Analysis of Reoperations after Surgical Treatment of Degenerative Cervical Spine Disorders: A Report on 900 Cases

Analyse von Revisionseingriffen bei degenerativen HWS-Veränderungen – Ein Report über 900 Fälle

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Key words

degenerative cervical spine
reoperation
fusion
corpectomy

Schlüsselwörter

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Reoperationen
Fusion
Korpektomie

Abstract

Abstract: Surgery on the degenerative cervical spine disorders aims at decompression of the neural structures and restoring the physiological profile of the cervical spine. The aims of the internal fixation are to gain primary stability, introduce a bony fusion and to correct the shape of the spine. The present study will give answers to the following questions: 1. What is the overall revision rate following an operative treatment of degenerative cervical disorders using common operative techniques? 2. Is there any influence of the fusion length to the overall revision rate and especially to the decompression ratio of adjacent segments? 3. What is the rate of revisions due to instrumentation failures? 4. Are there any differences concerning the revision rate between posterior and anterior instrumentation?

Material: We reviewed 900 patients, who underwent a cervical spine surgery with an internal fixation between January 1994 and December 2000.

Methods: Five different operative techniques were used: type I (mono- and bisegmental intersomatic decompression and fusion using anterior instrumentation), type II (multisegmental intersomatic decompression and fusion using anterior instrumentation), type III (multisegmental anterior intersomatic decompression and fusion with posterior instrumentation), type IV (one-level corpectomy with vertebral body replacement and posterior instrumentation) and type V (multi-level corpectomy with vertebral body replacement and posterior instrumentation). The minimum follow up period was 2.2 years (mean 4.2 years).

Results: In total, 121 revisions (13.4%) were recorded. The main indication for revision was implant failure in 5.4%. Operations type I showed the lowest revision rate (11%), while type V operations showed the highest revision rate (32%).

Zusammenfassung


Ergebnisse: Insgesamt waren 121 Revisionen (13,4%) erforderlich. Den höchsten Anteil mit 5,4% hatten hardware bezogene Revisionseingriffe. Mono- und bisegmentale Fusionen wiesen mit 11% einen hochsignifikant (p<0,001) geringeren Anteil an Revisionen gegenüber multisegmentalen Fusionen mit einem Anteil von 22% auf. Operationstyp I hatte mit 11% die geringste Revisionsrate, die höchste der Typ V mit 32%. Es zeigte sich eine höhere durch Materialversagen bedingte Revisionsrate bei den 735 ventralen Instrumentationen mit 6% gegenüber 3% bei den 165 dorsalen Instrumentationen. Allerdings ohne Signifikanz (p<0,13).
Conclusions: The influence of the fusion length on the revision rate was unexpectedly high. Adjacent level decompression was neither influenced by the length of the fusion nor the performed procedure. Compared to anterior instrumentation, posterior instrumentation showed a tendency for a lower revision rate without statistical significance. However, the posterior procedures showed a high revision rate regarding to wound healing problems.

Surgery to treat degenerative cervical spine disorders aims at decompressing the neural structures and restoring the physiological profile of the cervical spine. Depending on the indications and the extent of the decompression, discectomies and/or corpectomies inevitably lead to destabilisation of the cervical spine. The aims of internal fixation are to gain primary stability, improve the fusion rate and obtain a correction of the shape of the spine [13, 21, 30]. In our work, no cervical osteotomies were carried out to correct the cervical kyphosis, but we depended on the increase in the anterior column height that was achieved after ordinary anterior cervical decompression and fusion. In the present study five common operative techniques to decompress, fuse and stabilise the degenerative cervical spine were used.

This study tries to obtain answers to the following questions:

- What is the overall revision rate after operative treatment for degenerative cervical spine problems using common operative techniques with instrumentation?
- Is there any influence of the fusion length on the revision rate in general or for adjacent segment decompression in particular?
- How high is the rate of revision due to instrumentation failure?
- Is there any difference between the revision rate after anterior and posterior instrumentation?

Materials and Methods

Clinical Data

From January 1994 till December 2000, 900 patients were operated upon for degenerative cervical spine disease. Other cervical pathologies such as tumours, inflammations and trauma were excluded. 699 of the patients suffered from radiculopathy while myelopathic changes were detected in 201 of the patients. All patients were followed up in an outpatient setting (at 3 months, 6 months and one year postoperatively, then yearly). 14 patients were lost to follow up for different reasons (5 deaths from other medical reasons, 9 changes of residence). The mean follow-up period was 4.2 years (2.2–8 years). There were 463 (51%) men and 437 women. The mean age was 53 years (SD=11.3). This study is a retrospective one.

The indications for the procedure were divided into: stenosis (539 patients=60%), soft disc herniations (261 patients=29%), and lastly erosive osteochondrosis and segmental instability without stenosis (100 patients=11%). This differentiation was chosen arbitrarily with possible overlaps. For analysis reasons the fusion length was partially divided into two groups (monosegmental and multisegmental).

Surgical techniques (types of operations)

The operative techniques used were divided into different categories according to fusion length and approach of the instrumentation:

Type I = Mono- and bisegmental intersomatic decompression and fusion with anterior instrumentation (Fig. 1)

The tricortical grafts were harvested from the anterior iliac crest [27]. Anterior cervical approaches were performed according to Cloward [6]. The Smith-Robinson technique [28] applying temporary interbody distraction was used. The posterior longitudinal ligament as well as osteophytes or herniated disc fragments were removed under visualisation of the operative microscope. The endplates were burred down to bleeding subchondral bone, leaving anterior and posterior edges to brace the graft. The tricortical graft was fashioned and placed in the recipient bed. Removal of distraction secured the graft under compression and this was followed by anterior plate fixation in all cases (Pilling Weck, Karlstein, Germany).

Fig. 1 Intersomatic fusion with iliac crest bone graft and anterior instrumentation (operation type I).
Type II = Multisegmental intersomatic decompression and fusion with an anterior instrumentation
The technique corresponds essentially to type one. This type embraces all operations with an anterior instrumentation of more than 2 segments (up to 4). Nevertheless this technique was only performed until 1997 and was then replaced by type III.

Type III = Multisegmental intersomatic anterior decompression and fusion with posterior instrumentation (Fig. 2)
The first steps correspond to type I and type II. After positioning the tricortical grafts in the disc space the patients were turned over within the same anaesthesia setting. The next step was the subperiostal exposure of the affected posterior cervical segments. The screw placement was performed according to Magerl. This technique, using a 25°–30° lateral and a 15° cephaled course parallel to the surface of the superior articular process poses less risk of facet joint violation [21]. In this way, the bilateral posterior cervical plates (Königsee-Instrumente, Königsee, Germany) were fixed in affected segments. Additionally, the laminae were decorticated and posterior fusion was carried out.
Since 1997, we have used this technique for multisegmental intersomatic fusion (it had replaced operation type II).

Type IV = Single-level corpectomy with vertebral body replacement and anterior instrumentation (Fig. 3)
After an anterior corpectomy and decompression under distraction an accordingly trimmed vertebral body replacement, e.g. Harms (DePuy, Acromed, Raynham, USA) or Königsee (Königsee-Instrumente, Königsee, Germany) titanium mesh was inserted in place. This titanium mesh was filled with autogenous cancellous bone yielded from the removed vertebral body. For additional fixation purposes, anterior plating was used (Pilling Weck, Karlstein, Germany).

Type V = Multilevel corpectomy with vertebral body replacement and posterior instrumentation (Fig. 4)
The anterior part of the procedure is similar to type IV. The posterior part of this operation type is the same as described for operation type III. We used this procedure for multilevel corpectomies. Patients with combined discectomy and corpectomy were added to this group. After discectomies a tricortical graft harvested from the iliac crest was inserted. All patients in type I, type II and type IV were immobilised postoperatively in an external orthosis (Philadelphia collar) for an average of 8 weeks after surgery.

Data analysis
All data were acquired from our internal data base. Reoperations were defined as secondary or third operations at the cervical or donor site within the follow-up period. Likewise, revisions were categorised for reasons of clarity as follows:
► Adjacent segment decompensation: This group comprises all revisions due to adjacent segment decompensation.
► Implant-related revisions: This encompasses all revisions which were related to the instrumentation, e.g. screw breakage or loosening, either for posterior or anterior procedures. One patient from group V was revised because of nerve root irritation by one of the posterior lateral mass screws. The group also included all dislocations of the graft or titanium mesh with loss of correction and increasing kyphosis.
► Wound healing problems: This group included all revisions caused by wound healing problems, e.g. wound haematoma, infection or dehiscence (especially with a posterior approach) as well as graft donor site wound complications. One oesophageal fistula was also included in this group. These non wound healing haematomas were mainly associated
Table 1  Fused segments in relationship to mean age

<table>
<thead>
<tr>
<th>Fused segments</th>
<th>Mean age (years)</th>
<th>Number of patients</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>49.1</td>
<td>392</td>
<td>11.50</td>
</tr>
<tr>
<td>2</td>
<td>53.7</td>
<td>307</td>
<td>9.80</td>
</tr>
<tr>
<td>3</td>
<td>58.3</td>
<td>122</td>
<td>10.20</td>
</tr>
<tr>
<td>4</td>
<td>61.2</td>
<td>60</td>
<td>7.80</td>
</tr>
<tr>
<td>5</td>
<td>65.5</td>
<td>11</td>
<td>6.70</td>
</tr>
<tr>
<td>6</td>
<td>65.5</td>
<td>8</td>
<td>7.70</td>
</tr>
</tbody>
</table>

with the posterior approach, with continuous drainage from the wound necessitating wound revision.

- **Re-decompression**: Re-decompressions were necessary for postoperative persisting pain and/or neurological deficits with radiologically proven residual stenosis.

- **Postoperative epidural haematoma**: This category included epidural haematomata mostly occurring within the early post-operative period leading to neurological deficits.

- **Pseudoarthrosis**: This category is exclusively reserved for revision due to clinically relevant pseudoarthrosis, which led to increasing kyphosis and pain. Pseudoarthrosis was diagnosed following the radiological criteria of Gertzbein et al. [11].

### Statistical analysis

First of all we did an explorative statistical analysis. In order to answer the questions of this study we used different statistical tests. Tests used included t-test for independent samples, Fisher’s exact test and the Chi-square test. In addition, we used oneway ANOVA, post-hoc test, and the Bonferroni test. We set the alpha level for statistical significance for all tests at p < 0.05.

### Results

900 patients with degenerative cervical disease underwent anterior or combined anterior/posterior fusions following discectomies and/or corpectomies. In total 1715 segments were fused. The segments most affected were C5-7 in 92%. In 32 cases, the caudally fused vertebra was the first thoracic and in 28 cases, the cranially fused vertebra was the second cervical vertebra. The distribution of the fused segments in relation to patients’ age is shown in Table 1. 699 patients (78%) underwent mono- or bisegmental fusion and in 201 patients (22%), fusion was multisegmental. There were 121 revisions (13.4%) in 108 patients (12%). Implant-associated revisions were responsible for 40% of the total revisions. The absolute numbers and percentages for the respective revision categories are listed in Table 2.

### Revision rate and fusion length

Comparing the overall revision rate between primary mono- and bisegmental operations with 77 out of 699 (11%) and primary multisegmental operations with 44 out of 201 (22%) we found a statistically significant difference (Chi-square test, p < 0.0001). Generally, patients without a revision had 1.9 segments fused compared to 2.1 segments for patients with a revision. This was also statistically significant (p = 0.013). Instrumentation-related problems (5.7%) were the predominant reasons for revision among the mono- and bisegmental group, whereas for the multisegmental group wound problems (7.5%) played the most important role. The instrumentation-related revisions amounted to 4.5%. On the other hand there was no difference in the rate of adjacent level decompression between the two groups (1.7% for mono- and bisegmental, 2% for multisegmental fusion). The numbers of the individual revision categories are given in Table 3.

### Revision rate and operative procedure

Total numbers and percentages of the revision categories based on the respective operative procedure are shown in Table 4. The type I procedure (intersomatic anterior fusion with instrumentation, mono- and bisegmental) was the most frequently performed procedure (n=623 cases) and showed the lowest overall revision rate (11%). Instrumentation-related revisions were the most common type of revision (6.4%). The Group V operation (two and more level corpectomies and posterior instrumentation), included 65 patients, with an average of 2.7 level corpectomies. The highest rate of revisions was found in this group (32%). Wound problems clearly outweighed other reasons for revision with an incidence of 13.8%. Regarding the instrumentation it has to be noted that these are summarised under instrumentation-associated revisions. In this study, out of 735 anterior instrumentations, 44 cases required instrumentation-related revision (6%). There were only 5 instrumentation-related revisions (3%) among the 165 posterior instrumentations. This difference has more of a tendency as it was not statistically significant (p=0.13).

The well known problems occurring at the harvesting site at the iliac crest are included under the wound healing problems. In this study 11 patients required revision due to problems at the graft donor site.

Table 1  Fused segments in relationship to mean age

<table>
<thead>
<tr>
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<td>1</td>
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</tr>
<tr>
<td>6</td>
<td>65.5</td>
<td>8</td>
<td>7.70</td>
</tr>
</tbody>
</table>

Table 2  Percentages of revision categories

<table>
<thead>
<tr>
<th>Revision category</th>
<th>Number of revisions</th>
<th>Percentage in relation to total number of patients (900)</th>
</tr>
</thead>
<tbody>
<tr>
<td>adjacent segment decompenation</td>
<td>16</td>
<td>13.2</td>
</tr>
<tr>
<td>hardware-related revisions</td>
<td>49</td>
<td>40.5</td>
</tr>
<tr>
<td>wound healing problems</td>
<td>21</td>
<td>17.4</td>
</tr>
<tr>
<td>re-decompression</td>
<td>15</td>
<td>12.4</td>
</tr>
<tr>
<td>recurrent bleeding</td>
<td>13</td>
<td>10.7</td>
</tr>
<tr>
<td>pseudoarthrosis</td>
<td>7</td>
<td>5.8</td>
</tr>
<tr>
<td>total</td>
<td>121</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 3  Revision categories and the length of spondylodesis

<table>
<thead>
<tr>
<th>Revision category</th>
<th>Mono- and bisegmental (699 patients)</th>
<th>Multisegemental (201 patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>adjacent segment decompenation</td>
<td>12</td>
<td>1.7</td>
</tr>
<tr>
<td>hardware-related revisions</td>
<td>40</td>
<td>5.7</td>
</tr>
<tr>
<td>wound healing problems</td>
<td>6</td>
<td>0.9</td>
</tr>
<tr>
<td>re-decompression</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>recurrent bleeding</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>pseudoarthrosis</td>
<td>5</td>
<td>0.7</td>
</tr>
<tr>
<td>total</td>
<td>77</td>
<td>11</td>
</tr>
</tbody>
</table>
Discussion

Revision rate and fusion length

In the literature there was no clear statement regarding this problem. The present study found a two-fold higher revision rate of 22% for multisegmental spondyloptosis compared to mono- and bisegmental procedures. This remarkable difference was due to the high revision rate (32%) of type V operations. Cervical fusions result in a significant increase in intradiscal pressure and segmental motion in the superior adjacent level. This could accelerate normal degenerative changes in these adjacent levels [5, 23, 25]. As with the lumbar spine [14], we expected different percentages in adjacent level decompensation between the two groups. This was not the case. The revision rate for this problem was 1.7% for mono- and bisegmental procedures and 2% for multisegmental fusions. The statistical analysis did not show any significance. We think that the reason behind this low rate of adjacent level disease was the low stress loads of the cervical spine compared to the lumbar spine. Keller [16] reported a 3.8% adjacent level decompensation after a two-year follow-up. Regarding problems at the bone graft donor site (iliac crest), the rate of revision was 1.2%. This corresponds to the results reported by Silber [27] (1.5% revisions in 187 patients).

Revision rate and operative procedure

Different entities within the group of degenerative changes of the cervical spine required different operative approaches which varied in their degree of difficulty. Numerous papers have described the effectivity of anterior fusion using an iliac crest bone graft combined with anterior plate fixation as a mono- or bisegmental procedure, both for degenerative and traumatic changes [1, 3, 4, 10, 12, 17, 22]. A survey of the results in the literature for this procedure showed that instrumentation-related problems were the main reason for revisions [3, 10, 19]. In our study, 623 patients underwent intersomatic anterior fusion with instrumentation (type I), and 40 revisions (6.4%) due to instrumentation failure were recorded in this group. Anterior instrumentations were responsible for a total revision rate of 6% (44 out of 735). Lowery and McDonough [19] described a 35% rate of instrumentation failure, requiring revision in 7% of patients. Interestingly, it is not easy to find viable numbers on instrumentation-related failure in large series.

The total revision rate of 11% out of 623 mono- and bisegmental intersomatic anterior fusions with instrumentation (type I) was slightly higher than that reported in the literature, which ranged from 6.5% to 10.6% [2, 3, 10, 15] for comparable procedures, although the number of patients included in these studies was far lower.

Biomechanical and clinical studies demonstrated favourable results with respect to stability and reconstruction of cervical lordosis for posterior instrumentation in cases with multilevel problems [9, 20]. Coe et al. [7] found that posterior plate fixation offered the best results with regard to torsional stability. This fact and the additional better restoration of the cervical alignment were the reasons for augmenting multisegmental intersomatic fusion and multilevel corpectomies with posterior instrumentation and fusion techniques since 1997.

When studying the instrumentation-related failures, we found a higher failure rate for anterior instrumentation (6%) compared to posterior instrumentation (3%). This was only a trend and had no statistical significance. This finding agrees with that of Keller [16] who reported a rate of 3.7% of implant-related revisions for posterior instrumentation.

For procedures including corpectomies (type IV and V) we registered an increase in the revision rate to 17 and 32%, respectively. Zdeblick and Bohlmann [31] reported a revision rate of 33% using fibula allograft after corpectomies with anterior instrumentation. Vaccaro [29] found a 9% failure rate for two levels and 50% failure rate for three level anterior corpectomies with anterior plate fixation.

Sasso et al. [26] discussed additional posterior stabilisation on the basis of his own high revision rate (22.2% instrumentation failure) after multisegmental corpectomies and anterior instrumentation. Our patients who underwent multilevel corpectomies (type V) and posterior plate fixation showed an instrumentation-related failure rate of only 6.5%, but concurrently a higher revision rate of 13.8% due to wound healing problems (Table 4).

Revision rate and wound healing problems

In type III and type V surgical techniques, the wound healing problems with the posterior approach ranged from 8 to 13.8%. (Table 4). Deen et al. [8] reported 9.5% rate of wound healing problems after posterior cervical instrumentation. In a series of 32 patients, Huang et al. [18] noted a 9% rate of wound infection in spondylotic myelopathy treated by multilevel laminectomy combined with lateral mass plate fixation. Another study, by
Pateder et al. [24], showed an 11.7% rate of wound infection after lateral mass screw fixation for cervical spine injuries. In our study we recorded a comparable revision rate (8%) for wound healing problems in after a type III procedure (multisegmental intersomatic anterior decompression and fusion with posterior instrumentation). The higher rate (13.8%) of wound healing problems after type V operations (multilevel corpectomy with vertebral body replacement and posterior instrumentation in the same sitting) could be explained by the longer duration of the surgery.

In contrast, the incidence of wound healing problems after an anterior approach (groups I, II, and IV) was comparatively lower and ranged from 0.5% (group I) to 1.4% (group IV).

Limitations of this study
The presented work is a retrospective study performed to evaluate five different operative procedures. The analysis was done to establish the rate of revision and the reasons. For better clarification all revisions were classified into six categories. This categorisation is too vague to answer special questions. As the rates for pseudoarthrosis (0.8%), postoperative bleeding (1.4%), and the necessity for re-decompression (1.7%) were low, these issues were not addressed further. In many cases, pseudoarthrosis may be the cause behind instrumentation failure. We believe that the real pseudoarthrosis rate may be much higher than that reported. The clinical symptoms as well as the operative procedures differed widely. Therefore, we did not evaluate the different procedures as such.

Conclusions
This study presents data regarding rate of revision after the operative treatment of cervical spine disorders. The overall rate of revisions was 13.4%. The influence of the fusion length on the revision rate was unexpectedly high. Adjacent level decompensation was neither influenced by the length of the fusion nor by the performed procedure. Compared to anterior instrumentation, posterior instrumentation showed a tendency towards a lower rate of revision but without statistical significance. However, posterior procedures had a higher revision rate due to wound healing problems. Implant failure revisions occurred with a rate of 5.4%. The revision rate for multilevel corpectomies was unacceptably high (32%).

Conflict of interest: None

References