Acta Neurochir (Wien) (1988) 90: 127–135

Acta Neurochirurgica

Clinical Long-term Results of Anterior Discectomy Without Fusion for Treatment of Cervical Radiculopathy and Myelopathy

A Follow-up of 164 Cases

H. Bertalanffy and **H.-R. Eggert**

Department of General Neurosurgery, University of Freiburg i. Br., Federal Republic of Germany

Summary

Between 1976 and 1983, 251 patients underwent surgery for the treatment of cervical degenerative disc disease. Anterior microsurgical discectomy at one or more cervical segments without interbody fusion was performed in each case. 109 patients with radiculopathy and 55 patients with myelopathy were followed up clinically 1 to 8 years postoperatively. A soft disc lesion was found in 72, a hard disc lesion in 92 patients. Of all radicular symptoms and signs, brachialgia and motor deficits of the upper extremities showed the highest improvement rates. The medullary complaints were improved in 80%, the progression of the disease was arrested in 93% of myelopathic cases.

An excellent or good long-term result was achieved in 82% of patients with radiculopathy and 55% of those with myelopathy. The outcome was best in cases with soft disc lesions, with monosegmental disease, in individuals under 50 years of age, and in patients with a sudden onset and a short duration of symptoms. These results are comparable with those obtained by other surgical methods.

Keywords: Cervical spine; radiculopathy; myelopathy; discectomy without fusion.

Introduction

Different types of cervical disc lesions cause either nerve root or spinal cord compression, or both, leading to the clinical picture of radiculopathy and/or myelopathy [60, 71]. Various operative procedures for the treatment of this degenerative disease have been described. During the past 3 decades the anterior cervical surgery with interbody fusion [3, 11, 67, 74] gained importance and was adopted by numerous authors. Nevertheless excellent results were achieved with each technique.

The first reports on anterior discectomy without interbody fusion [7, 9, 32, 34, 35, 57, 77, 78] showed that the bone graft in anterior cervical disc surgery is not essential for the success of this operation. We adopted this method in 1976 in our institution and use anterior spondylodesis [75] mainly for the treatment of posttraumatic unstable cervical spine.

The present study deals with preoperative and operative findings in 251 consecutive patients suffering from degenerative cervical disc disease who were treated by anterior cervical discectomy without interbody fusion. Clinical long-term results in 164 patients are analyzed. The type of disc lesion receives special attention because of its operative importance and prognostic value.

Clinical Material and Methods

Patients

Between January 1976 and December 1983, 251 patients underwent surgery for the treatment of cervical degenerative disc disease. All of the patients had previously received conservative treatment for at least four weeks, however, their condition nevertheless progressively deteriorated.

One hundred and forty-six patients (58%) presented the clinical picture of a lateral cervical disc syndrome and 105 patients (42%) that of a medial cervical disc syndrome. Of the patients, 185 (73%) were men and 66 (27%) were women. Age ranged from 25 to 79 years. The mean age in patients with radiculopathy was 47, in those with myelopathy 54 years ($p < 0.001$). The frequency of radicular and medullary symptoms was the same in men and women.

History

Twenty-three percent of the patients suffered an acute onset of symptoms, 77% a gradual one. Patients with soft disc lesions and radicular symptoms had the highest incidence of sudden onset (73%), those with hard disc lesions and medullary symptoms the highest incidence of gradual onset of symptoms (38%) ($p < 0.001$). The duration of symptoms ranged from 5 days to 25 years (mean 21 months).

In 37% of patients the symptoms lasted less than 4 months, in 30% between 4 and 12 months, and in 33% longer than 12 months. In patients with hard disc lesions and myelopathy the symptoms lasted significantly longer than in patients with soft disc lesions and radiculopathy ($p < 0.001$). Thirty-six patients (14%) had a previous history of cervical injury. In 106 patients (42%) the cervical disc symptoms were associated with more or less pronounced complaints caused by lumbar discopathy, 13 patients (5%) had already had a previous lumbar disc operation. Five patients (2%) had a Klippel-Feil deformity. Two of them presented with radicular, three with medullary symptoms. All of them had hard disc lesions in 1 or 2 adjacent cervical segments.

Four patients (1.6%) had undergone previous cervical disc operation (Cloward procedure) in an adjacent segment in another institution.

Clinical Evaluation

One hundred and forty-six patients (58%) presented with purely radicular symptoms and 28 (11%) with purely medullary signs. In 77 (31%) the myelopathic symptoms and signs were combined with radicular ones. Myelopathy in this study refers to both groups together, pure myelopathy and combined radiculo-myelopathy. Of the patients with radicular complaints, 29% had monoradicular, 71% multiradicular symptoms and signs. The most frequent complaint in patients with radiculopathy was radicular type pain (Fig. 1), the C 6 dermatome being affected in most of the cases.

In patients with myelopathy the most frequent initial symptom was a spastic gait disturbance. These patients also had the longest duration of symptoms (mean 34 months).

Positive contrast myelography (Duroliopaque, Amipaque) was performed in 95% of the patients. Due to an overlap, a discography was performed in 35% and a computed tomography of the cervical spine in 19% of cases. Electromyography was carried out in 54% of the patients.

Follow-Up

Follow-up data were obtained from questionnaires (answered by 183 patients) and from the neurological examination of 164 patients undertaken between 12 months and 8 years postoperatively (mean 3.3 years postoperatively).

One hundred and nine patients (66%) belonged to the group with radicular, 55 (34%) to that with medullary complaints. Seventy-two patients (44%) had soft disc, 92 (56%) hard disc lesions.

All data were coded and analyzed statistically by means of the SPSS computer programme.

Results

Operative Findings

The standard anterior approach is used as described by Cloward [10], from the right side. Under magnifica-

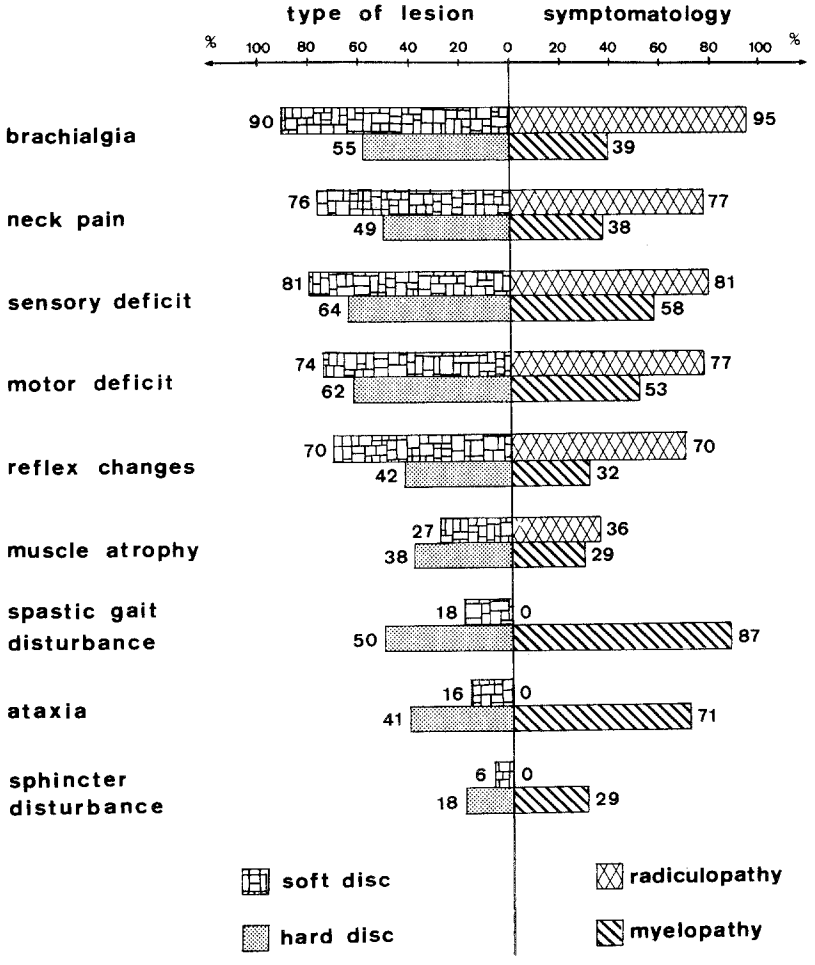

Fig. 1. Frequency of main symptoms and signs related to type of lesion and symptomatology

tion of an operating microscope, all disc material is removed, including the cartilaginous plates. Special care is taken to remove all posterior and lateral osteophytes and spurs on both sides, even in cases with pure soft discs, to prevent root compression when the interspace narrows postoperatively, as has been suggested by other advocates of this procedure [19, 32, 36].

A detailed description of the operative procedure is given by Seeger [73]. The patient is allowed out of bed with a cervical collar the day after the operation.

All of our operations were performed by 12 neurosurgeons, 80% of them by 5.

In total, 371 cervical discs have been removed in 251 patients. The most frequently affected segment was C 5/6 (Fig. 2). The operative finding was a ruptured disc (soft disc lesion with perforated posterior longitudinal ligament and free sequestra) in 89 segments (24%), a soft protrusion (soft disc lesion, posterior longitudinal ligament not perforated) in 51 segments (14%), and lateral and/or dorsal osteophytes (hard disc lesion, according to the terminology of Odom and Scoville [60, 71]) in 231 segments of discectomy (62%).

Soft protrusions may be combined with osteophytes; in these cases only the predominant lesion which was responsible for the clinical symptomatology was considered. Epidural disc fragments (free sequestra) were found in 43% of patients with radicular and in 25% of those with medullary symptoms ($p < 0.01$), in 64% of the patients with soft discs.

Soft disc lesions were predominantly monosegmental (mean 1.2 segments), hard disc lesions frequently bi- or trisegmental (mean 1.6 segments, $p < 0.001$). The posterior longitudinal ligament was left intact in 22%, was removed unilaterally in 31%, and completely in 47% of cases.

One hundred and forty-five patients (57.8%) were operated on at one cervical level, 93 patients (37%) at two, 12 patients (4.8%) at three, and one patient (0.4%) at four levels. Older patients had multisegmental discectomies more often than younger ones. The number of surgically treated levels also differed according to sex, type of lesion, and clinical symptomatology: males, patients with hard disc lesions, and those with medullary symptoms had significantly more multisegmental lesions than the other groups.

In 19 patients with involvement of two or more levels, both hard disc and soft disc lesions were found in the same patient but at different segments. In order to allocate the patient to one of the two groups soft disc—hard disc, only the segment with the main finding was considered in these cases. This resulted in the distribution: 110 patients with soft disc lesions (44%) and 141 patients with hard disc lesions (56%).

Soft disc lesions led significantly more frequently to the clinical picture of radiculopathy (79%), hard disc lesions more frequently to that of myelopathy (55%) ($p < 0.001$).

The distribution according to the type of lesion was

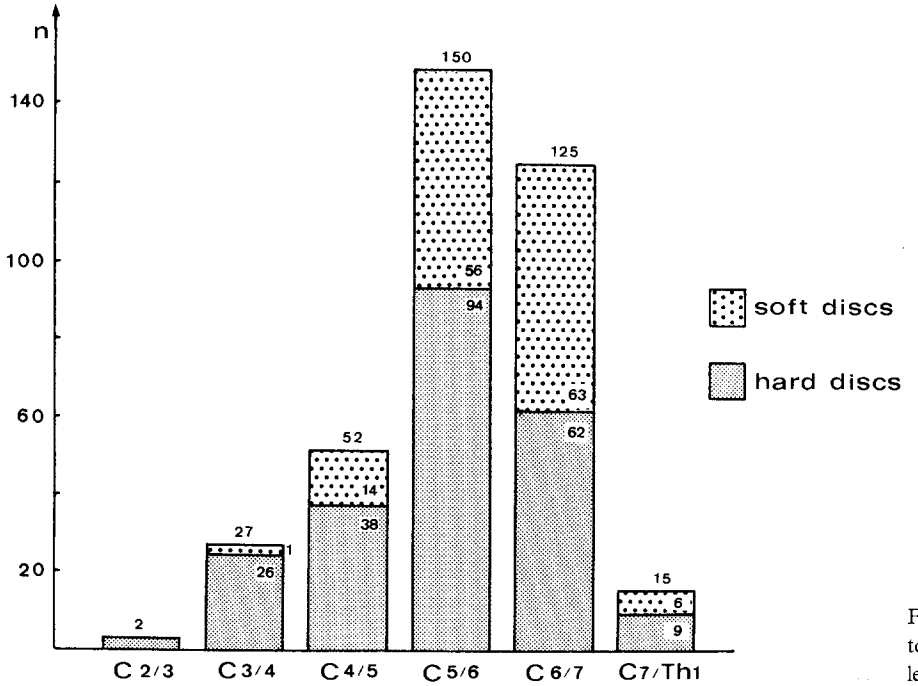

Fig. 2. Frequency of disc prolapses related to the cervical segments and the type of lesion

unrelated to sex, but significantly related to age and duration of symptoms. Sixty percent of the patients under 50 years of age had soft discs, 70% of the patients over 50 years had hard discs ($p < 0.001$). The mean duration of symptoms in patients with soft discs was 8.5 months, in those with hard discs 31 months ($p < 0.001$).

Both, hard and soft disc lesions, occurred predominantly in the lower cervical spine (Fig. 2).

Complications

There was no operative mortality. In one patient suffering from severe myelopathy a persistent deterioration was observed postoperatively, probably due to medullary contusion. In another patient with radiculopathy, a slight paraparesis occurred postoperatively, which disappeared within a few hours.

In two patients a cervical root was injured during the operation without there being any additional postoperative deficits. An epidural haematoma occurred in four patients (1.6%) and required reoperation.

Less severe complications due to the anterior approach, *e.g.*, Horner's syndrome, transient recurrent nerve palsy, dysphagia, and wound infection occurred in twelve patients (4.8%).

Five patients (2%) had reoperations in the same level due to recurrent complaints between 5 months and 5 years after the operation. Fourteen other patients (5.6%) underwent anterior cervical discectomy during this time in adjacent segments. The complications will be published in more detail elsewhere [5].

Clinical Outcome

On the day of discharge from the hospital, the preoperative complaints had been relieved in 7%, markedly improved in 41%, partially improved in 39%, were unchanged in 8%, and worse in 5%. The postoperative stay varied from 1 to 42 days, the average hospital period was 5.6 days.

According to the patients' self estimation, complaints were improved more often among the soft disc lesions than the hard discs and more often in radiculopathy than in myelopathy patients (Table 1).

Brachialgia and radicular motor deficits showed the highest improvement rate in patients with radiculopathy, whereas in patients with myelopathy the spastic gait disturbance was least responsive to the surgical treatment (Table 2).

The clinical results of surgery at the time of follow-up examination were categorized according to the criteria of Roosen and Grote [68] (Table 3). The results were

Table 1. *Self-Estimation of Overall Operative Result in 183 Patients, Related to the Type of Lesion and Symptomatology*

Groups	Improved		Not improved	
	N	%	N	%
Soft disc lesion	72	91	7	9
Hard disc lesion	72	69	32	31
Radiculopathy	100	86	16	14
Myelopathy	44	66	23	34

Table 2. *Relief of Symptoms and Signs in Patients with Radiculopathy and Myelopathy*

Symptoms and signs	No. of patients	Percentage			
		Cured	Improved	Stabilized	Worsened
Radiculopathy					
Neck pain	139	29	36	24	11
Brachialgia	131	78	6	12	4
Radicular motor deficit	139	60	22	8	10
Radicular sensory deficit	147	29	24	35	12
Reflex changes	124	18	18	47	17
Muscle atrophy	61	52	20	18	10
Myelopathy					
Spastic gait disturbance	50	30	2	64	4
Ataxia	39	54	0	46	0
Motor deficits	24	71	0	12	17
Sensory deficits	13	77	0	23	0
Hyperreflexia	49	20	20	49	11
Sphincter disturbances	20	50	20	25	5

Table 3. *Clinical Categories for Evaluation of Late Results (According to Roosen and Grote* [68])

Grade	Definition
I	Symptom-free. No neurological deficit. (Excellent)
II	Subjective complaints markedly improved. Mild, well compensated neurological disorders. (Good)
III	Complaints unchanged, preoperative neurological status improved. (Fair)
IV	No change in symptoms and neurological findings
V	Deterioration in patients condition. (IV + V Poor)

definitely better in the radiculopathy and soft disc groups than in the myelopathy and hard disc groups (Table 4).

The mean value of the outcome variable (1 to 5) was calculated for comparison of the patient groups: 1.95 for the entire patient population (164 patients), 1.50 for patients with soft discs and radiculopathy, 1.80 for patients with soft discs and myelopathy, 1.86 for patients with hard discs and radiculopathy, and 2.75 for patients with hard discs and myelopathy.

The differences between the groups compared are statistically significant. Patients with soft discs and radiculopathy achieved the best, those with hard discs and myelopathy the worst long-term result.

long-term result (mean outcome variable of 3.36 as compared with 1.61 in the group not involved in any proceedings) [6].

Radiological Findings

Standard antero-posterior, oblique and lateral flexion-extension films were taken at two days, between six months and one year postoperatively and at follow-up review.

The initial radiological changes following operation were a subtotal obliteration of the involved disc space, an osseous defect of the adjacent dorsal spurs, and a slight motion at the operative site without impairment of cervical stability.

Follow-up radiographic studies (mean 3.3 years postoperatively) revealed in 75% a complete osseous fusion; however, there was functional stability of the cervical spine in all patients. A mean kyphotic angulation of 4.8° occurred in the segment of discectomy regardless of the type of lesion. Limitation of mobility of the cervical spine was slight in monosegmental operations and reduced by 50% in bi- and trisegmental discectomies. Postoperative course as well as clinical long-term results were not significantly influenced by the postoperative X-ray appearance.

Table 4. *The Clinical Long-Term Result According to Symptomatology and Type of Lesion*

Groups	No. of patients	Mean result	Grade					p-value
			I	II	III	IV	V	
Radiculopathy	109	1.67	56%	26%	13%	5%	0	
Myelopathy	55	2.49	24%	31%	25%	13%	7%	0.0002
Soft disc lesion	72	1.56	60%	26%	11%	3%	0	
Hard disc lesion	92	2.25	34%	28%	22%	12%	4%	0.0000

The result was not significantly linked to sex, preoperative occupation, preoperative trauma, and lumbar discopathy associated with cervical discopathy, nor did it vary significantly among the different neurosurgeons.

Among the factors which significantly influence the operative outcome, the type of disc lesion is of major importance (Table 4). The patient's age at the time of operation, the pattern of the onset of symptoms, the duration of symptoms, and number of involved levels markedly influence the surgical result (Table 5).

A group of 11 patients who at the time of follow-up were involved in annuity proceedings had the worst

Table 5. *Factors Which Influence the Surgical Result*

Factors		No. of patients	Mean value of result	p-value
Age	< 50 years	87	1.72	
	> 50 years	77	2.22	0.003
Onset of symptoms	sudden	36	1.48	
	gradual	128	2.08	0.000
Duration of symptoms	< 4 months	69	1.69	
	> 12 months	58	2.36	0.000
No. of levels	monosegmental	96	1.76	
	multisegmental	68	2.22	0.008

Radiological data will be published in more detail elsewhere [23].

Discussion

The objective of this retrospective investigation was to compile the late results of cervical ventral discectomy in order to be able to assess better the value of this method, which has not yet found general acceptance.

As has been pointed out by several authors [19, 38, 47, 51, 57, 65, 80], the primary goal in anterior cervical disc surgery is removal of the disc fragment or osteophyte causing the compression in order to relieve the pressure on the cervical nerve root and/or the spinal cord. Still, there is some disagreement in the literature about how to treat the osteophytes and the posterior longitudinal ligament.

We agree with other authors [8, 19, 20, 31, 36, 38, 43, 44, 46, 49, 51, 57, 65, 80] that the posterior osteophytes should be removed completely and we perform anterior bilateral foraminotomy to prevent root compression by narrowing of the intervertebral space after discectomy. Incomplete removal of posterior osteophytes made reoperation necessary in five cases of our series.

Some authors do not find it necessary to resect the posterior longitudinal ligament [4, 13, 26, 57, 66, 83], others do it [8, 19, 29, 32, 37, 43, 44, 49, 51, 80] or remove the ligament routinely [63, 81].

Sometimes the thickened ligament can buckle after narrowing of the intervertebral space, thus causing cord or root compression [19]. In our series this occurred in at least three patients who were re-explored and whose symptoms were relieved after the thickened and swollen ligament had been resected.

The high incidence (35%) of a perforation of the posterior longitudinal ligament with free herniated disc fragments in our series made partly or complete removal of the ligament necessary in 78% of the cases. Therefore we consider it important to try to clinically and radiographically distinguish between a soft protrusion and a ruptured disc with free herniated disc fragments. High resolution computed tomography [53], eventually combined with intrathecal [45] or intravenous [70] administration of contrast medium, or magnetic resonance tomography [54, 76] can be very helpful in demonstrating the exact location of a herniated disc. Additionally, a free herniated disc fragment may be suspected according to the clinical signs, *e.g.*, sudden onset and short duration of symptoms. In these cases, resection of the posterior longitudinal ligament is essential and a rather accurate prediction concerning the outcome is possible.

Some authors failed to distinguish between the two clinical pictures of radiculopathy and myelopathy when reporting the results [26, 32, 64, 80, 83]. Our experience has shown that the operative outcome is significantly better in radicular cases than in myelopathic ones, which concurs with other reports [25].

The majority of authors perform discectomy without fusion mainly in cases with nerve root compression [1, 4, 8, 9, 16, 19, 24–26, 28, 29, 31, 32, 35, 37, 41, 43, 44, 47, 51, 57, 64, 65, 69, 80, 83]. Our own results in radicular cases correlate well with the results of those series and also with the results of other series obtained with different operative methods [2, 10, 18, 27, 33, 47, 55, 56, 72]. Nevertheless, many authors employ anterior discectomy without fusion also for treatment of spinal cord compression due to cervical degenerative disc disease [1, 8, 25, 26, 29, 31, 32, 38, 41, 43, 44, 46, 48, 49, 52, 61, 64, 80].

Our results, in contrast to other reports [48, 55, 58, 59, 84], clearly demonstrate that anterior cervical discectomy is quite effective in the surgical treatment of cervical myelopathy. The progression of this disease was arrested in 93% of our cases, 80% improved, and 55% achieved a desirable late result. This concurs with the results of other authors using the same method [1, 25, 29, 38, 41, 46, 49, 61] and with the results obtained by anterior discectomy with fusion [14, 15, 17, 18, 40, 42, 50, 62] or by laminectomy [14, 15, 20, 22, 30, 82].

There are different opinions in the literature with regard to the factors which influence the operative outcome. According to our series the following factors are of major importance: type of disc lesion, age at operation, pattern of onset of symptoms, duration of symptoms, and number of operated levels.

In agreement with several authors [2, 12, 28, 37, 64] and contrary to the reports of others [47], in our series patients with soft disc lesions achieved a significantly better outcome than patients with hard discs (radicular and myelopathic cases being considered together) or patients with soft discs and myelopathy had a similar outcome to patients with hard discs and radiculopathy.

In our series of 251 patients, those with soft disc lesions predominantly developed symptoms of nerve root compression. This concurs with other series [41]. Twenty-seven of the patients with soft discs, however, developed medullary symptoms. Two of them showed the clinical picture of pure myelopathy, in the remaining 25 the medullary symptoms were combined with radicular ones. As O'Laoire has emphasized [61], it is essential to differentiate compression of the spinal cord due to prolapsed cervical disc from that due to cervical spondylosis, because disc excision in cases of cord

compression due to prolapsed intervertebral disc carries an excellent prognosis. We fully agree with this statement.

We found that the outcome in younger patients (under 50 years of age—50 being the mean age of our series) was significantly better than the outcome in older individuals (over 50 years). Like other authors [21], we could find a correlation between age at the operation and type of lesion. Soft discs occur more frequently in younger persons than in older ones.

Patients with a sudden onset and a short duration of symptoms (less than four months) had a significantly better long-term result than those with gradual onset and a duration of symptoms exceeding 12 months, which underlines the importance of early operation. This finding correlates with that of other authors [21, 35]. The group of patients with sudden onset and symptoms lasting less than 4 months consisted predominantly of individuals with soft disc lesions and radicular symptoms. This too explains the good outcome in these patients.

Finally, similar to other series [37, 39], patients with a single level of discectomy achieved a significantly better result than patients where two or more levels were involved. There is also a correlation between the number of levels involved and type of lesion, age, sex and symptomatology. Soft disc lesions occur more frequently at a single cervical level than hard discs. Multisegmental disease was found predominantly in older individuals, in males, and in patients with medullary symptoms.

In conclusion, we consider anterior discectomy without fusion for the treatment of cervical radiculopathy and myelopathy a safe, effective and technically simple procedure, which produces equally good results without major complications, as has been previously pointed out by several authors [16, 25, 26, 28, 32, 38, 47, 64, 69, 83].

Acknowledgement

The authors are grateful to Aeskulap-Werke AG, D-7200 Tuttlingen, Federal Republic of Germany, who also provided the surgical instruments, for supporting this study.

References

1. Arnasson O, Carlsson CA, Pellettieri L (1987) Surgical and conservative treatment of cervical spondylotic radiculopathy and myelopathy. Acta Neurochir (Wien) 84: 48–53
2. Aronson N, Bagan M, Filtzer DL (1970) Results of using the Smith-Robinson approach for herniated and extruded cervical discs. Technical note. J Neurosurg 32: 721–722
3. Bailey RW, Badgley CE (1960) Stabilization of the cervical spine by anterior fusion. J Bone Joint Surg 42-A: 565–594
4. Benini A, Krayenbühl H, Brüderl R (1982) Anterior cervical discectomy without fusion. Microsurgical technique. Acta Neurochir (Wien) 61: 105–110
5. Bertalanffy H, Eggert H-R, Complications of anterior cervical discectomy without fusion in 450 consecutive patients (in preparation)
6. Bertalanffy H, Eggert H-R, Gilsbach J (1988) Langzeitergebnisse nach fusionsloser zervikaler Bandscheibenoperation (Diskektomie) unter besonderer Berücksichtigung einiger arbeitsmedizinischer Aspekte. In: Hohmann D, Kügelgen B, Liebig K, Schirmer M (eds) Neuroorthopädie 4. Springer, Berlin Heidelberg New York Tokyo (in press)
7. Boldrey EB (1964) Anterior cervical decompression (without fusion). Presented at the American Academy of Neurological Surgery, Key Biscayne, Florida
8. Bollati A, Galli G, Gandolfini M, Marini G, Gatta G (1983) Microsurgical anterior cervical disk removal without interbody fusion. Surg Neurol 19: 329–333
9. Busch G, Schürmann K, Samii M (1975) First experiences with the anterior discectomy without fusion of the cervical spine in cases of acute disc rupture. In: Penzholz H, Brock M, Hamer J, Klinger M, Spoerri O (eds), Advances in neurosurgery, Vol 3. Springer, Berlin Heidelberg New York, pp 357–363
10. Cloward RB (1962) New method of diagnosis and treatment of cervical disc disease. Clin Neurosurg 8: 93–132
11. Cloward RB (1958) The anterior approach for removal of ruptured cervical discs. J Neurosurg 15: 602–617
12. Conolly ES, Seymour RJ, Adams JE (1965) Clinical evaluation of anterior cervical fusion for degenerative cervical disc disease. J Neurosurg 23: 431–437
13. Coppola AR (1978) Anterior cervical dicectomy (Letter). J Neurosurg 49: 781
14. Crandall PH, Batzdorf U (1966) Cervical spondylotic myelopathy. J Neurosurg 25: 57–66
15. Crandall PH, Gregorius FK (1977) Long-term follow-up of surgical treatment of cervical spondylotic myelopathy. Spine 2: 139–146
16. Cuatico W (1981) Anterior cervical discectomy without interbody fusion. An analysis of 81 cases. Acta Neurochir (Wien) 57: 269–274
17. Dereymaeker A, Ghosez J-P, Henkes R (1963) Le traitement chirurgical de la discopathie cervicale. Résultats comparés de l'abord postérieur (laminectomie) et de l'abord ventral (fusion corporéale), dans une cinquantaine de cas personels. Neurochirurgie 9: 13–20
18. Dohn DF (1966) Anterior interbody fusion for treatment of cervical-disc conditions. JAMA 197: 897–900
19. Dunsker SB (1976) Anterior cervical discectomy with and without fusion. Clin Neurosurg 24: 516–521
20. Epstein JA, Carras R, Lavine LS, Epstein BS (1969) The importance of removing osteophytes as part of the surgical treatment of myeloradiculopathy in cervical spondylosis. J Neurosurg 30: 219–226
21. Eriksen EF, Buhl M, Fode K, Klaerke A, Kroyer L, Lindeberg H, Madsen CB, Strange P, Wohlert L, Espersen JO (1984) Treatment of cervical disc disease using Cloward's technique. The prognostic value of clinical preoperative data in 1,106 patients. Acta Neurochir (Wien) 70: 181–197
22. Fager CA (1973) Results of adequate posterior decompression in the relief of spondylotic cervical myelopathy. J Neurosurg 38: 684–692

23. Gilsbach J, Bertalanffy H, Spöhr G, Radiological long-term findings after discectomy without fusion (in preparation)
24. Gilsbach J, Eggert H-R, Best S (1981) Vor- und Nachteile der vorderen zervikalen Bandscheibenoperation ohne Verblockung. Z Orthop 119: 600–601
25. Giombini S, Solero CL (1980) Considerations on 100 anterior cervical discectomies without fusion. In: Grote W, Brock M, Clar HE, Klinger M, Nau HE (eds) Advances in neurosurgery, vol 8. Springer, Berlin Heidelberg New York, pp 302–307
26. Granata F, Taglialatela G, Graziussi G, Avella F, Terracciano AM (1981) Management of cervical disk protrusions by anterior discectomy without fusion. J Neurosurg Sci 25: 231–234
27. Gregorius FK, Estrin T, Crandall PH (1976) Cervical spondylotic radiculopathy and myelopathy. A long-term follow-up study. Arch Neurol 33: 618–625
28. Gros C, Privat JM, Safdari H (1984) Exérèse discale sans greffe dans le traitement des cervico-brachialgies. Acta Orthop Belg 50 (1): 33–38
29. Guarnaschelli JJ, Dzenitis AJ (1982) Anterior cervical discectomy without fusion: comparison study and follow-up. In: Brock M (ed) Modern neurosurgery 1, Springer, Berlin Heidelberg New York, pp 284–291
30. Guidetti B, Fortuna A (1969) Long-term results of surgical treatment of myelopathy due to cervical spondylosis. J Neurosurg 30: 714–721
31. Hakuba A (1976) Trans-unco-discal approach. A combined anterior and lateral approach to cervical discs. J Neurosurg 45: 284–291
32. Hankinson HL, Wilson CB (1975) Use of the operating microscope in anterior cervical discectomy without fusion. J Neurosurg 43: 452–456
33. Henderson CM, Hennessy RG, Shuey HM, Shackelford EG (1983) Posterior-lateral foraminotomy as an exclusive operative technique for cervical radiculopathy: A review of 846 consecutively operated cases. Neurosurg 13: 504–512
34. Hirsch C (1960) Cervical disc rupture. Diagnosis and therapy. Acta Orthop Scand 30: 172–186
35. Hirsch C, Wickbom I, Lidström A, Rosengren K (1964) Cervical disc resection. A follow-up of myelographic and surgical procedure. J Bone Joint Surg 46-A: 1811–1821
36. Hoff JT, Wilson CB (1978) Microsurgical approach to the anterior cervical spine and spinal cord. Clin Neurosurg 26: 513–528
37. Husag L, Probst Ch (1981) Antero-laterale, zervikale mikrochirurgische Discektomie. Schweiz Arch Neurol Neurochir Psychiatr 129: 47–59
38. Husag L, Probst Ch (1984) Microsurgical anterior approach to cervical discs. Review of 60 consecutive cases of discectomy without fusion. Acta Neurochir (Wien) 73: 229–242
39. Jacobs B, Krueger EG, Leivy DM (1970) Cervical spondylosis with radiculopathy. Results of anterior discectomy and interbody fusion. JAMA 211: 2135–2140
40. Jeffreys RV (1979) The surgical treatment of cervical spondylotic myelopathy. Acta Neurochir (Wien) 47: 293–305
41. Jomin M, Lesoin F, Lozes G, Thomas III CE, Rousseaux M, Clarisse J (1986) Herniated cervical discs. Analysis of a series of 230 cases. Acta Neurochir (Wien) 79: 107–113
42. Kadoya S, Nakamura T, Kwak R, Hirose G (1985) Anterior osteophytectomy for cervical spondylotic myelopathy in developmentally narrow canal. J Neurosurg 63: 845–850
43. Kadoya S, Kwak R, Hirose G, Yamamoto T (1982) Cervical spondylotic myelopathy treated by a microsurgical anterior approach with or without interbody fusion. In: Brock M (ed) Modern neurosurgery 1. Springer, Berlin Heidelberg New York, pp 292–298
44. Kosary IZ, Braham J, Shacked I, Shacked R (1976) Microsurgery in anterior approach to cervical discs. Surg Neurol 6: 275–277
45. Landmann JA, Hoffmann Jr. JC, Braun IF, Barrow DL (1984) Value of computed tomographic myelography in the recognition of cervical herniated disc. AJNR 5: 391–394
46. Lesoin F, Bouasakao N, Clarisse J, Rousseaux M, Jomin M (1985) Results of surgical treatment of radiculomyelopathy caused by cervical arthrosis based on 1,000 operations. Surg Neurol 23: 350–355
47. Lunsford LD, Bissonette DJ, Jannetta PJ, Sheptak PE, Zorub DS (1980) Anterior surgery for cervical disc disease. Part 1: Treatment of lateral cervical disc herniation in 253 cases. J Neurosurg 53: 1–11
48. Lunsford LD, Bissonette DJ, Zorub DS (1980) Anterior surgery for cervical disc disease. Part 2: Treatment of cervical spondylotic myelopathy in 32 cases. J Neurosurg 53: 12–19
49. Mann KS, Khosla VK, Gulati DR (1984) Cervical spondylotic myelopathy treated by a single-stage multilevel anterior decompression. J Neurosurg 60: 81–87
50. Mayfield FH (1966) Cervical spondylosis: a comparison of the anterior and posterior approaches. Clin Neurosurg 13: 181–188
51. Martins AN (1976) Anterior cervical discectomy with and without interbody bone graft. J Neurosurg 44: 290–295
52. McPherson WF (1977) Advantage of anterior cervical discectomy. J Tenn Med Assoc 70: 879–880
53. Miyasaka K, Isu T, Iwasaki Y, Abe S, Takei H, Tsuru M (1983) High resolution computed tomography in the diagnosis of cervical disc disease. Neuroradiology 24: 253–257
54. Modic MT, Weinstein MA, Pavlicek W, Boumphrey F, Starnes D, Duchesneau PM (1983) Magnetic resonance imaging of the cervical spine: technical and clinical observations. AJR 141: 1129–1136
55. Mosdal C (1984) Cervical osteochondrosis and disc herniation. Eighteen years' use of interbody fusion by Cloward's technique in 755 cases. Acta Neurochir (Wien) 70: 207–225
56. Mosdal C, Overgaard J (1984) Lateral cervical fecetectomy. The surgical pathology of radicular brachialgia. Acta Neurochir (Wien) 70: 199–205
57. Murphy MG, Gado M (1972) Anterior cervical discectomy without interbody bone graft. J Neurosurg 37: 71–74
58. Nurick S (1972) The natural history and the results of surgical treatment of the spinal cord disorder associated with cervical spondylosis. Brain 95: 101–108
59. Nurick S (1972) The pathogenesis of the spinal cord disorder associated with cervical spondylosis. Brain 95: 87–100
60. Odom GL, Finney W, Woodhall B, Durham NC (1958) Cervical disc lesions. JAMA 166: 23–28
61. O'Laoire SA, Thomas DGT (1983) Spinal cord compression due to prolapse of cervical intervertebral disc (herniation of nucleus pulposus). J Neurosurg 59: 847–853
62. Phillips DG (1973) Surgical treatment of myelopathy with cervical spondylosis. J Neurol Neurosurg Psychiatry 36: 879–884
63. Reynolds AF (1979) Epidural bleeding in anterior discectomy (Letter). J Neurosurg 50: 126

64. Robertson JT, Johnson SD (1980) Anterior cervical discectomy without fusion: long-term results. Clin Neurosurg 27: 440–449
65. Robertson JT (1978) Anterior operations for herniated cervical disc and for myelopathy. Clin Neurosurg 25: 245–250
66. Robertson JT (1973) Anterior removal of cervical disc without fusion. Clin Neurosurg 20: 259–261
67. Robinson RA, Smith GW (1955) Anterolateral cervical disc removal and interbody fusion for cervical disc syndrome. Bull John Hopkins Hosp 96: 223–224
68. Roosen K, Grote W (1980) Late results of operative treatment of cervical myelopathy. In: Grote W, Brock M, Clar HE, Klinger M, Nau HE (eds) Advances in neurosurgery, vol 8. Springer, Berlin Heidelberg New York, pp 69–77
69. Rosenørn J, Hansen EB, Rosenørn M-A (1983) Anterior cervical discectomy with and without fusion. A prospective study. J Neurosurg 59: 252–255
70. Russel EJ, D'Angelo CM, Zimmermann RD, Czervionke LF, Huckmann MS (1984) Cervical disc herniation: CT demonstration after contrast enhancement. Radiology 152: 703–712
71. Scoville WB (1966) Types of cervical disc lesions and their surgical approaches. JAMA 196: 479–481
72. Scoville WB, Dohrmann GJ, Corkill G (1976) Late results of cervical disc surgery. J Neurosurg 45: 203–210
73. Seeger W (1982) Microsurgery of the spinal cord and surrounding structures. Springer, Wien New York
74. Simmons EH, Bhalla SK, Butt WP (1969) Anterior cervical discectomy and fusion. A clinical and biomechanical study with eight-year follow-up. J Bone Joint Surg 51 B: 225–237
75. Smith GW, Robinson RA (1958) The treatment of certain cervical-spine disorders by anterior removal of the intervertebral disc and interbody fusion. J Bone Joint Surg 40-A: 607–624
76. Sprenkel van der JWB, Mauser HW, Huynen CHJN, Kneepkens RHAM, Tulleken CAF (1986) MRI in neurosurgical diagnosis and management of craniocervical junction and cervical spine pathology. Clin Neurol Neurosurg 88: 245–251
77. Susen AF (1966) Simple anterior cervical discectomy without fusion. Presented at the American Academy of Neurological Surgery, San Francisco, California
78. Tew JM Jr., Mayfield FH (1975) Anterior cervical discectomy—a microsurgical approach (Abstract). J Neurol Neurosurg Psychiatry 38: 413
79. Tew JM Jr., Mayfield FH (1976) Complications of surgery of the anterior cervical spine. Clin Neurosurg 23: 424–434
80. Tribolet N de, Zander E (1981) Anterior discectomy without fusion for the treatment of ruptured cervical discs. J Neurosurg Sci 25: 217–220
81. U HS, Wilson CB (1978) Postoperative epidural hematoma as a complication of anterior cervical discectomy. J Neurosurg 49: 288–291
82. Wiberg J (1986) Effects of surgery on cervical spondylotic myelopathy. Acta Neurochir (Wien) 81: 113–117
83. Wilson DH, Campbell DD (1977) Anterior cervical discectomy without bone graft. J Neurosurg 47: 551–555
84. Wohlert L, Buhl M, Eriksen EF, Fode K, Klærke A, Kroyer L, Lindeberg H, Madsen CB, Strange P, Espersen JO (1984) Treatment of cervical disc disease using Cloward's technique. III. Evaluation of cervical spondylotic myelopathy in 138 cases. Acta Neurochir (Wien) 71: 121–131

Authors' address: Helmut Bertalanffy, M.D., Department of Neurosurgery, University of Freiburg, Hugstetterstrasse 55, D-7800 Freiburg i. Br., Federal Republic of Germany.