when the patient had no disabling symptoms.

In tables where the frequency of reoperation is used to indicate an effect, we considered all patients (alive or dead) in the group concerned when calculating this frequency.

Statistical Evaluation

Even in this material it has been necessary in many contexts to use small groups for testing relevant relationships. Consequently several levels of statistically significant levels are used. $p < 0.001$ is considered as almost certainly statistically significant. $p < 0.01$ highly significant and $p < 0.05$ significant.

In a few cases the exact p value is given either to demonstrate similarities or—in context of important arguments—to demonstrate the significance level in small samples of patients.

The method used is: comparing groups of patients: Chi-square contingency tables or Fischer's exact probability test. Trends in curves with binary logistic regression methods (the GLIM system)[4]. The 95% confidence limits due to binominal distribution. Comparing age and duration of symptoms by SEM.

Reliability of Data Obtained and Homogeneity of Material

The retrospective nature of the study gives some inborn errors, *e.g.* lack of standardized examinations and possibly also of relevant observations. In the parameter concerning muscular atrophy there was a lack of information in 3% of the material. In all other parameters the uncertainty is less than 3%.

In a study comprising 150,000 registrations, errors in transferring data from the patient's sheet to the computer's disc are inevitable. Of the 115 primary parameters we cross-linked 55 parameters in the computer programme. Errors were found in approximately 1% of the registrations. All recognized errors were

corrected. The corrected parameters concerned clinical findings, operative activity, follow-up examinations, and time registrations.

Over a fifteen-year period some shifts in the profile of symptoms, signs, diagnostic methods, and indication for surgery are to be expected. To form an estimate of the possible effect of the result, we divided the material into 4 periods. These were compared according to preoperative and operative findings. This showed that the preoperative clinical findings were very similar for all periods except with regards to monoradicular symptoms and signs, which increased during the period.

Correspondingly, a shift in the operative strategy towards 1-level fusions has taken place, but a remarkable similarity was found in the percentages of operations on all myelographic relevant discs.

Comparing the "profiles" in the patients responding with those in the dead patients we found significant differences in age at admission (51 and 55 years respectively) and time of operation (7 and 10 years since the operation respectively).

Furthermore, we found differences in myelographic findings and operative strategy similar to those which were found during the first 8 years. This means worse and more widespread findings in the myelogrammes and consequently a more extensive surgery.

Results

General Results

The age distribution is shown in Fig. 1. The average age was 51 years—range 16–77 years. The figure also shows the change in the age distribution at the time of the questionnaire, and the time of death of 118 patients. 41% were women and 59% men, and no significant difference in the age distribution related to sex could be observed.

A total of 1,953 spondylosyndeses were performed in the 1,106 patients, the levels of operation appear from Table 2. On average 74 patients were operated on per year (range 29–110), which means about 50 operations per 1 million inhabitants per year in the area of admission to the hospital.

The general results obtained in different ways are seen in Fig. 2. There is a fairly good accord between the Surgeon's assessment of effectiveness at the 3 month follow-up examination and the patient's own estimate 1–15 years after surgery, but only 46% had a good functional result. A good correspondence between working capacity and a good functional result is established too.

Fig. 3 shows that 80% of the patients with a good and 45% of those with a poor functional result marked "a subjective effect of operation" in the questionnaire.

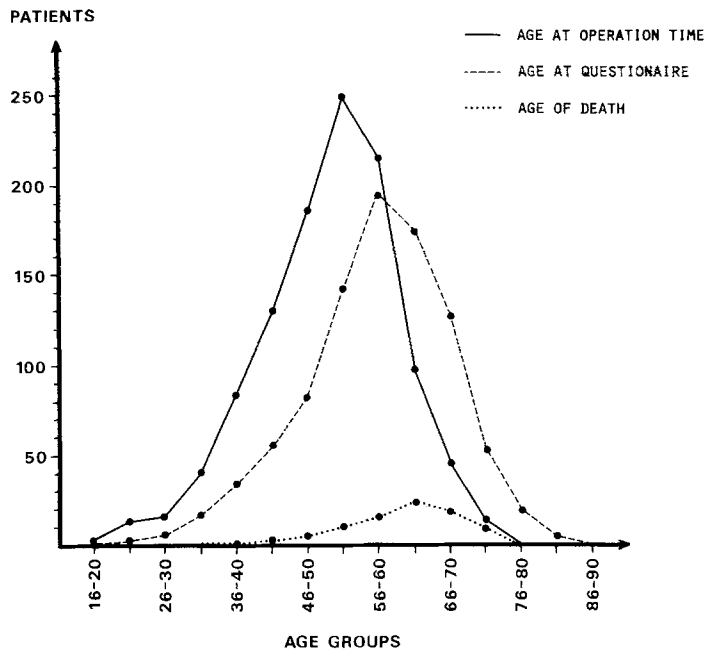

Fig. 1. The age distribution of 1,106 patients who underwent Cloward's operation

Table 1. *Number of Registered and Calculated Parameters in Each Patient*

Parameters concerning	Primarily registered	Calculated	Total
Clinical conditions	28	2	30
Radiological conditions	10	12	22
Operative	10	1	11
Postoperative	25	3	28
Follow-up	33	2	35
Questionnaire	9	6	15
Total	115	26	141

Subgroup per parameter: average 6.4.

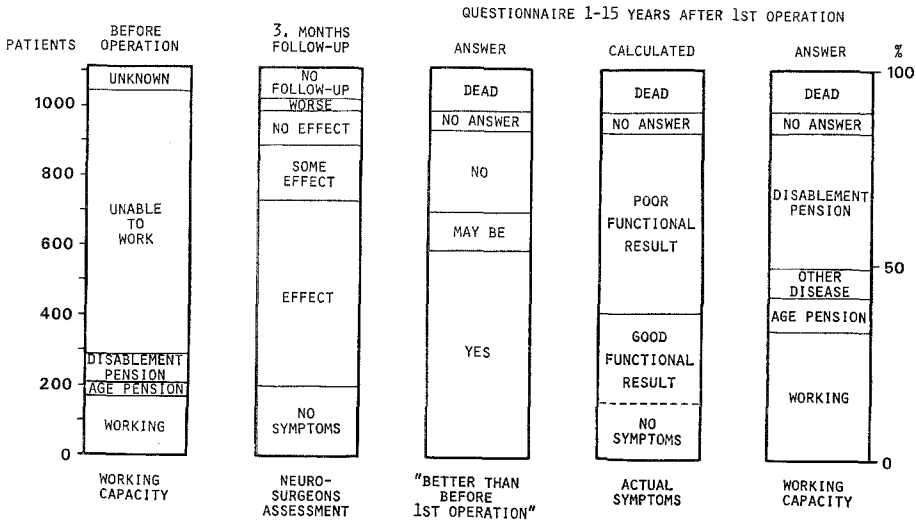

Fig. 2. The preoperative working capacity related to the result at the 3-month follow-up examination and the answers on the questionnaire

Table 2. *The Levels of the Cervical Spondylosyndeses in the First Operation in 1,106 Patients*

Level	Disc	Number	Percentage
C 2/C 3	2	1	0.1
C 3/C 4	3	82	7.4
C 4/C 5	4	231	20.9
C 5/C 6	5	849	76.8
C 6/C 7	6	657	59.4
C 7/Th 1	7	33	3.0
Total		1853	

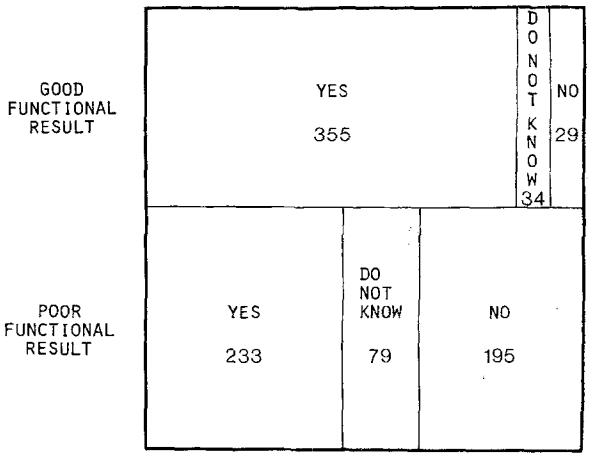

Fig. 3. Outcome measured by questionnaire. The square represents all answering patients and shows the relation between the patients' actual symptoms and their answers to the question "Better than before first operation"

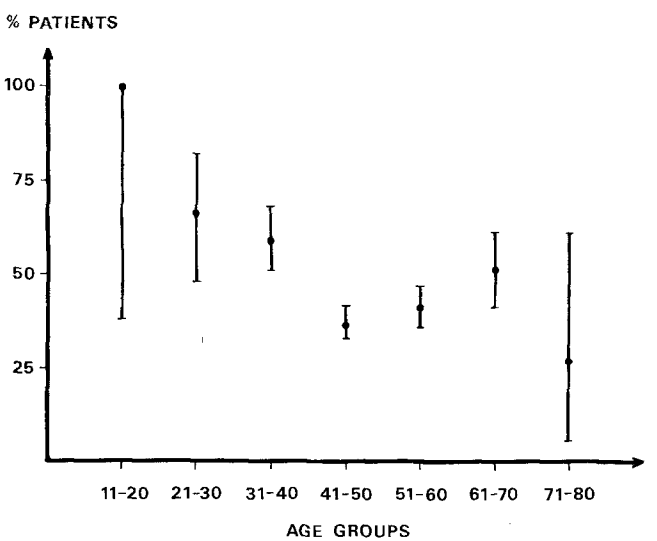

Fig. 4. The patients' indications on the questionnaire "Good functional outcome" related to age

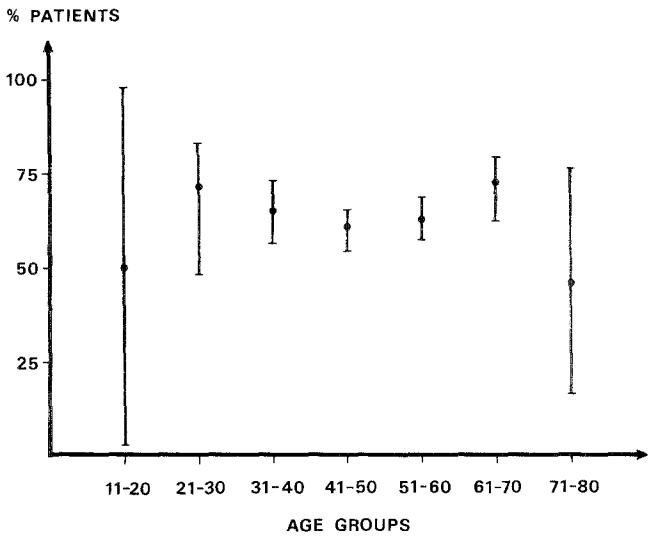

Fig. 5. Percentage of patients answering "Better than before first operation" related to age

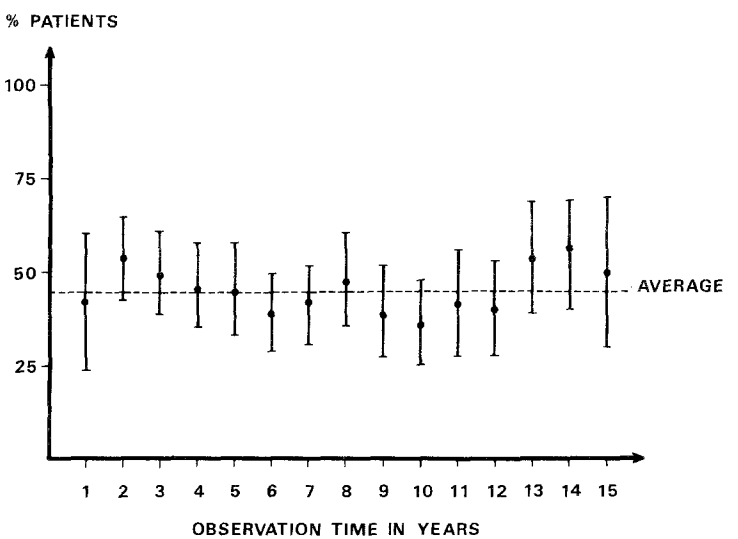

Fig. 6. The patients' indications on the questionnaire "Good functional outcome" related to observation time

Table 3. *The Outcome Related to Number of Spondylosyndeses*

Number of spondylosyndeses	First operation		Final number of Spondylosyndeses	
	Patients	Effect*	Patients	Good functional result
○	485	84%	441	48%
○ ○	511	84%	503	43%
○ ○ ○	95	88%	128	39%
○ ○ ○ ○	14	85%	32	38%
○ ○ ○ ○ ○	1	100%	2	50%
	1106	84	1106	45%

* Based on first follow-up after surgery (mean 3.8 months).

Table 4. *Outcome in Relation to Cutting the Posterior Ligament*

Posterior ligament	Patients	Good functional result	Level of reoperations	
			Former	Another
Intact	70	50%	4%	4%
Partly cut	56	53%	4%	4%
Totally cut	975	45%	8%	6%
Unknown	5	0%	20%	0%
Total	1106	45%	8%	6%

Fig. 4 shows a significant difference with regards to a good functional result between patients above and below the age of 40 at the time of surgery ($p < 0.001$). This difference, however, cannot be recognized from the answer to the question "better than before first operation" (Fig. 5).

Fig. 6 shows that the postoperative observation time does not affect the result for which reason the patient's condition one year postoperatively can be considered stable.

Results in Relation to Different Surgical Techniques

The results in relation to the number of spondylosyndeses appear in Table 3. At the 3-month follow-up examination no

significant difference in the result could be ascertained. The percentage of patients with a good functional result decreased, if the patients were subjected to more spondylosyndeses ($p = 0.1$).

Table 4 shows the result in relation to cutting the posterior spinal ligament. Some of the Surgeons cut the entire ligament routinely, whereas others, in cases of a suspected free herniated disc only, cut the ligament partially. From the table only an insignificant difference in the result appears. Cutting the ligament did not cause

Table 5. *Outcome in Relation to Bone Graft*

Bone graft	Patients	Good functional result	Reoperation at the level
Homograft	442	43%	9%
Autograft	631	46%	6%*
Kieler bone graft	23	43%	22%*
Unknown	10	71%	10%
Total	1106	45%	7%

* $p < 0.01$.

any instability of the cervical spine at X-ray 3 months postoperatively—only 1.4% and 2.7% of the patients with partly cutuncut or cut ligaments, respectively, developed a pronounced kyphosis. The difference in frequency of reoperation is obviously due to different indications.

Table 5 shows that a good functional result was independent of the graft used, but an increased frequency of reoperation was recorded, when calfbone (Kielerbone®) grafts were used.

In patients with one spondylosyndesis a free disc herniation was found in 29% of the cases, but this specific finding did not affect the result.

Complications

Peroperative complications, including bleeding from the burr-hole (10.8%), root arteries (0.4%), approach (0.5%), and dural lesions (2.1%) were all without significance for the result. The dural

Table 6. *Postoperative Complications*

Complications	Present before discharge	Present at 3 months follow-up	Death within 3 months
Associated to general disease			
Cardio-pulmonary failure	11	NR*	4
Associated to spinal cord or roots			
Pain in the neck	9	7	0
Pain in upper extremities	30	17	0
Radicular symptoms	35	20	0
Slight medullar symptoms	9	2	0
Paraplegia	1	1	0
Tetraplegia	3	2	1
Associated to approach			
Haematoma	19	0	0
Superficial infection	11	0	0
Graft infection	3	0	0
Laryngeal oedema	18	0	1
Persistent swallowing problems	9	9	0
Palsy of a recurrent nerve	12	6	0
Neurogenic respiratory Insufficiency	5	0	0
Associated to donor place			
Infection	6	0	0
Pain	5	2	0
Total number of complications	186 (17%)	66 (6%)	6 (0.6%)
Total number of patients	146 (13%)	56 (5%)	6 (0.6%)

* Not registered.

lesion was exclusively associated with total cutting of the posterior ligament, and in 5 cases a secondary closure was necessary.

Nine patients (0.8%) had vertebral haemorrhage and one of these patients developed tetraplegia—2 others developed serious, but reversible postoperative neurogenic respiratory insufficiency.

Table 6 shows the postoperative complications. Four patients—2 without medullary symptoms prior to surgery—developed serious medullary affection. In the 3 patients with graft infection, the graft was removed. About two thirds of the initial complications were overcome in the first 3 months, after which

symptoms remained in 5% of the patients. The total number of complications seems to be related to the number of grafts inserted, which is shown in Fig. 7 (statistical insignificant $p = 0.08$).

Table 7 shows the postoperative radiological findings. At the routine X-ray on the third postoperative day 4.4% of the grafts

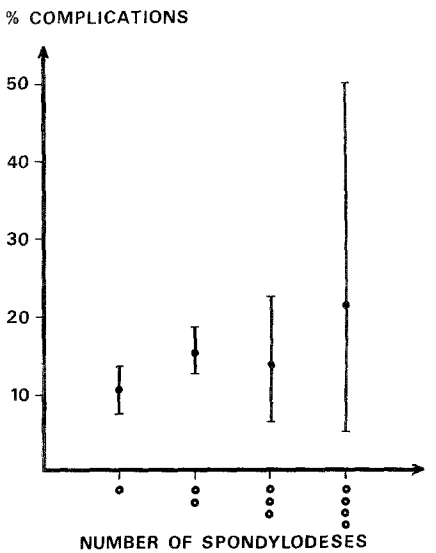

Fig. 7. Percentage of postoperative complications related to number of spondylosyndeses

were found to be incorrectly inserted. 34% of the patients in this group were reoperated within a year.

At the 3-month follow-up examination 86 patients (5%) had abnormal X-ray findings, but only 18 of those patients were reoperated within the first year. Only in cases of graft fractures or extruded grafts a high frequency of reoperation was found.

The degree of kyphosis was registered at the X-ray, but even a severe angulation ($> 15°$) did not give rise to a high reoperation rate.

Discussion

The aim of this study was to evaluate the results of Cloward's operation in cervical disc disease. The results achieved in principle reflect: the sample of admitted patients, the specific indications for

Table 7. *Postoperative Radiological Findings and Number of Reoperations at the Level Within 1 Year*

Findings at the X-ray examination	Number of patients	Number of reoperations
Before discharge		
Correctly inserted graft	1019	39
Incorrectly inserted graft	44	15
No investigation	43	2
At 3-month follow-up examination		
Normal graft healing	916	32
Slight necrosis of graft	38	1
Severe necrosis of graft	8	1
Fracture of graft	31	12
Extruded graft	6	4
Instable graft	3	0
No investigation/description	104	6
No kyphosis	652	27
Slight kyphosis	331	17
Severe kyphosis	25	6
No investigation/description	98	6
Total	1106	56

surgery, the skill of the Surgeons and Department involved and the method of measuring the result.

Basically the material consists of patients referred for cervical, radicular and medullar symptoms, but in the final specific selection for surgery additional factors are involved: working incapacity, failure of other therapies, social factors etc. Apart from this the patient's symptoms and signs may be fluctuating, depending on activity of the disease, work-related symptoms and, in many cases, symptoms which are very subjective and difficult to measure. No doubt these difficulties in preoperative classifications can lead to controversial conclusions as how to select the right patient[16].

Over the period some shifts in the sample of patients are evident, although the symptoms or signs were similar. When a new therapeutical procedure is established, more patients with pro-

nounced symptoms are treated at the beginning than later on, as demonstrated.

The method of measuring the result is very essential as demonstrated in Fig. 3.

The 3-month follow-up examination provides an "objective" assessment, but may be biased because of the Neurosurgeon's encouragement and the patient's dependence on the Surgeon. This method of measuring says something about the immediate result after surgery. The result is similar to the findings of other authors[1, 3, 10, 20]. Asking about late recurrence for the purpose of estimating long-term results can be done as Lundsford *et al.*[10] did, but in this study we tried to get the patient's "objective" assessment of the present state. In general the term "good functional result" is used for measuring the outcome owing to the close relation to working capacity[9]. One drawback of the method is that the patient might misunderstand the questions. Another disadvantage of this method is that a poor effect on neurological signs could be expected as reported in surveys concerning lumbar disc disease[19] and as demonstrated here, too.

The basic question: "Are you better now than before the first operation" could be used, too, and might in some respects offer better information about the subjective effect of operation.

In practice, however, in most cases these 2 methods were equally suitable for the determination of differences, despite a certain degree of overlap in the groups.

A fairly good correlation between the result at the 3-month follow-up examination and the answer of: "better than before the first operation" was found, as the Surgeon registered 71% of the patients experiencing a definite effect of the operation, whereas 63% of the patients said they experienced an effect, although surgery was performed 1–15 years before. Furthermore 20% and 25% respectively had no symptoms.

Forty-six per cent of the patients had no disabling symptoms, corresponding to the number of patients who still worked or received the usual old age pension. Lunsford *et al.*[10] found that 67% of the patients had excellent and good results, but 38% suffered from a late recurrence of one or more symptoms.

Dohn[5] reported in a series of 135 patients with radicular symptoms that 50% had no disabling symptoms. Taheri and Gueramy[17] had in a mixed series 88% with good results and in a review by K. Gorter[7], which comprised 345 patients with medullar symptoms—treated by different approaches—the operations were

effective in 76% of the patients. The differences in the outcome are obvious, but might be ascribed to different methods of statement and selection of patients.

The age distribution is similar to the age distribution in other series[2, 15, 10]. Most patients underwent surgery between the age of 50 and 60 years suggesting an age related degenerative disease. The need for surgery diminishes as from age of 60, apparently owing either to the patient's decreasing physical activity or to increasing stiffness of the neck, reducing the symptoms. The latter argument could be supported by the facts that the patient's statement one year after surgery will almost be the final statement (Fig. 6) and that working capacity is closely related to age and not to observation time[9].

The long-term results as shown here support the effect of a stable fusion[14], which also could be obtained by discectomy alone[11].

The fusion was stable whether the posterior ligament was cut or uncut, and the results were equal.

For a period calf bone grafts were used because of the evident advantages: shorter operation time and a less uncomfortable postoperative period for the patients. The drawback of the technique was an increased number of reoperations. Dohn[5] started that he had stopped the technique for lack of stability, whereas Taheri and Gueramy[17] showed that these grafts functioned well in their hands in a series of 200 patients.

The cervical osteoarthrosis often affects several vertebral interspaces, and other authors[12, 13] found a poorer result in these patients. Like Lunsford *et al.*[10], at the 3-month follow-up examination, we found no differences in the outcome. The reason for the differences between the series is probably the selection of these patients. The questionnaire suggests a poorer effect in cases of more spondylosyndeses—though it is not significant ($p < 0.1$)—but this finding is probably caused by the effect of reoperations rather than by the number of spondylosyndeses[6].

As stated by Tew and Mayfield[18] most of the preoperative complications do not affect the results, but lesions of the vertebral artery may be disastrous to the patient. In a statement of postoperative complications there is often a gradual transition from evident complication to a poor operative result. Besides this, the result of the statement will depend on how severe a clinical finding should be before it is registered as a complication. In this survey we registered symptoms of deterioration of at least one

week's duration. Two thirds of the patients suffering from postoperative complications had no symptoms at the 3-month follow-up examination. Five per cent of the patients are still suffering and that corresponds to the frequency registered by Dohn[5], but is higher than that indicated by Tew and Mayfield[18]. The most serious neurological complications—the tetra- and paraplegia—were found in few patients and were probably due to lesion of the anterior spinal artery. Three of the six postoperative deaths were clearly connected with Cloward's operation, and the death of one patient from laryngeal oedema gave rise to a more intensified postoperative care.

The remaining 3 deaths were caused by cardio-pulmonary failure in a preoperatively high risk group.

The postoperative radiological findings reveal an unsatisfactory radiological result in 5% of the patients, which is a somewhat higher proportion than stated by other sources[17, 18]. The low frequency of reoperations indicates that conservative therapy is the treatment of choice, however, unless the patient's symptoms dictate otherwise.

Conclusions

1. During the 15-year postoperative follow-up period the patients' symptoms and signs were nearly constant.
2. Significant differences in the myelographic findings and operative strategy were present resulting in a trend towards fewer spondylosyndeses in a single patient recently.
3. The statement as to effectiveness made by the patient was independent of age and observation time.
4. The functional result was very significantly better in young patients and clearly related to postoperative working capacity.
5. The functional result was independent of observation time.
6. The result was independent of the number of primarily inserted grafts (1–5 levels).
7. Cutting or partly cutting or uncutting the posterior spinal ligament affects neither the stability nor the result.
8. There was no difference in result whether a free disc herniation or osteochondrosis was found.
9. Use of calfbone grafts caused more reoperations.
10. About 5% still suffered from complications 3 months postoperatively—but few (3.6%) developed a severe medullary affection.

11. 81% experienced an immediate effect, and 63% experienced a long-term effect of the operation.

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