

Anterior approach to the cervical spine for treatment of spondylosis or disc herniation: Long-term results. Comparison between ACD, ACDF, TDR

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Abstract

Background and Aim. Many surgical techniques are used for the treatment of cervical myelopathy and radiculopathy due to spondylosis or disc herniation. The aim of this article is to evaluate and to compare the long term outcomes of 1. anterior cervical discectomy (ACD), 2. anterior cervical discectomy with fusion (ACDF) and 3. anterior cervical discectomy with total disc replacement (TDR) in order to find the most appropriate surgical option according to the medical condition of the patient.

Materials and Methods. Three retrospective cohort studies were performed to assess the long-term results of ACD, ACDF and TDR procedures. Data from the three studies were compared by statistical methods to highlight the differences in results.

Results. All patients presented a neurological improvement that endures. The results of three surgical techniques were different as regards the alignment of the cervical spine, the preservation of mobility and the pathology of adjacent space.

Conclusions. TDR is the most appropriate technique in young patients, below the age of 55 years and whose pathology is prevalently a hernia. The best surgical choice is ACDF in patients above the age of 55 years and in all those cases in which there is a prevalence of spondyloarthrotic alterations. In highly selected cases, in which the cervical spine is in a flattened condition and the intervertebral space is very restricted ACD, according to Hirsh, is a surgical method which ensures a very high degree of spinal motility preservation. *Clin Ter* 2014; 165(4):e263-270. doi: 10.7417/CT.2014.1741

Key words: anterior cervical discectomy, arthroplasty, cervical spine, disc herniation, fusion, spondylosis

Introduction

There are two principal surgical routes to the cervical compression of the spinal cord and/or root caused by disc herniation or spondylosis, the anterior and the posterior one (1, 2).

For each of these approaches, there are many variations, both in terms of surgical technique and the type of prosthetic material employed.

Using the anterior surgical approach, it is possible to perform any of the following: a straightforward anterior cervical discectomy (ACD) (3-6), a discectomy with fusion (ACDF) (7-10), a discectomy with fusion and instrumentation (ACDFI) (11-12), a corpectomy (13, 14), or a discectomy with application of an artificial disc (total disc replacement: TDR) (15, 16).

Given the lack of evidence-based medicine (EBM) guidelines, spinal surgeons have tended to use one or more of the above techniques in relation to their experience, ability and preferences.

The aim of this study was to evaluate and to compare the long term outcomes of ACD, ACDF and TDR in order to look for the most appropriate surgical options according to the patient's medical condition.

Materials and Methods

Three retrospective cohort studies were performed to assess the long-term results of ACD, ACDF and TDR procedures.

The selection criteria used for inclusion in these studies were:

- 1) surgery involving a single level;
- 2) preoperative Nurick score ≤ 4 ;
- 3) preoperative mJOA ≥ 10 .

Limiting the study to those patients whose prognosis was a positive one from the beginning gave me the chance to evaluate accurately if the a surgical techniques ACD, ACDF, TDR guarantee the right decompression of the spinal chord and whether in the long run it would provoke new myelofaradicular compressions caused either by disalignment and/or vertebral instability, or by a new spondylosis in the level already operated, or by an "adjacent space" pathology .

In the first study, 26 cases (13 males and 13 females) were selected from a total of 185 patients operated between 1995 and 2000 for myelopathy due to cervical spondylosis and/or herniated disc, via the anterior route, with various techniques.

The 26 that were chosen had all been operated on with ACD according to the Hirsh technique(5), which involves the conservation of the joint plates (cartilaginous end-plates) normally removed in order to favor inter-body fusion. Since the year 2000, patients have no longer been treated with ACD.

In the second study (ACDF), at first, 30 cases were selected from a total of 90 patients who had been operated upon by the anterior route between 2004 and 2008. Of these 30, we were only able to trace and study 27 (14 males and 13 females).

For the third group, we selected another 27 patients (14 males and 13 females) from the same 90 afore mentioned. This group included patients who had been operated upon for arthroplasty.

All patients were operated upon by the same surgeon, who is also the first author of the present article.

The ages of the patients in the first group ranged from 36 to 68 years (with an average age of 51.7); in the second group from 45 to 73 years (with an average age of 61.7) and in the third group from 27 to 56 (with an average age of 47.4). The duration of the follow-up for the first group (ACD) ranged from a minimum of 6 to a maximum of 15 years (with an average of 10.2); for the second group (ACDF) from 3 to 5.9 (average 4.7) and for the third group from 3 to 6 (average 4.5) (Table 1).

ACD was carried out prior to the year 2000 in cases presenting a very narrow disc space.

In such cases, the introduction of a cage would have required the removal of a considerable amount of bone with a micro drill. Needless to say, none of these cases presented preoperative misalignment or instability.

TDR was performed in patients below the age of 50 with a pathology, which was prevalently related to hernia rather than to spondylarthrosis. In two cases, arthroplasty was carried out in response to a specific request from the patient. The ACDF technique was the routine option in all patients presenting with extensive spondylarthrosis at several levels.

Table 1. It shows the levels of the operations and the pathology types.

	ACD	ACDF	TDR
N° of Patients	26	27	27
Average age	51,7y	61,7y	47,4y
Sex	13M 13F	14M 13F	14M 13F
	Level		
C5-C6	14	13	16
C6-C7	7	5	7
C7-T1	-	-	-
C4-C5	3	7	3
C3-C4	2	2	1
	Pathology		
Herniation	13	3	19
Spondylosis	11	16	2
Both	2	8	6

Legend ACD: anterior cervical discectomy. ACDF: anterior cervical discectomy with fusion. TDR: anterior cervical discectomy with total disc replacement. y: years. M: male. F: female.

All patients were newly assessed, both clinically and radiologically. For the first group, all the data was collected and reviewed only by the first author of the present article who also carried out the follow-up examinations. Subsequently, however, two other authors independently reviewed the information gathered. For the other two groups, on the other hand, two teams checked each patient independently. The subsequent comparison of data between the teams showed the evaluations to be homogeneous.

In each case, we evaluated the patient's clinical conditions both preoperatively and at the most recent follow-up examination. This was done using both the Nurick scale (5, 17-19), which provides a good indication of the quality of life and Chile's modified JOA (mJOA) scale (20, 21), which provides more specific information regarding neurological conditions.

We also assessed the lateral X-rays, the T1-T2 sagittal turbo-spin echo and T2 axial gradient echo MR images, evaluating the cervical spine posture and also searching for any signs of a residual spinal compression at the operated level, or any pathological conditions involving the adjacent spaces. At the last follow-up control, dynamic flexion-extension X-rays were also performed to identify any instability and to evaluate spinal motility. To establish whether there was any lordosis, kyphosis or flattening of the cervical spine, we based our assessment on both visual impressions and on the Risser-Ferguson method (22). Later on, we compared our visual impressions with the precise measurements of the Risser-Ferguson angle (Table 2).

To assess alignment of the two vertebrae adjacent to the discectomy level, we used the Lippman-Cobb method that is performed by tracing two lines along the upper and lower articular surfaces and lowering the perpendicular lines to meet them. The angle formed by the intersection of the perpendiculars expresses the degree of alignment.

To evaluate cervical spinal motility at the last follow up, we used a goniometer; we measured and noted on the X-ray images the range of motion in degrees between a normal neck position and a maximum forward flexion and also between a normal neck position and a maximum extension.

After having collated the data regarding pre and post-operative medical history, upon incidence of the phenomenon of fusion and pathology of the adjacent space (defined as degeneration of a previously healthy disc or worsening of a previous degenerative condition) and variations between pre and post-operative stages of the alignment/posture of the cervical spine ab.3, we carried out an ANOVA analysis using SPSS® ver. 15.0 software to look for all possible statistical correlations that could explain the aforementioned data.

Table 2. Curvature of the cervical spine.

Visual impression	Risser-Ferguson angl
Kyphosis	<0°
Flattening	1° to 10°
Lordosis	>10°

Results

Figures 1 and 2 show the variation of the neurological state between the pre and post-operative stages. There is considerable homogeneity among the three groups regarding the post-operative long term results measured using the Nurick scale and the mJOA scale. It is clear, however, that the pre-operative condition of the group of patients treated with ACDF was worse compared to the other two groups.

Figure 3 illustrates the incidence of the phenomenon of inter-body fusion in groups treated with ACD and TDR. We excluded the group with ACDF since in this group fusion was the therapeutic element and occurred in 100% of cases. The TDR technique emerged as being by far the best compared to ACD in preserving inter-vertebral motility and avoiding fusion.

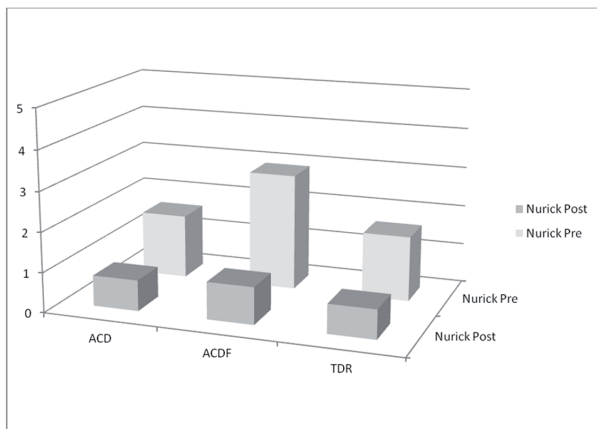


Fig. 1. The variation of the neurological state between the pre and post-operative stages: Nurick scale.

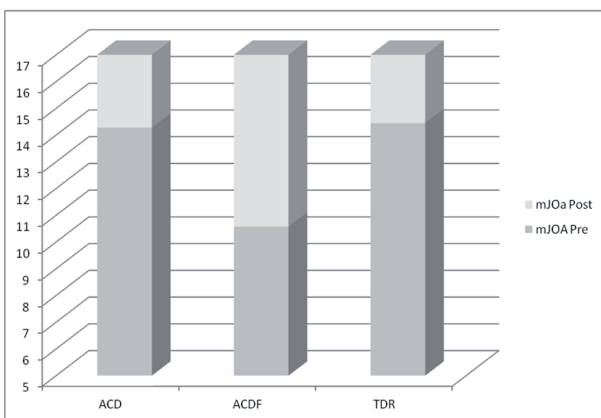


Fig. 2. The variation of the neurological state between the pre and post-operative stages: mJOA scale.

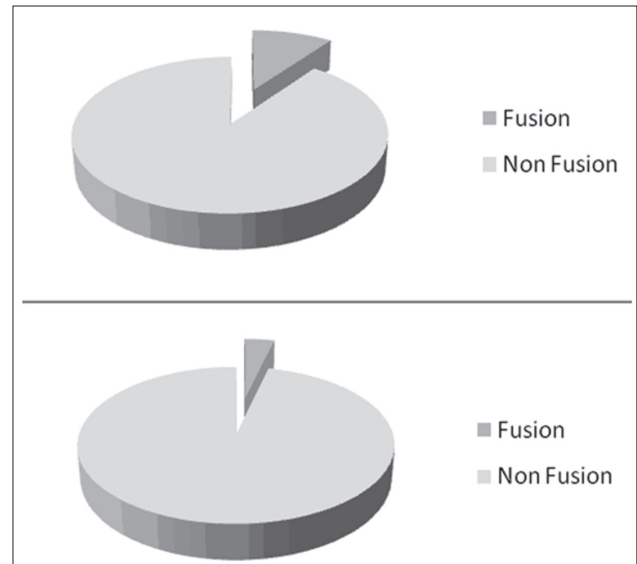


Fig. 3. ACD Fusion; TDR Fusion.

Figure 4, on the other hand, shows the comparison between our results regarding the incidence of fusion in groups of patients treated with the ACD technique and those in the literature. The Hirsch technique, which we adopted, causes a minor incidence of fusion compared to those techniques that sacrifice cartilaginous plates. In our group of patients treated with the ACD technique, no cases of instability were verified.

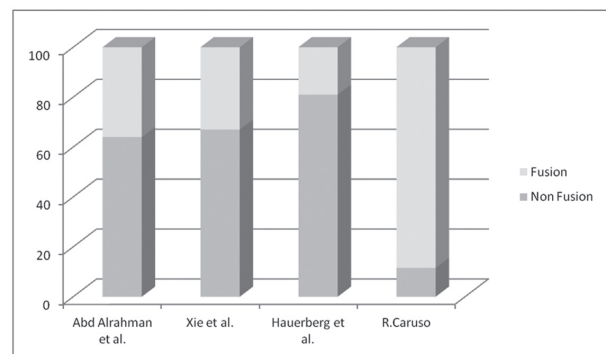


Fig. 4. It shows the comparison between our results regarding the incidence of fusion in groups of patients treated with the ACD technique and those in the literature.

The incidence of pathologies of the adjacent space was higher in the patients treated with the ACDF technique, while the phenomenon in the group treated with ACD manifested itself only in those patients who had had an intervertebral fusion. No cases of pathology of the adjacent space were recorded in the group of patients treated with the TDR technique (Fig. 5).

Variations of alignment manifested themselves more frequently in the group treated with ACD. The only variations

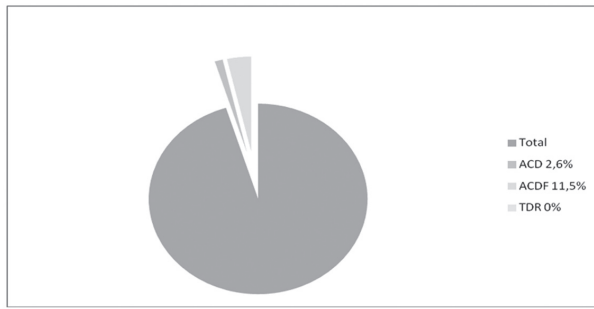


Fig. 5. Adjacent space pathologies.

in the kyphotic sense of the alignment/posture of the cervical spine were, actually, recorded for this group (Fig. 6).

The data illustrated above were subjected to a statistical variance analysis. The results and neurological improvement measured according to the Nurick scale and the mJOA score were chosen as dependent variables. The independent variables, on the other hand, were the pre-operative alignment and the type of operation, while age was considered a co-varied parameter.

A preliminary analysis of the variables and of the correlations between variables in the sample was needed in order to highlight positive interactions but also to seek out if there were any interactions capable of confusing the results and invalidating the conclusions.

The first positive result emerged looking at the correlation between Nurick and mJOA (post-operative scores). This correlation demonstrates that the two scales measure the phenomenon in question in a convergent fashion, demonstrating intrinsic consistency and reciprocal predictability.

The second form of interaction that we identified, more complex than the foregoing, can be defined as “influence of alignment, given a type of operation, in reaching a neurological result”. Such interaction was significant, it demonstrated that there exists a quota in terms of long term neurological results which is determined by pre-operative alignment.

The third significant interaction emerged between age and type of operation. The patients treated with ACDF had an average age which was significantly higher than that of the groups treated with ACD and TDR. This could potentially create problems in the processing of the statistics. It seemed

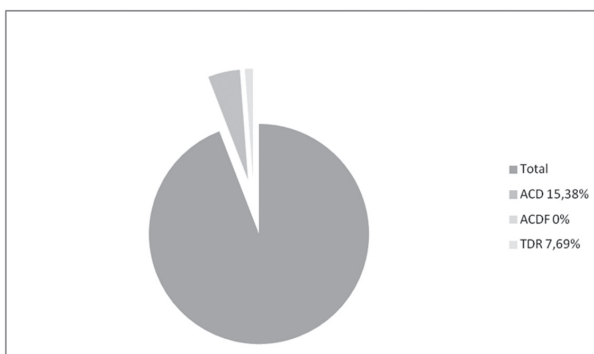


Fig. 6. Change in cervical spine alignment.

evident, however, that the obligatory nature of treatment with the ACDF technique for this subpopulation of patients which included elderly people with graver clinical and radiological alterations, rather than being a limitation for statistical processing, could constitute an advantage.

The behavior of these independent variables namely age and type of operation, was analyzed also in a smaller sample composed of 45 subjects treated with either ACD or TDR. This sample was conveniently homogenisable by age (age below 57 years), and was certainly homogenous on account of “absence of fusion”. This way, it was possible to carry out a comparative analysis of the long term results of these two separate techniques (ACD and TDR) which were less risky in terms of the possibility of developing a pathology of the adjacent space.

To sum up, therefore, the analyses were carried out initially for the entire sample (three groups divided according to the operation technique: ACD, TDR and ACDF), with a view to comparing the results for the three techniques. Subsequently, they were repeated for the smaller sample, which enabled comparison between ACD and TDR only.

Here follow the diagrams that present the results of the statistical processing in graph form.

The first analysis used the Nurick post-operative index as an independent variable (Fig. 7).

The figure illustrates that the interaction between pre-operative alignment of the cervical spine, type of operation and long term results is statistically significant.

The analysis was carried out with the inclusion of the group treated with ACDF first and then it was repeated with the smaller sample that allowed for comparison between ACD and TDR. This comparison emerged as highly significant not just in statistical, but also in clinical terms (Fig. 8).

As figure 7 shows, there are differences between the groups (using the Nurick scale, the lower the result, the greater the clinical validity of the technique). The statistically significant differences concern the cases presenting pre-operative lordotic alignment. According to the Nurick scale, here, TDR appears as the best technique compared to the others, while ACD is the worst technique for the

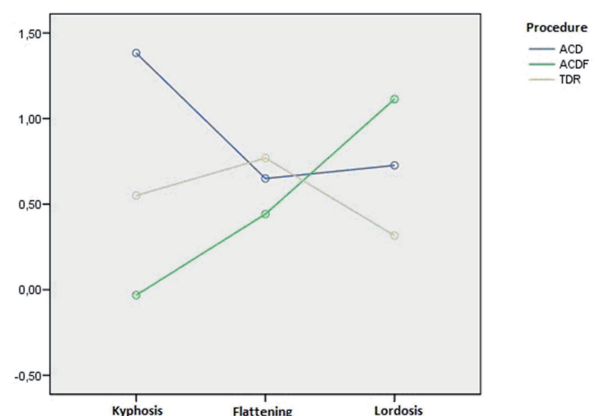


Fig. 7. Estimated Marginal Means of Nurickpost.

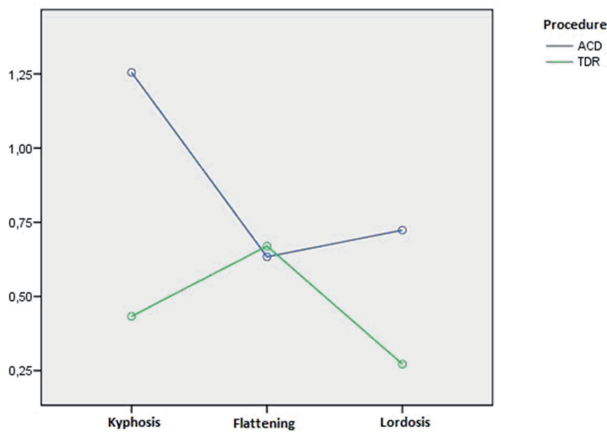


Fig. 8. Estimated Marginal Means of Nurickpost.

treatment of a kyphotic cervical spine. In the cases where cervical spines had become flattened, the comparison between the three techniques did not yield substantially different neurological results.

However the analyses repeated just for the ACD and TDR groups (Fig. 8) produced results that were statistically significant for each of the averages reported. The image shows that in the treatment of the cervical spine, both kyphotic and lordotic, TDR is indisputably superior to ACD. In the treatment of a straightened cervical spine, on the other hand, both techniques give the same results, and it therefore seems that whatever is placed within the inter-vertebral space doesn't matter after a discectomy for a flattened cervical spine.

A second analysis of the variance was carried out using as an independent variable the value of improvement of mJOA (Fig.9).

The high values reached by patients treated with ACDF are influenced by the worse pre-operative scores. The only interaction which was statistically relevant, in the comparison "between" the patients operated upon using TDR is the difference in the improvement results measured in mJOA. Kyphotic patients, if treated with TDR, have a greater expectation of clinical improvement compared to patients with flattening of the cervical spine or with lordosis. This

indicates that, in our sample, kyphotic patients are those who, starting off in conditions that were on average worse than those of others, have on average obtained results equal to the others and have therefore enjoyed more conspicuous improvements. The final interesting datum, which would probably be worthwhile studying in more sizeable samples, is the substantial equivalence between the results of patients with pre-operative lordotic alignment who were treated with TDR and those in the same preoperative condition who were treated with ACD.

The third analysis was conducted using as a dependent variable the improvement expressed in Nurick between the pre and post-operative states and studying the behavior of the other independent variables in the sample that compared ACD and TDR.

In Figure 10, three interactions can be noted of which only one is not significant, the one concerning the difference in improvement between ACD and TDR for flattened spines (expressed in Nurick), the remaining two are significant and highly informative showing the advantage of using TDR as the more appropriate technique in the treatment of spondylosis related myelopathy in both lordotic and kyphotic cervical spines.

These data are even more significant in that it confirms what has previously been affirmed regarding the analysis of the variance for the results of the three operations.

To conclude, we searched finally for an eventual correlation between the results expressed in the mJOA scale and the Risser-ferguson angle in order to highlight any possible linear interaction between alignment of the cervical spine and neurological results. In this case, the variable alignment (Risser Ferguson) was analysed as "continuous" in contrast to the previous statistical processing, in which the alignment was considered as a category variable in three steps (kyphosis, flattening, lordosis).

The analysis was conducted with a "One Way Anova" which expressed a relation of the type "what result?" – "what angle?". Certainly, this data is not able to provide definitive information and other tests will have to be carried out on populations more numerous and homogenous in terms of parameters such as age, and more homogenous in terms of radiological and clinical levels of pre-operative pathology.

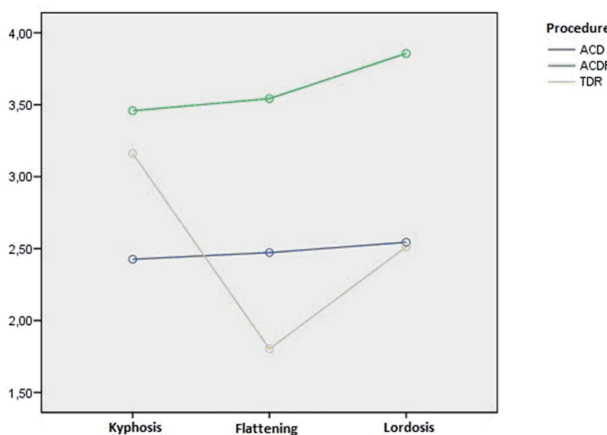


Fig. 9. Estimated Marginal Means of Better Mj.

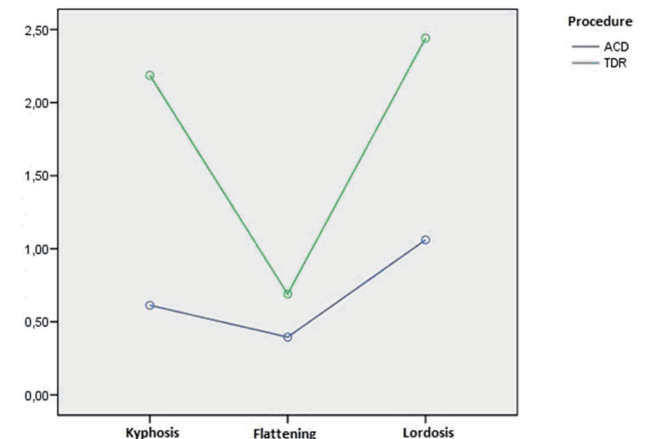


Fig. 10. Estimated Marginal Means of Better Nu.

A correlation in the limits of statistical significance has been traced between the Risser Ferguson angle and mJOA. The mJOA scale has been preferred, for this study, to the Nurick scale since the former indicates the neurological status per se, while the latter indicates the same in relation to quality of life.

If these examinations were carried out over a larger sample of patients and the results appeared to be statistically significant, one would have evidence that kyphotic alignment of the cervical spine is that which, in general, responds less to decompressive surgical therapy.

Discussion

Since as far back as the 1960s, there has been a continuous debate regarding the most appropriate technique to use among ACD, ACDF and ACDFI without reaching a universally accepted scientific conclusion.

Many studies have shown that the clinical outcomes of these 3 methods are identical (3, 23-27). In truth, however, over the years, ACDF and ACDFI have become far more widely used (28) because the majority of surgeons believe they ensure better spinal fusion than ACD, which is thought to carry a risk of spinal instability and kyphosis.

The published data show, however, that ACD has a high percentage of fusion, between 70% and 80%, and that instability and kyphosis are fairly uncommon. Nowadays, ACD almost always includes removal of the disc plates to encourage inter-body fusion, although this was not contemplated in the technique originally described by Hirsh (6, 27, 29-31).

Even at the time of Cloward (9) and Smith-Robinson (10), spinal fusion was considered one of the curative features and main purposes of this surgical procedure.

When this type of surgery was introduced, inter-body fusion was desired above all to eliminate the action of the dynamic factor in the etiopathogenesis of myeloradiculopathy at the operated level (32): this was due to the fact that in the era before the introduction of microsurgery, when use of the operative microscope was still not well-established, there was no certainty of achieving a satisfactory decompression. Subsequently, various reasons were given for desiring bone fusion:

- 1) maintenance of cervical alignment;
- 2) elimination of potential instability;
- 3) preservation of disc height and angulation, thereby reducing potential neural foramen compromise.

From the 1980s on, a growing number of papers (33-35) emphasized how vertebral fusion, by modifying normal cervical spine dynamics, favors the so called "adjacent segment" pathology. This consists of a degeneration of the discs above and below the operated level, with the formation of new herniations and/or spondylosis (or an acceleration of the degree of degeneration of the adjacent discs) which represent new potential sources of myeloradicular compression.

On the basis of these studies, a new type of prosthesis that is inserted into the operated disc space, known as the "artificial disc" has recently been introduced (36-39), the aim of which is to achieve a degree of intervertebral mobility resembling that of a healthy disc.

Obviously, all this seems to imply that some authors (40) no longer consider fusion to be a curative feature in addition to decompression.

This study examines and compares three types of operation by the anterior route.

The limitations to this study are the retroactivity and the small number of patients researched. Its positive aspects include the extended follow up period and the uniformity of the sample studied, since all of the patients were treated and operated on by the same surgeon.

The first element that emerges from the study is that a good decompression of the bone marrow, which is today easily obtained by an expert spinal surgeon, allows for, in all three of the techniques, an improvement of the patient's pre-operative neurological condition. According to our study, however, the degree of improvement is conditioned by pre and post-operative alignment of the spine and kyphosis is the major obstacle in this sense.

In accordance with the data in the literature on the subject, TDR is superior to the ACDF and ACD techniques in improving the neurological state of patients with kyphotic pre-operative alignment of the spine. There are no significant differences among the procedures in case of flattening of the cervical spine. ACD was the only of the three techniques in which there occurred, in three cases, a variation for the worse of the position of the spine between the pre and post-operative states: two cases of flattening of the cervical spine from an initial state of lordotic alignment and a variation from lordosis to kyphosis.

Motion Sparing Surgery, with the exclusion, clearly, of the ACDF technique, is guaranteed in an excellent fashion by TDR.

Our study, which has a significantly long follow-up, shows how arthroplasty allows for good motility of the operated segments even at a distance of years subsequent to the operation. Our data is in disagreement with what has been affirmed by several authors, or rather, that also with TDR, over time, a fusion is created. The only case of fusion that we have had among our arthroplasties was, not by chance, in the most elderly patient in the group (57 years), who presented a pathology which was prevalently spondyloarthrotic not just in the space operated on, but also at other levels and in this case the artificial disc had been implanted upon the patient's specific request.

The fusion occurred by heterotopic ossification.

The ACD technique according to Hirsh, though being distinctly inferior to TDR, also ensures a high percentage of cases of inter-segmental motility with distinctly lower economic costs.

As it had been logical to expect, the pathology of the adjacent space manifests itself above all in patients operated upon using ACDF (11.53%), while it is totally absent in those of the TDR group. In the ACD group there was only one instance (2.6%) of adjacent space pathology in a case where fusion had occurred.

In conclusion, by taking into consideration the data obtained in the present study, we feel that a protocol of choice may be hypothesized regarding the most appropriate operational technique for the anterior route in the cases in which one has to intervene at just one level. In young patients, below the age of 55 years and with a pathology, which is prevalently

hernia, we feel that TDR is the most appropriate technique. This technique should be used also in cases of young patients with spondyloarthritis limited to the space to be operated upon. In patients above the age of 55 years and in all those cases in which there is a prevalence of spondyloarthrotic alterations present in a less serious manner at other levels, we feel that the best choice is ACDF. In highly selected cases, in which the cervical spine is in a flattened condition and the intervertebral space is very restricted, so that the introduction of a cage would require the removal of a considerable amount of bone with a micro-drill, one could perform ACD according to Hirsh, which is not a technique which belongs to the Stone Age, as some neurosurgeons might think, but rather a surgical method which ensures a very high degree of spinal motility preservation, thus impeding the onset of adjacent space pathology.

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