Factors influencing surgical outcome after anterior stabilization of the cervical spine with heterogeneous material

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Abstract

Intervertebral fusion through an anterior approach with polymethylacrylate is a well-established neurosurgical technique in the treatment of cervical spine degeneration. However, questions still remain concerning the post-surgical outcome. Factors influencing surgical outcome that could help to predict which patients need further post-surgical treatment and what to expect after surgery are the subject of numerous studies. In the present study, we retrospectively collected data from patients who had undergone intervertebral fusion and defined which pre-operative factors could influence the surgical outcome. Between 1993 and 1997, 379 patients were surgically treated with the ventral fusion technique in our hospital. In 2006, we sent a questionnaire to the patients and 164 responses were received. We identified pre-operative presence of severe pain, hypesthesia, palsy and gait disturbance as negative predictive factors, whereas age, body mass index, pre-operative physical strain and the cervical segment involved did not seem to influence prognosis. In conclusion, identifying pre-operative factors which influence prognosis after intervetebral fusion will help predict post-operative outcome.

Introduction

In modern medicine, the surgical treatment of degenerative diseases of the cervical spine has been the subject of much discussion. Many techniques and approaches have been described and new ones are reported every year. Historically, a major point of discussion concerned which approach would be of most help to the patient, *i.e.* the posterior or anterior approach. The posterior approach with laminectomy or hemilaminectomy was inappropriate in terms of reaching ventrally located hyperostotic deformities. There was some significant injury to the vertebral arteries, the spinal cord and nerve roots.[1-3] With more sophisticated diagnostic procedures it could be seen that, in most cases, degeneration in the cervical spine was caused by pathological changes of the intervertebral disc demanding a different approach to the cervical spine, namely the anterior approach with the advantage of minimum irritation of the nerve roots and the spinal cord. On the other hand, the anterior approach is associated with complications such as injury to the recurrent nerve and carotid artery and esophageal and/or tracheal damage. One of the pioneers in advocating the anterior approach was the neurosurgeon Cloward who reported the intervertebral fusion in the 1950s.[4] At the same time, similar reports came from the orthopedic surgeons Robinson and Smith.[5,6] Cloward's technique has since been adopted and modified by many neurosurgeons all over the world. There is still further controversy concerning the fusion of cervical segments above and below the discectomy level. The answer to this question is still unknkown. Different kinds of material can be used as spacers in anterior cervical spondylodesis. Titanium cage as disc replacement[7] and polyetherethereketone (PEEK - Cage) are examples of heterogeneous materials, and autogenous iliac crest graft is an example of an autogenous material.[8-10] It is possible that, compared to iliac bone crest, cages are able to retract the intervertebral space and, therefore, increase the foraminal height (nerve root decompression) for a longer period of time.[11] A problem that occurs when using an iliac crest graft is pain induced by irritation of the periosteum on the iliac crest. This was the reason why Grote and Röttgen modified the fusion technique by using heterogenous materials. Today, polymethylacrylate (PMMA or Palacos®) and new materials with carbon fibers,[12,13] synthetic material or disc prostheses are also used as spacers.[14] The present study evaluates factors influencing the outcome of cervical intervetebral fusion with the use of PMMA.

Materials and Methods

Patient population

Patients undergoing surgery for cervical degenerative diseases by anterior fusion between the years 1993-1997 were evaluated. A questionnaire was sent to 379 patients in 2006 allowing a retrospective follow up 9-13 years after surgery. Objective parameters were evaluated such as duration of absence from work or participation in a rehabilitation program, as well as subjective parameters such as the patient's own perception of the surgical result.

Three patient groups could be defined: patients with *soft disc* disease suffering from isolated disc herniation, with *hard disc* disease suffering from osteophytes and ossified disc herniations, and with *both* representing a combination of the two described groups.

Operation technique

In the present study, patients were operated on by an anterior cervical approach. The vertebral bodies of the involved segments were distracted, and the osteophytes and the vertebral discs were removed. PMMA was injected into the intervertebral space. Once the PMMA had hardened, the distraction was removed.

Outcome

The surgical outcome was defined in accordance to Odom's classification[3] that has also been discussed in other studies.[15] Outcomes were defined as: Excellent - no complaints referable to cervical disease, able to carry on daily occupations (Odom I); Good - intermittent discomfort, related to cervical disease, but not significantly interfering with work (Odom II); Moderate/Poor - subjective improvement, but physical activities significantly limited/no improvement or worse compared with the pre-operative condition (Odom III and IV).

Statistics

Factors evaluated in the present study were: age, body mass index (BMI), pre-surgical complaints, duration of symptoms until the operation, *soft disc, hard disc, both,* operated cervical segment, postoperative rehabilitation, pre-operative physical strain, presence of other disc herniations, additional diseases, postoperative occurrence of degenerations above and below the operated segment. The statistical

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Key words: intervertebral fusion, cervical disc degeneration, polymethylacrylate.

Conflict of interests: the authors declare no potential conflict of interests.

Received for publication: 30 March 2012.
Revision received: 10 May 2012.
Accepted for publication: 15 May 2012.

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Clinics and Practice 2012; 2:e60
doi:10.4081/cp.2012.e60

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evaluation was performed by χ^2 analysis, 4-fold table test and Fisher's exact test.

Statistical significance was defined as $P<0.05$ in the χ^2 analysis. When the requirements of the χ^2 analysis could not be met (*i.e.* less then 5 samples per field) Fisher's exact test was used.

Results

Of the 379 patients invited to take part in the study, 164 answered the questionnaire (43.3%); there were 36.9% females and 63.1% males. Mean age was 49 years. The youngest patient was 28 years old and the oldest 71 years old. Mean body mass index was 26.2 (range 16.7-40.0). There were no additional diseases in 81.7% (n=134) of patients, 1.8% (n=3) suffered from polyneuropathic disease, 3% from diabetes, and 10% had other minor diseases. Forty-one per cent of patients suffered from *soft disc*, 10.4% had *hard disc* disease and 48.2% *both*.

Pre-operative symptoms

Eighty-one per cent (n=133) of patients suffered pre-operative pain, 80% (n=131) had hypesthesia, 32% (n=53) had palsy and 14.6% (n=24) suffered from gait disturbance.

Postoperative imaging

Postoperative diagnostic imaging had been performed in all patients. In 68% (n=111), a conventional cervical X ray, in 24% (n=40) magnetic resonance imaging (MRI) and in 8% (n=13) computed tomography scan had been performed. Unfortunately, the images could only be recalled from our digital archive for 90 patients. In 8.7% of the patients who had undergone surgery a degeneration progress in the operated segment was identified.

Pre-operatively there were additional degenerative changes (although these were less significant) in the neighbouring segments in 14% (n=23). Degenerations in one segment above the operated segment were seen in 91.3% (21 of 23) of the patients and in one segment below the operated segment in 52.2% (12 of 23). In 7.8% of the patients, new degeneration occurred in segments above that operated and in 10% in segments below. There was no statistically significant risk of developing degenerative changes in neighboring segments of the cervical spine after intervertebral fusion with PMMA.

Surgical complications

Eighty per cent of the patients suffered no surgical complications (n=133). In 3% (n=5) bleeding and in another 0.6% (n=1) an infection occurred. In 3.7% (n=4) there was a permanent hoarseness, 4.3% (n=7) of patients complained of a worsening of symptoms, 9.1% (n=8) had a temporary dysphagia.

Overall evaluation of surgical outcome

The surgical outcome was judged as excellent in 41.5% (n=68), in 36% (n= 59) good, in 20.3% (n=35) as moderate/poor, whereas 1.2% (n=2) did not answer this question.

Insignificant factors for surgical outcome

The duration of the pre-operative symptom did not influence the surgical outcome of the patients since there was no statistically significant difference in results. Similarly, no significant correlation between surgical outcome and age, additional diseases, BMI, pre-operative physical strain, operated cervical segment, and *hard disc, soft disc* or *both* could be shown.

Significant factors influencing the surgical outcome

Further surgery

Only 5% (n=3) of the patients with excellent surgical results underwent further surgery in the period up till 2006, whereas 20% (n=12) of patients with good outcome and 20% (n=7) with moderate/poor outcome underwent a second operation in the cervical spine. There was a statistically significant correlation of more then one cervical spine operation and an unfavorable outcome ($P<0.05$) (Figure 1).

Presence of postoperative residual symptoms and outcome

Figure 2 shows the correlation between patients treated in hospital versus those treated in a rehabilitation facility to the surgical outcome. Residual symptoms were present in 42.2% of patients who did not receive any postoperative treatment (n=45), in 62% of those who received ambulatory postoperative treatment (n=89), in 67% of those treated in a rehabilitation facility (n=9) and in 80% of those patients who had hospital and ambulatory rehabilitation. There was a significant correlation of postoperative treatment and unfavorable outcome ($P<0.05$).

Pre-operative pain influences the postoperative outcome

Forty percent of patients with severe pain before surgery (n=80) also suffered from residual pain after surgery. On the other hand, when pain before surgery was less severe (n=53) only 10% of patients suffered from postoperative pain (Figure 3). Pre-operative pain has a negative impact on the surgical outcome ($P<0.05$).

Pre-operative hypesthesia correlates with unfavorable outcome

Thirty-seven percent of patients with hypesthesia before surgery (n=131) suffered from the same symptom after surgery. When there were no hypesthetic complaints before surgery, only 15% of patients reported such a symptom after surgery (Figure 4). The presence of pre-operative hypesthesia correlates significantly with an unfavorable outcome ($P<0.05$).

Palsy and surgical outcome

In 95% of patients without pre-operative palsy (n=111), this symptom was still absent postoperatively, whereas in patients presenting this symptom before surgery it persisted in 15% (Figure 5). Presence of pre-operative palsy is a negative predictive factor of surgical outcome ($P<0.05$).

Pre-operative gait disturbance has a negative influence on surgical outcome

In 33% of patients suffering from pre-operative gait disturbance (n=24), the symptom persisted after surgery. Among those patients who did not present this symptom before surgery (n=140), this symptom occurred in only 5% after surgery (Figure 6). Gait disturbance was significantly correlated with an unfavorable outcome ($P<0.05$).

Further surgery

Up till 2006, 87% (n=142) of patients did not require a second cervical spine surgical procedure. In 1.2% (n=2) of patients, further surgery was carried out on the same segment and in 12.2% (n=20) on neighboring segments (Figure 7).

Discussion

Use of PMMA as an intervertebral spacer in ventral fusion is an established method. PMMA can temporarily reach temperatures of 67°C during hardening and some critics of the method have discussed thermogenic neural tissue necrosis resulting from its use. An early study of Grote and Roosen has provided experimental evidence to disprove this.[16] Also in our experience, thermogenic damage of neural tissues was not seen. However, the possibility that postoperative complications and pain could be due to thermogenic damage that is not identifiable via MRI or other imaging cannot be excluded. It had been shown that PMMA was at least as safe as iliac crest bone graft, without the additional risk of iliac wound infection, pelvic bleeding and pain in the graft area. Even as new materials such as carbon or titan cages are about to replace PMMA, a sur-

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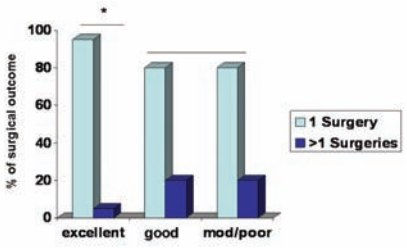


Figure 1. Surgical outcome worsens with the number of cervical spine operations. Five percent (n=3) of the patients with excellent surgical results had a second surgical intervention, whereas 20% (n=12) of patients with a good outcome and 20% (n=7) with moderate/poor outcome had a second surgical intervention in the cervical spine (*P<0.05).

vey of 100 German neurosurgical departments (conducted in 2002) showed that PMMA is used in 40% of cervical intervertebral surgeries.[17] Annual PMMA failure is reported to be 0.15%, whereas in tricortical iliac graft annual failure rates are 0.53% and in carbon cages 0.05%.[17] Dyslocation of the spacer has been reported in 0.7% a year of PMMA and 0.35% a year in carbon and titan cages.[17]

In the present study, mean patient age was 49 years with a standard deviation of 8.5 years. The age of the patient population was similar to the populations of numerous other similar studies.[9,15,18,19]

We could find no correlation between age and surgical outcome. Hamburger *et al.*[19] also failed to show such a correlation in their 2001 study. In contrast to our expectations, additional diseases or a higher BMI, which could affect patient mobilization after surgery, were not seen to influence outcome. Other authors reported that lumbar spine symptoms had a negative impact on the outcome of cervical spine surgery.[19] In the present study, this was not included in the questionnaire.

Irrespective of the fact that the lower segment of the cervical spine is more affected by disc herniations because of the local stronger anatomical forces, there was no negative influence of lower cervical spine segment degenerations and outcome. This result agrees with those of other studies.[19] Concerning the differ-

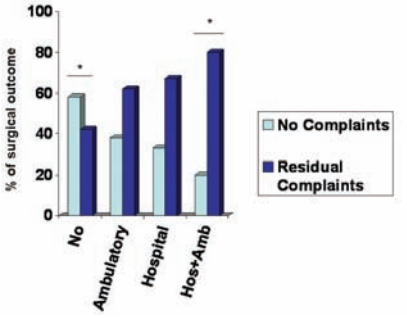


Figure 2. Presence of postoperative residual symptoms and outcome. Correlation between patients treated in hospital versus those treated in a rehabilitation facility to the surgical outcome. Residual symptoms were present in a significantly higher rate in patients received further therapy additional to surgery (*P<0.05).

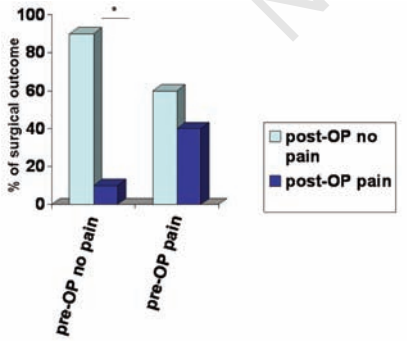


Figure 3. Pre-operative pain influences the postoperative outcome. Forty percent of patients with severe pain before surgery (n=80) also suffered from residual pain after surgery. On the other hand, when pain before surgery was less severe (n=53) only 10% of patients suffered form postoperative pain (*P<0.05).

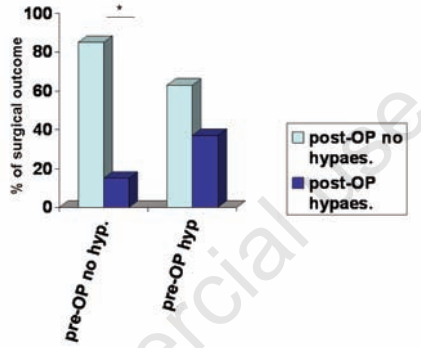


Figure 4. Pre-operative hypesthesia correlates with unfavorable outcome. Patients with hypesthesia before surgery (n=131) suffered significantly higher incidences of the same symptom after surgery compared to patients without this symptom pre-operatively (*P<0.05).

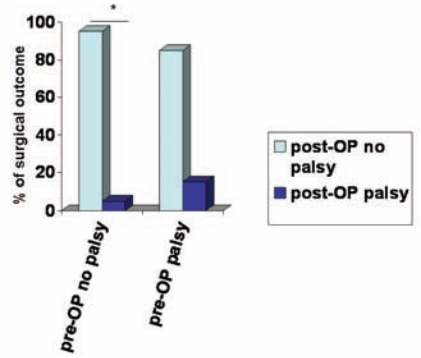


Figure 5. Palsy and surgical outcome. In 95% of patients without preoperative palsy (n=111) this symptom was still absent postoperatively, whereas in patients having this symptom before surgery the symptom persisted in 15 % (*P<0.05).

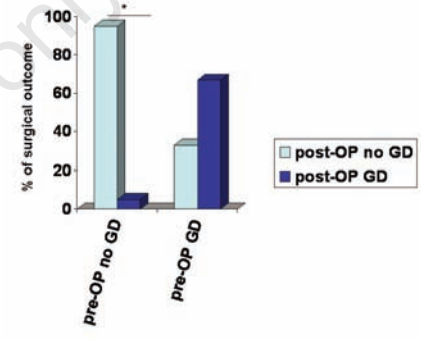


Figure 6. Pre-operative gait disturbance influences negatively surgical outcome. In 33% of patients suffering pre-operatively from gait disturbance (n=24) the symptom persisted after surgery. When patients did not have this symptom before surgery (n=140), then only in 5% did this symptom occur after surgery (*P<0.05).

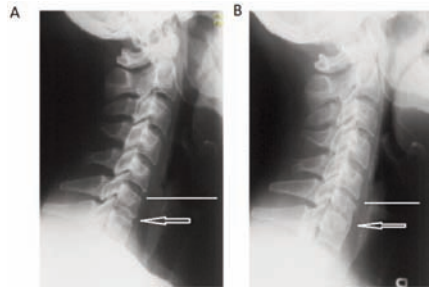


Figure 7. X ray immediately after surgery on C6/7 and eight years after surgery. (A) Pre-operative degeneration on C6/ can be seen (white arrow). At C5/6, a normal height of the disk is identified (white line). (B) Eight years after surgery, ossification on the segment C6/7 can be seen (white arrow) and additionally a decrease and degenerative signs on the segment C5/6 (white line) in now present.

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entiation between *soft disc* and *hard disc*, we failed to find a significant correlation between the type of degeneration with and without osteophytes and the outcome. In contrast to the present study, Hamburger *et al.*[19] reported that patients with *hard disc* degenerations had a better outcome. In the evaluation of symptoms, it was shown that pain was the most prevalent complaint followed by numbness and, at a lower rate, palsy. Gait disturbance was the least common symptom. These results were expected and are explained by the fact that, in the case of disc herniations, the thin fibers responsible for the pain are the first to be damaged by compression followed by the thicker fibers that are responsible for sensitivity and movement.[20] Gait disturbance indicates myelopathy. In most cases, this damage is irreversible and this is why patients with this symptom had an unfavorable outcome after surgery. We expected a correlation between duration of pre-operative symptoms and outcome after surgery. Patients who had longer lasting symptoms were expected to have a worse post-surgical outcome. However, this hypothesis could not be proven in the statistical analysis. In another study, it had been reported that patients with symptom duration of less than three months had a better surgical outcome.[19] The mean duration of treatment in hospital in our study was eight days (range 3-18 days). In similar studies, this was five days (range 2-20 days).[19] The duration for which patients were incapacitated was ten weeks (maximum 81 weeks). Hamburger *et al.* reported that in 39% of cases the disability lasted less than one month, in 32% between one and two months, in 10% between two and three months, and in another 10% more than six months. Two (1.3%) of the patients in our study had to have occupational retraining. Other studies have reported that approximately 3% of patients needed occupational retraining. In the present study, it is seen that patients who received ambulatory treatment and/or therapy in a rehabilition facility had a worse outcome than those who were discharged and sent home. This can be explained by the fact that the patients who were discharged had no complaints after surgery whereas those who were sent to have further rehabilitation treatment had postoperative complaints that in part did not resolve completely. Most of the patients undergoing surgery were able to return to their daily routine after surgery and were socially active. In the same way, it has been reported that 51% of office workers (15.8% Odom III and IV) had an Odom I outcome whereas only 26% patients working in more physically demanding jobs had Odom I (30% Odom III and IV).[19] There are a number of studies showing that neighboring segments to the intervertebral fusioned segment start to undergo degenerative changes.[21,22] Additionally, it has been shown biomechanically that there is elevated interdiscal pressure in segments above and below that operated.[23] In the present study, we report new degenerative changes in the cervical spine after surgery in 8.7% of cases. Unfortunately, the study design was not appropriate to allow us to perform a statistical analysis of these data. Further prospective studies on this issue are needed.

Conclusions

In summary, 77% of our patients had an overall outcome of Odom I and II. Other similar studies show Odom I and II in 77.5%,[19] 78%[24] and 70%[15] of patients, respectively. We tried to clarify why the 23% of patients with Odom III and IV fare worse according to identifying factors that pre-operatively predict a negative outcome. Irrespective of the intervertebral spacer and the surgeon, factors such as severity of pre-operative pain, presence of numbness, palsy or gait ataxia predict an unfavorable surgical outcome.

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