

# Adjacent Disc Degeneration In The Cervical Spine: Personal Data And A Critical Reappraisal Of The Literature

R Donk, R Bartels

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## Abstract

**Objective:** Anterior cervical discectomy with fusion (ACDF) is often performed. More recently, degeneration of the adjacent segment (ADD) has gained more attention, and it was thought to be related to an ACDF. Arthroplasty could prevent the occurrence of ADD. The often cited proof for the existence of newly formed ADD is critically reconsidered, and especially its clinical relevance is questioned. **Methods:** Retrospectively, the data of 37 patients who were operated on between 1998 and 2002 were retrieved. Re-surgeries after ACDF with stand alone cages were noted. An independent investigator contacted the patients and asked previously determined questions. The literature was also reviewed, and articles frequently cited in the discussion about ADD are critically reviewed. **Results:** Thirty-four patients participated. The mean follow-up was  $9.6 \pm 1.2$  years. At the last follow up, 74% of the patients had a good to excellent result, 24% a moderate result, and 2% a fair result. Six patients underwent a new surgery after the index surgery of whom only one due to a clinical symptomatic new ADD. The annual rate of ADD was 0.32 %. The number of articles dealing with ADD were strongly correlated with those about arthroplasty. Revision of the available data resulted in a lower annual rate that resembled the rate of ADD after arthroplasty. **Conclusion:** Our personal data confirmed the estimation of the annual rate of ADD after CADF of less than 1%. In one study it resembled the annual rate after arthroplasty. The clinical relevance of ADD should seriously be questioned.

## INTRODUCTION

Anterior cervical discectomy with fusion (ACDF) for a symptomatic degenerated disc is a frequently performed procedure. Degeneration or progression of existing degeneration of the adjacent segment(s) is related to ACDF, and is called adjacent disc degeneration or disease (ADD), or adjacent segment degeneration (disease). The concept of ADD in clinical practice is remarkable. ACDF has been performed since the 1960s, and until now a clinical series of patients suffering from clinical ADD has not been described. However, one of the arguments for using a cervical disc prosthesis is the prevention of ADD. Because of the incongruence between clinical facts and theoretical assumptions, a critical re-appraisal of the concept of ADD is warranted.

## METHODS

First, personal data were retrieved. A retrospective IRB approved study was conducted. Patients were included who underwent ACDF with stand alone cage and autogenous bone graft treated by a single surgeon (RB) from July 1, 1998 to July 1, 2002.

Two databases were used; one recording implants, the other recording surgical activities. The technique of implanting a stand-alone cage with autologous bone has been described previously(1,2). Data of interest were gender, date of birth, date of primary surgery (index surgery), reason for surgery (radicular or myelopathic symptoms), level of involved disk pathology, size of the implanted cage, and finally if other surgeries were performed, the kind of surgery and the reason for this surgery.

In first instance, all patients were contacted by telephone. An independent person (MJ) without a neurosurgical background asked the patients standard questions. These involved other surgeries at the neck after the index surgery, current complaints regarding the neck surgery (table 1) according to modified Odom's criteria(3), hoarseness, and finally dysphagia . Both hoarseness and dysphagia should have been related to the index surgery.

Table 1: score of current complaints

Finally, if a patient was operated on again due to problems of the adjacent level, the preoperative radiological examinations were examined to see if the adjacent level had

already signs of ADD previous to the index surgery. Clinically relevant ADD was defined as new degeneration of the adjacent disc necessitating additional surgery.

If the patients could not be contacted by phone, a list with the same questions was sent to the patients. If the patients had moved, the new addresses were retrieved through governmental instances.

For statistical analysis SPSS 17.0 was used. Numerical values are represented as mean  $\pm$  standard deviation. If appropriate a median  $\pm$  standard deviation is provided. A range is also shown. The annual rate of ADD is calculated the number of patients with ADD divided by the sum of the years of follow-up per patient.

Secondly, landmark papers dealing with ADD are identified and critically reviewed. It should be clearly stated that the article was not designed as a systematic review or meta-analysis.

## RESULTS

### PERSONAL DATA

In this period, thirty-seven patients were surgically treated for a herniated disk causing radiculopathy (N=32) and/or myelopathy (N=5). Twenty patients were males. The mean age at the index surgery was  $49.4 \pm 8.5$  (32.0-70.0) years. Thirty-four patients could be contacted. One man had been deceased seven years after surgery (he did not receive other surgical treatments for the neck except for the laminectomy after ACDF, see below), one male patient had moved towards another country, and one male patient refused participation. The mean period of follow-up was  $9.6 \pm 1.2$  (7.6 – 12.1) years.

The levels of the index surgery are represented in Table 2. Fifty carbon fibre cages (Depuy Spine, Amersfoort, The Netherlands) were used in thirty-seven patients. All cages had a standard size. The height of the cages is shown in Table 3.

**Figure 1**

Table 2: levels incorporated at the index surgery (N= 37)

Level	Number of patients
C3- C4	4
C4- C5	1
C5 – C6	9
C6 – C7	9
C7 – Th1	1
C4 – C5 and C5- C6	3
C5 – C6 and C6 – C7	10
<b>Total</b>	<b>37</b>

**Figure 2**

Table 3: cages used in 37 patients and 50 levels

Height of cage (millimeters)	Number
4	24
5	18
6	5
7	3
<b>Total</b>	<b>50</b>

At the last follow up, twenty-five patients (74%) had a good to excellent result, eight (24%) a moderate result, and one (2%) a fair result. Thirteen patients did not have any

complaints anymore, twelve only minimal complaints, and eight had on a daily base complaints but did not need any medical intervention. One patient still had severe complaints but less than preoperatively. These complaints were not new but maintained after the surgery. He could manage the situation very adequately, and sometimes he consulted an anesthesiologist. None of the patients mentioned worsening of the symptoms compared to the preoperative situation. This summary of the results included also the patients that were operated twice.

Six patients underwent repeated surgery for neck complaints. The median time between index surgery and second surgery was  $1.8 \pm 1.7$  (0.2 – 4.9) years. The reasons for the surgeries were: degeneration of the adjacent level (n=3), persistent myelopathic symptoms and signs (n=1), recurrence of radicular pain due to osteophytic compression at the same levels as were treated at the index surgery (n=1), luxation of the cage with difficulty of swallowing (n=1).

In the patient with a luxated cage, the cage was re-implanted and a fixation with a plate (Atlantis, Medtronic, Heerlen, The Netherlands) was performed. Prior to the index surgery, this patient had had a cervical laminectomy because of an intramedullary located ependymoma that had been removed successfully. One patient noted recurrence of the same complaints as preoperatively due to osteophytic spurs that compressed the nerve roots. A dorsal cervical foraminotomy was successfully performed. In another patient the result of anterior decompression for myelopathic changes was not satisfying. He did not mention any relief of the myelopathic complaints. New radiological examination still disclosed a stenotic spinal canal and he underwent a laminectomy. Afterwards, he noticed a slow but gradual improvement.

ADD was treated by cervical anterior with discectomy and implantation of a standalone cage. Revision of the original radiological exams learned that in two (66.6%) patients the adjacent discs had already signs of degeneration.

One patient suffered from hoarseness related to the index surgery. None of the patients complained of dysphagia (expressed as discomfort when swallowing).

The sum of the years follow – up for this study or the moment of re- surgery for ADD for the 34 patients was 312.0. Only in one case the adjacent level was degenerated, whereas it looked radiographically completely normal before the index surgery. Therefore, the annual rate for ADD is calculated as  $(1/312) \times 100\%$  is 0.32 %.

## LITERATURE

### NORMAL AGEING

Although ADD was related to a surgical procedure, knowledge of the normal ageing is warranted for interpreting the prevalence of ADD.

The roentgenographic ten years follow – up of originally asymptomatic persons has been described(4). Thirty of the 157 persons did not have initially degeneration but developed it at the follow up, seventy had a progression of an already present degenerated disc, and fifty-seven persons did not reveal any signs of degeneration at follow up. The last category were younger (44 years) than the other two categories ( 48 and 52 years, respectively). Fifteen percent developed pain. Only one patient was operated because of cervical radicular pain.

Recently, the MRI findings in 223 initially asymptomatic volunteers with a follow up of 10 years are represented(5). The age at the initial MRI was  $39.0 \pm 15.0$  years ( range 11-71 years). During this period 9.9% of the participants complained of neck pain, 30.0% of stiff shoulders and 4.0 % of numbness in the upper extremities. 34.1% of the subjects had one or more clinical symptoms. None of them underwent cervical spine surgery. In 84.8% of the participants progression of degeneration at one or more levels was seen.

The same authorgroup compared in another study(6) patients who underwent an ACDF, the adjacent segments to the corresponding levels in the above mentioned group of asymptomatic volunteers. Sixty - four patients underwent ACDF, and were compared with 201 asymptomatic volunteers from the previous discussed cohort. The authors concluded that patients with an ACDF had a significantly higher incidence of progression of the degeneration at the adjacent segment. However, the baseline characteristics were not comparable. The ACDF group was significantly older. From the previous study it was known that progression of degeneration differed amongst age groups. Other possible confounding factors were not investigated. Therefore, comparison of these two groups did not validate firm conclusions.

Since progression of existing degenerative disc disease is related to the natural phenomenon of ageing, ADD should be restricted to newly developed degeneration of the adjacent disc. For the patient is only symptomatic ADD relevant. Therefore, our attention will focus on ADD for which the

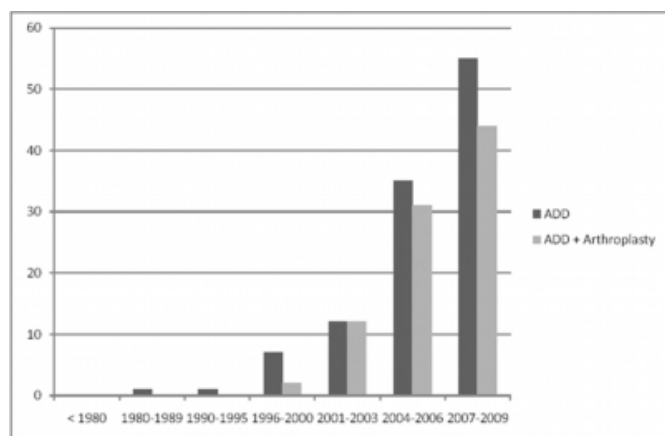
patients sought medical attention.

### ADD AND LITERATURE

The literature was reviewed performing a Pubmed search till January 1<sup>st</sup>, 2011 was performed using the following search string: ((adjacent segment degeneration) OR (adjacent disc degeneration) OR (adjacent disc disease)) AND cervical. In a second search the following string was added: AND ((arthroplasty spine) OR ((disc or disk) prosthesis)). The resulting number of articles found by the literature search is shown in Figure 1. It revealed a clear correlation between the terms adjacent disc degeneration and cervical arthroplasty. Pearson's correlation coefficient was 0.993 and highly statistically significant ( $p < 0.0001$ ).

### Figure 3

Figure 1: Number of articles retrieved by a Pubmed search till January 1, 2011. ADD represented the number of articles dealing with cervical adjacent disc degeneration. ADD + arthroplasty disclosed the number of articles dealing with cervical adjacent disc disease in combination with arthroplasty.



### ADD AND FUSION

A very often cited article is written by Hilibrand et al(7). An annual rate of ADD after a CADF of 2.9% was calculated. However, the authors mentioned a large number of patients that were lost to follow up. Correcting for this and in a best case scenario (nobody of the missing persons suffered from a symptomatic ADD) the annual rate would reduce to 1.3%. It was also stated that 69% of the patients developing ADD had at the first surgery already signs of a degenerated disc. It merely was a progression of an existing problem. He recommended treating those levels also at the first surgery. Therefore, a new calculation estimated an annual rate of ADD after CADF of 0.4%.

Gore et al. reported a series of 48 patients with an average follow up of 21 years(8). Radiologically, all patients developed postoperatively ADD. In sixteen patients symptoms recurred differing from solely neckpain to radicular pain. Eight patients did not have any surgery for the recurrence. Only one of them had radicular pain. The other eight patients underwent additional surgery. Of them seven suffered from radicular pain. The mean time for recurrence of the complaints was 3.5 years for those receiving additional surgery, and 10.8 years for the patients not been operated again. Since it is debatable if neckpain can be contributed due to ADD, only radicular pain is considered relevant to symptomatic ADD. An annual rate of 1.5% after 11 years and 0.8% after 21 years can be calculated for ADD warranting additional surgery. The annual rate is calculated based on mean and not actual follow up. However, the surgical series included patients treated between 1968 and 1975. Surgical techniques and implants have greatly been evolved since then.

In another study by Gore et al.(9) the results of a larger sample are reported. 133 Patients were followed for a mean of  $5 \pm 3.3$  years. Eleven underwent additional surgery because of clinical symptomatic ADD. The time between the index surgery and the resurgery was not provided. The patients were retrieved from 1961 till 1981.

Another frequently cited article is written by Goffin et al(10). Degeneration of adjacent segments was found in 92% of the cases with a mean follow up of more than five years ( $8.4 \pm 2.6$  years) after the index surgery. However, of the living patients only 55.1% contributed to the study. The number of ADD is probably less than the reported 92%. Of the studied patients, 36.7% was operated because of a traumatic lesion of the cervical spine. A traumatic event does affect the whole cervical spine including the segments adjacent to the injured segment. The influence of the trauma is not similar to degeneration, and those patients should be excluded. Plate fixation was used when a corpectomy was performed or when fusion should be achieved at more than two disc levels. Therefore, it can be concluded that different techniques are used for different diseases. Certainly this will influence the number of ADD. Finally, the authors did not mention how many patients did not suffer from any degeneration at the index surgery. If ADD is defined as developing new signs of degeneration the number is presumably much less than 92%. It is remarkable that only 11 (6.1%) patients of 180 patients were operated again

because of ADD, or 11 (3.4%) of 327 still living patients. In other words, with a mean follow of 8.4 years 0.73% of the patients will need a resurgery because of symptomatic ADD after a CADF or 0.4% in a best case scenario. It should be explicitly stated that the population is different from those suffering from simple degenerative, one or two level disc disease. Would this have been the case, the annual rate would probably have been lower.

## **ADD AND ARTHROPLASTY**

Arthroplasty was considered to prevent ADD. More and more studies are published reporting the results of arthroplasty.

Recently, the long-term follow up of a disc prosthesis was reported(11). Each patient was followed at intervals of two years. Eighty-nine patients completed six years follow-up. In this time four patients were operated upon because of clinically symptomatic ADD. So, 4 patients with ADD were seen in a total of 534 years follow-up, resulting in an annual rate of 0.75 %. If these patients are followed for 8 years, and none of the other patients will develop ADD the annual rate will fall to 0.56 %, and to 0.44 % at ten years follow up. These results closely resembled the recalculated rates from the previous studies. It should be noted that the annual rate of ADD differed with the time of follow-up. To compare annual rates, the follow up should be the same.

## **DISCUSSION**

ADD is thought to be related to CADF. A higher annual rate has been estimated in the original reports. Frequently, this relationship is used to use cervical disc prostheses. A critical review of the articles resulted in different and lower rates. This is confirmed by our data.

The clinical relevance of ADD should seriously be questioned. For the patient, family and treating physician ADD that generates symptoms or signs is relevant. Radiological confirmation of ongoing degeneration of the intervertebral disc at the adjacent level to a fused level without complaints of the patient is not important. We strictly defined ADD as the occurrence of new clinical symptoms and signs in a patient due to newly developed degeneration in an adjacent segment to a surgically fused segment.

The ultimate treatment of ADD will be a new surgery in the neck or consultation of therapists or anesthesiologists after a complaint free period. A surgical treatment or a pain

treatment by an anesthesiologist will every patient remember, and therefore, recall bias was assumed not to be an issue. It is also a parameter that facilitates easy comparison between populations.

Because of the definition of ADD , radiographic examinations were not relevant in our opinion. Only in the judgment of the patients about her/his performance was considered important , and the history of seeking medical attention for recurrent signs and symptoms necessitating surgery. For this reason any radiographic examination for study purposes was not performed. Neither were questionnaires used like SF 36 or neck disability index, since a comparison to earlier moments could not be made and the series is not entirely comparable to other series. Instead a modification of Odom's criteria was used as a base for the questions to the patients about the result. The result of the surgery was in fact not the subject of this study.

On the other hand, the choice for a very strict end point as in this study is subject of discussion. Patients with minor symptoms or patients who will not consider surgery will be excluded as having ADD. However, it was asked if patients sought medical attention for complaints of the neck. Therefore, it is assumed that the rate for ADD will be slightly higher than the calculated one.

Six patients were operated again of which only one was due to new ADD. Two patients had symptomatic progression of already existing degeneration of the adjacent level. Discussion about insufficient surgery is possible, since Hilibrand already stated that an adjacent degenerative segment should be incorporated in the fusion(12). In another patient an anterior procedure alone was not sufficient for decompression of a stenotic spinal canal. The luxation of the cage occurred in a patient with a previous cervical laminectomy. This can be identified as inadequate surgery since the posterior tension band is deficient, and this event should have been anticipated. Nowadays, we do not perform a standalone cage in patients with a deficit in the posterior tension band. Finally, in the case with the development of symptomatic osteophytes at the levels of the CADF, pseudarthrosis with ongoing degeneration could be an explanation.

Flaws and biases are related to the retrospective nature of this study of personal data. Retrieval bias is often a problem. Since two databases of the hospital (one for surgical implants, one for surgical codes) were used, we are really

confident that all patients were retrieved that underwent an ACDF with standalone cage by RB in that period. Recall bias will neither be a problem as mentioned before. Although the response rate was high, it would have been optimal if the two missing patients had participated. In the worst case scenario the annual rate would increase from 0.32% to 0.96% . To calculate this number, we used the 312 year follow-up, and did not include the years till the second surgery for the two additional patients. So, the annual rate will be lower than 0.96 if the two patients had been both operated for symptomatic ADD after ACDF with standalone cage. In our opinion, the size of the study will not be a problem since a rate was calculated. A trend is seen, and larger studies will probably have more power. However, the question remains how large is large enough, and will it still be possible to perform such a study?

It appears that at longer follow up, the occurrence of ADD after ACDF and after arthroplasty was equal. This is confirmed by a recent systematic review(13).

Apart from normal ageing, reasons to develop ADD are manifold. The relation between fusion of one segment and altered motion or extra stresses to the adjacent level has been investigated intensively. However, the results are not uniform(14,15). In a clinical study comparing prosthesis versus CADF, the authors stated explicitly that postoperatively at two years, no statistical differences were present in adjacent motions compared with preoperative motions in both groups(16).

Another important issue could be surgical technique. This item did not gain much attendance. To identify the correct level a needle is often introduced in a disc before radiographic confirmation. It has been shown that placement of a needle in a healthy disc can cause degeneration in animals(17,18,19). In humans placement of a needle in the incorrect disc increased the risk for ADD three times(20). In the recently performed randomized controlled trials, the method to confirm the appropriate level has not been standardized. Based on our own experience, we know that for certain disc prostheses radiographic examination takes place from the beginning even before the incision, whereas for other procedures the spine has been exposed and the longus colli muscles have been dissected before radiographic verification of the level is performed.

Furthermore, the influence of a plate should not be underestimated. Although ACDF with plate is popular, the

usefulness of a plate for single or double level surgery has not scientifically been established(21,22). Placement of a plate warrants a wider dissection with possible damage to the adjacent discs. Even if the plate is implanted without any problems, the plate can be too large(23). At the moment of implantation it will not reach the adjacent disc, but after a slight subsidence it can certainly reach the adjacent level and accelerate degeneration. In the recent randomized controlled trials these possibilities are not taken into consideration. A more appropriate trial would compare ACDF without a plate and cervical arthroplasty.

## **CONCLUSION**

Although cervical anterior discectomy has been performed since the sixties of the former century, an increasing interest in ADD was seen in the last two decades. The annual rate of ADD has been estimated too high. After critical review and review of our personal data, it is probably less than 1 percent. A simple literature search disclosed a strong relationship with cervical disc prostheses or arthroplasty. The question whether this was industry driven remained unsolved. The underlying thoughts for the introduction of cervical disc prostheses were clinical results that were at least as good as and probably better than the known procedures, and the prevention of adjacent disc degeneration. Meanwhile, it has been established that any clinical benefit from the cervical disc prostheses cannot be expected(24,25). The prevention of adjacent disk degeneration was the only argument to promote techniques as cervical arthroplasty. Given the low prevalence of (especially clinical relevant) ADD after ACDF as well as after arthroplasty, its relevance should be questioned. It should even be questioned whether a new technique should be developed and tested to prevent a more or less theoretical problem. In fact, at least 100 patients should be treated with a perfect device to prevent ADD in one patient.

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**Author Information**

**Roland D. Donk, M.D.**

Department of Orthopedic Surgery, Canisius Wilhelmina Hospital

**Ronald H.M.A. Bartels, M.D, Ph.D.**

Department of Neurosurgery, Radboud University Nijmegen Medical Centre