Rev esp cir ortop traumatol. 2011;**55(3)**:170-174

Revista Española de Cirugía Ortopédica y Traumatología

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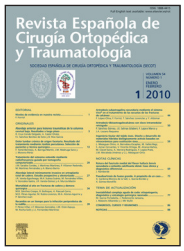

ORIGINAL ARTICLE

Incidence and risk factors of adjacent disc degeneration after lumbar fusion

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Received July 8, 2010; accepted February 3, 2011

KEYWORDS
Lumbar arthrodesis;
Adjacent disc injury;
Risk factors;
Incidence

Abstract
Objective: The aim of this retrospective study is to determine the incidence, the rate of adjacent disc degeneration (ADD) and to analyse the major risk factors after instrumented lumbar fusion.
Materials and methods: Retrospective consecutive study of 230 patients, with lumbar degenerative disease, who underwent lumbar or lumbosacral instrumented spine fusion between 1990 and 2000. We used radiographic criteria (X-RAY and MRI) in order to determine ADD, and we analysed the following risk factors: age, gender, number of levels fused, adjacent disc status before surgery, segmental lordosis and lumbosacral lordosis, and finally, the facet joint angle of adjacent disc.
Results: ADD was found in 41 (17.82%) patients, the mean follow-up period was 8.5 years. The average age was 59 years with female predominance. L5-S1 fusion showed a significant ($P < .05$) lower risk for developing degenerative changes at the adjacent segments than any other fusions. The cranial level of the fused segment was mainly affected in 36 (87.8%) patients and 19 (46%) patients required surgery. The average interval from surgery to the development of ADD was 6.1 years.
Conclusions: There is a risk of 17.82%(41 patients) of being affected by radiographic ADD in an average of 6 years after the first surgery, with a risk of 6.26% (19 patients) of having surgery. The gender, number of levels fused and fusion to the sacrum were the main risk factors.

PALABRAS CLAVE
Artrodesis lumbar;
Lesión disco adyacente;
Factores de riesgo;
Incidencia

Incidencia y factores de riesgo de degeneración de los discos límites a una fusión lumbar

Resumen
Objetivo: Determinar la incidencia y analizar los posibles factores de riesgo de desarrollar una degeneración del disco adyacente después de una artrodesis lumbar instrumentada.

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1888-4415/$ - see front matter

Material y método: Estudio retrospectivo consecutivo de 230 pacientes con patología degenerativa lumbar, tratados entre los años 1990 y 2000 mediante una artrodesis instrumentada posteroexterna lumbar o lumbosacra. Se ha valorado la afectación del disco adyacente, mediante un criterio radiológico con RX y RM, y se han analizado los siguientes factores de riesgo: la edad, el sexo, el número de niveles instrumentados, el estado del disco límite previo a la cirugía, la lordosis del segmento instrumentado y la lordosis lumbosacra, y la sagitalización de las facetas articulares del disco límite.
Resultados: Hemos observado 41 pacientes (17,82%) afectos de síndrome del disco adyacente, con un seguimiento medio de 8,5 años. La edad media fue de 59 años con predominio del sexo femenino. La fusión L5-S1 presenta menos incidencia de afectación del disco límite ($p < 0,05$). Se afectó mayoritariamente el disco adyacente proximal en 36 pacientes (87,8%) y 19 pacientes (46%) requirió cirugía. El tiempo medio hasta el diagnóstico del disco adyacente radiológico ha sido de 6,1 años.
Conclusiones: Existe un riesgo del 17,82%(41 pacientes) de presentar disco adyacente radiológico a los 6 años después de la primera cirugía con un riesgo de 6,26%(19 pacientes) de ser intervenido. El sexo, el número de niveles fusionados y la fusión hasta el sacro han sido los principales factores de riesgo.

Introduction

Lumbar or lumbosacral fusion is a surgical procedure that is widely accepted for treatment of degenerative problems in the spine. The use of pedicular instrumentation has resulted in a reduced incidence of pseudarthrosis, allowing for early patient mobility. However, there are studies suggesting an early and higher incidence of adjacent disc involvement with the use of rigid instrumentations.[1,2]

Although the exact aetiological mechanism for development of the adjacent disc involvement is unknown, degeneration of the mobile segments adjacent to a fusion has been described in the literature. In a biomechanical cadaver study, Lee et al[3] demonstrated a greater solicitation of forces in the disc adjacent to a lumbar fusion, with progressive degeneration and facet hypertrophy of this disc.

There are various experimental studies corroborating the biomechanical solicitation in the discs adjacent to a lumbar fusion; however, the clinical studies appear to be contradictory. Van Horn et al[4] found no greater incidence of degeneration at the adjacent level between a fused group and a control group. On the contrary, Guigui et al[5] did corroborate greater degeneration in the group of patients who had undergone fusion.

In light of the studies conducted to date, it is reasonable to assume that progression of the degenerative disease[6,7] as well as biomechanical impairments are 2 determining factors in the development of adjacent disc disease.

The objective of this retrospective study is to determine the incidence and rate of degeneration of the adjacent disc and to analyse possible risk factors for developing degeneration in the disc adjacent to a lumbar fusion.

Materials and methods

Consecutive retrospective study of 230 patients who underwent surgery for degenerative lumbar pathology between 1990 and 2000. The most common pathology was canal stenosis (42%), followed by spondylolisthesis (28%), post-discectomy disc degeneration (17%), and degeneration with herniated disc (13%). In all these patients, decompression was completed, if there was neurological compromise, and an instrumented posterolateral arthrodesis with pedicular screws and autologous graft from the iliac crest.

Control x-rays were done on all patients at 1 month, 3 months, 6 months, and annually. It was considered a proper fusion if there was good fusion mass, with no interface between graft and vertebral body, no instability on dynamic x-rays, and good clinical tolerance.

Radiological criteria were used to define involvement of the adjacent disc, and the diagnosis was made through simple x-ray and magnetic resonance imaging. The adjacent disc was considered to be involved when, on simple x-ray, there was more than a 4-mm reduction in disc height, more than a 4-mm anterior instability, retrolisthesis and angulation of more than 10º, and when MRI showed degenerative discopathy, disc protrusion or herniation, and segmental stenosis.

The following risk factors were analysed: age, sex, number of levels instrumented, adjacent disc status prior to surgery evaluated by MRI (C. Pfirrmann classification[8]), lordosis of the instrumented segment and lumbosacral lordosis (Cobb angle), and sagittalization of the articular facets of the adjacent disc (MRI axial slices), where angles of more than 45º have a greater probability of developing a degenerative listhesis.[9]

The results collected were analysed using the statistics program SPSS, a *P* value of less than .05 for the difference between groups being set as significant.

Results

With a mean follow-up period of 8.5 years (2-13 years), we identified 41 patients (17.82%) out of 230 patients in the

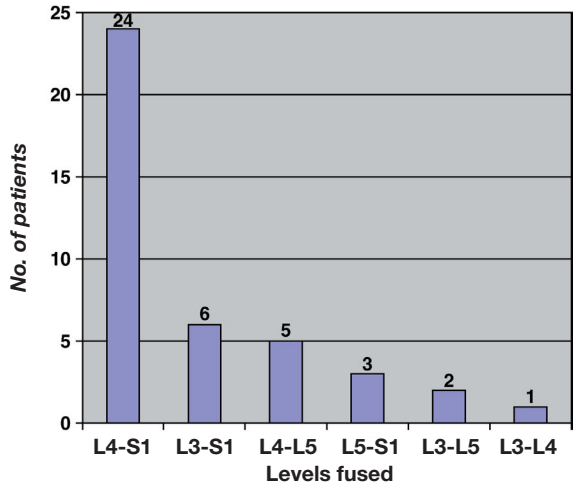

Figure 1 Distribution of patients with adjacent disc involvement according to levels previously fused.

entire series who had adjacent disc involvement per x-ray and/or MRI during the 1990-2000 period. In the 41 patients with adjacent disc degeneration on x-ray, the arthrodesis was consolidated.

The mean age of patients with adjacent disc involvement was 59 years (45-80 years), and the mean age for the entire series was 49 years (29-70 years). For the 41 patients with adjacent disc involvement on x-ray, the distribution by sex was 18 males and 23 females; comparing to the entire series, we observed that 18 males (14%), out of a total of 131, and 23 females (21%), out of a total of 109, were affected ($P<.05$).

The previous surgery performed (fig. 1) in the adjacent disc involvement series was, in 78.04% of cases (32 patients), fusion of 2 or more segments, and in 80% of cases (33 patients), the fusions included the sacrum; the most common arthrodesis performed was L4-S1 fusion in 24 patients. Patients with previous L5-S1 fusion have less adjacent disc involvement ($P<.05$). Patients with fusions

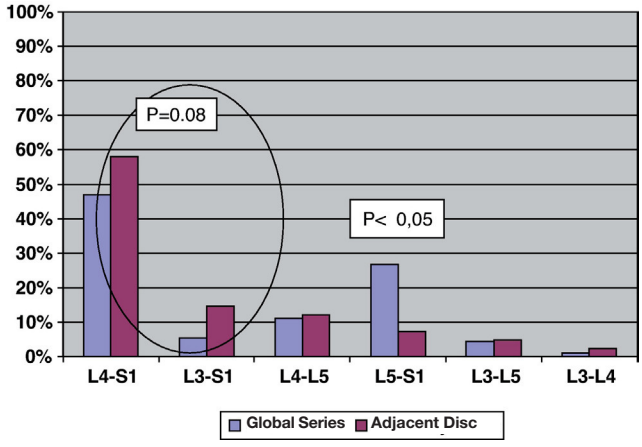

Figure 2 Distribution of patients comparing the entire series with the adjacent disc involvement series.

down to the sacrum or with a greater number of segments fused have a borderline statistically significant chance ($P=.08$) of developing adjacent disc involvement (fig. 2).

Patients with adjacent disc involvement presented with the following symptoms: low back pain (27%), isolated sciatica (2%), lumbosciatica (20%), and neurogenic claudication (20%), with 31% remaining asymptomatic. These patients' x-rays showed segmental stenosis in 25 patients (60.97%), degenerative retrolisthesis in 8 patients (19.51%), discopathy in 5 patients (12.19%), and herniated disc in 3 patients (7.31%) The most common involvement was in the proximal adjacent disc (36 cases), and in 2 cases more than 1 adjacent disc was affected. Of the patients with adjacent disc involvement on x-ray, 46% (19 patients) required surgical intervention for it because they presented with clinical symptomatology. In 10 patients, posterior decompression and extension of the arthrodesis was performed; in 5 patients, decompression and dynamic stabilization, and in 4 patients, decompression alone.

Pre-operatively, on MRI, the majority of adjacent discs affected were grade II and III per C. Pfirrmann's classification.[8] We observed both a correct lordosis of the fused segment and a correct overall lumbosacral lordosis, with mean values of 29.57º and 47.82º, respectively. Analysing the facet angle, a sagittalization of the facet joints was noted in all patients in the adjacent disc involvement series, with a mean of 60.69º.

The mean time until the adjacent disc was diagnosed on x-ray was 6.1 years (2-13 years) which, in the 19 patients who underwent surgery, coincided with the onset of symptoms. In our 41-patient series, 19 (46.34%) underwent surgery—18 at the level immediately above and 1 at the level below. Three female patients required a second surgery on the next adjacent disc.

Discussion

Degeneration of the disc adjacent to a lumbar fusion is a problem frequently described in the literature. Although the exact mechanism by which this degeneration occurs is uncertain, it appears that biomechanical alterations may have an impact on the earliest adjacent disc involvement. In vitro experimental studies have confirmed an increase of mobility in the disc adjacent to a vertebral fusion.[3,10,11]

There are also in vivo studies that corroborate these phenomena. A prospective clinical study conducted by Axelsson[12] demonstrated increased mobility in the adjacent segment following a non-instrumented posterolateral fusion. Various in vivo studies conducted with animals show greater adjacent disc degeneration in the group that underwent fusion compared to the control group.[13,14]

The in vivo animal studies suggest that the increased degeneration in the disc adjacent to a lumbar fusion is due to biomechanical factors, but the clinical studies are contradictory. Various authors conclude that the adjacent disc condition is the physiological process of degeneration and aging in the vertebral column. Seitsalo[15] conducted a study to evaluate the incidence of adjacent disc involvement in 227 patients treated conservatively or with fusion and found no differences between the two groups. Similar

studies done by other authors have reached the same conclusions.[16,17]

In a recent study conducted by Guigui[5] comparing age and sex between posterolateral fusion patients and a control group, a higher incidence of degenerative changes was found in the discs next to a lumbar fusion.

These are all retrospective studies with heterogeneous population groups, and it has remained difficult to attribute degenerative changes in the adjacent disc to a fusion, to progression of the degenerative disease, or even to biomechanical overload factors.

In our study, the incidence of adjacent disc involvement was 17.82%, according to x-ray criteria, with 31% being asymptomatic. If we look at the literature, the incidence varies rather widely, ranging from 5.2% to 100%, owing to studies being conducted in different population groups with different methodologies, which influences these disparate results. The incidence of adjacent disc degeneration is generally higher if x-ray criteria are used than if clinical criteria are used.[18-20]

In our series, the mean time to x-ray diagnosis of adjacent disc disease was 72 months, with all our patients having instrumented vertebral fusions. If we compare this with other studies in the literature, we note a shorter interval between the instrumented fusion surgery and the diagnosis of adjacent disc disease. Aota[1] found a mean time of 25 months to x-ray diagnosis of adjacent disc involvement in patients with instrumented fusion. Other studies in the literature corroborate this trend, noting a shorter interval to diagnosis of disc involvement in instrumented fusions[18,21] compared to that reported in other studies with non-instrumented fusions.[2]

Injury of the inferior facet from placement of the pedicular instrumentation is also described as a risk factor in the literature, and this could contribute to an instability of the adjacent disc.[1] We observed a sagittalization of the facet joints in all patients with adjacent disc disease in our series, although we could not attribute this morphological change to the pedicular instrumentation directly. Correct placement of the pedicular screws without injuring the facet joint may be a determining factor in reducing the incidence of adjacent disc lesions.

The alteration of sagittal alignment is described in the literature as a possible risk factor for developing adjacent disc involvement.[18,22] Although there are no conclusive studies, the lower incidence of adjacent disc involvement on x-ray in our series, compared with other studies in the literature, could perhaps be attributed to the fact that, in the majority of cases, sagittal alignment was within normal limits.[18] A recent study conducted by Min JH et al[20] shows that hypolordosis of the fused segment may contribute to development of early degeneration in the adjacent disc.

The number of segments fused may have an impact on degeneration in the adjacent disc. Fusion of 2 or more levels results in a stronger mechanical solicitation in this adjacent disc.[11,23] In our series, we observed almost statistically significant values indicating a higher probability of developing adjacent disc degeneration when 2 or more levels are fused. However, Kumar et al[18] found no higher incidence of adjacent disc involvement with an increase in the number of levels fused. Other authors, such as Carl et al,[24] A.C. Disch, W. Schmoelz, G. Matziolis, S.V. Schneides, C. Knop, and M. Putzier, Higher risk of adjacent segment degeneration after floating fusions; long-term outcome after low lumbar spine fusions, J Spinal Disord Tech. 21 (2008), pp. 79–85. Full Text via CrossRef | View Record in Scopus | Cited By in Scopus (4),[24] found a higher incidence of adjacent disc involvement on x-ray in floating L4-L5 fusions, with a mean follow-up of 13 years in their study, compared to fusions including the sacrum; however, the clinical results in the 2 groups are similar.

Another factor described in the literature as being implicated in adjacent disc involvement is previous disc degeneration.[25] In our study, we found no discs with a previous advanced degree of disc degeneration; if we had, we would have included it in the anticipated fixation.

Age and sex of the patient are also set forth in the literature as risk factors; in our study, we noted that female patients were more often affected.[1,19,23]

Currently, there are new surgical treatments for degenerative pathology of the lumbar spine, such as disc prostheses and dynamic devices, that preserve mobility and are designed to avoid fusion of the lumbosacral spine and alteration of its biomechanics. Studies are presently limited and have not been in progress long enough to allow confirmation that adjacent disc involvement has been reduced. Even though the use of dynamic fixation and interspinous devices in the disc above an arthrodesis is an alternative that may prevent its deterioration, there are currently no studies that have demonstrated this. In any case selected in our clinical practice, we use Dynesys-type dynamic fixations, with clinical results similar to a fusion. Because there is a significant number of repeat surgeries due to adjacent disc pathology, we believe it is crucial that research be continued and alternatives be found that would reduce the risk of disc involvement adjacent to a lumbar or lumbosacral arthrodesis.

Prospective, long-term studies would be required, most likely, to better define the risk factors and be able to reduce the incidence of patients who suffer lesions of the disc adjacent to a lumbar fusion.

Conclusions

- There is a 17.82% risk (41 patients) of developing adjacent disc involvement on x-ray 6 years after the primary surgery.
- There is a 6.26% risk (19 patients) of undergoing surgery for adjacent disc pathology 6 years later.
- More common in females.
- Lower incidence of adjacent disc involvement with L5-S1 fixations ($P<.05$)
- 30% of patients asymptomatic.
- Segmental stenosis is the most common radiological diagnosis.
- Sagittalization of the articular facets was a consistent factor in all patients, with adjacent disc involvement.

Evidence level

Evidence Level IV.

Conflict of interest

The authors declare that they have no conflict of interest.

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