Pain Provocation at Lumbar Discography as Analyzed by CT/discography

(腰椎疾患の椎間板造影法時疼痛誘発現象のCT/discographyによる解析)

Shoshi Maezawa, M.D. and Toshiyuki Muro, M.D.
前沢祥司　　室捷之

Department of Orthopaedic Surgery,
Gifu Prefectural Tajimi Hospital,
Japan

Abstract:

Pain provocation (PP) was analyzed in 1477 intervertebral discs subjected to lumbar CT/discography. The relation between PP and the degree of general degeneration and anular disruption assessed according to the Dallas Discogram Description as indices of intradiscal deterioration was investigated. PP was also evaluated after dividing the discs by the clinical diagnosis. PP showed little relation with intradiscal deterioration, while a strong relation was found between it and herniated nucleus pulposus (HNP). In HNP, discs with extraligamentous extrusion and sequestration types, large protrusions, the maximum protrusion site at the nerve root portion, and herniation routes passing through the central portion of the disc showed a high pain provocation ratio (PPR). PPRs of discs associated with spinal canal stenosis were extremely low. [Key words: lumbar discography, CT scanning, pain provocation]

INTRODUCTION

Paralleling the incresed availability of magnetic resonance imaging (MRI) for the diagnosis of spinal disorders, the value of discography, which has long been controversial, is being increasingly discounted.[29] However, the clinical usefulness of CT/discography (CTD) in which CT scans are obtained after conventional discography has also been affirmed because of the clear images obtained.[2, 20, 21, 27, 30, 34] Furthermore, with discography unlike other methods, pain provocation (PP) is seen, with the presence of this phenomenon providing strong evidence of disc disease. The importance of PP induced at the time of discography has been also emphasized in studies comparing this method with MRI.[11, 23, 32]

However, much still remains to be learned about the mechanisms involved and the types of disease process associated with the induction of this phenomenon. In the present study, based on the CTD findings of lumbar discography we analyzed the relation between PP and intradiscal deterioration, and furthermore, the relation between PP and various clinical conditions affecting the spine.

MATERIALS AND METHODS

Five hundred and twenty-three patients with lumbar spinal disorders (1477 discs) undergoing CTD at the Department of Orthopaedic Surgery, Gifu Prefectural Tajimi Hospital between October 1984 and June 1991 were studied. All patients complained of low-back pain and/or sciatica and did not respond to the ordinary conservative treatment. They were admitted to our hospital to undergo intradiscal injection therapy mainly using corticosteroids.[28] In this therapy, lumbar discography is necessary, because this treatment is indicated for all degenerated discs. Of 523 cases(1477 discs), 232 cases (289 discs) were operated on after ineffective intradiscal therapy. The 523 patients comprised 379 men and 144 women ranging in age from 12 to 80 years, with a mean age of 40.3 years.

The clinical diagnosis, based on the clinical signs and symptoms, plain roentgenography, myelography, discography(CTD), and /or MRI findings, was lumbar disc herniation in 378 cases, lumbar spinal canal stenosis in 102, isthmic spondylolysis and/or -olisthesis in 18, and other conditions in 25.

Of the 1477 discs, 1068 were in men and 409 in women, with 147 discs in patients aged 10-19 years, 282 20-29 years, 296 30-39 years, 330 40-49 years, 239 50-59 years, 137 60-69 years, and 46 ≧70 years. As for the examined level, 19 discs were at L2-L3, 498 at L3-L4, 515 at L4-L5, and 445 at L5-S1.

Discography was performed using a single 21-gauge needle which was inserted via a lateral approach. A maximum of 2cc of Conray 60 ^{R} (Meglumine iothalamate) was instilled manually followed by Betamethasone acetate 1ml into the affected disc.[28] The degree of resistance and volume accepted were recorded, and any pain induced during the procedure noted. One to two hours after plain radiographic evaluation, CT imaging was performed. The CT scans were obtained on a Siemens Somatom DR3 with window level and window width both approximately 400 HU. Parallel to the disc 4-5 slices of 2-mm thickness were performed at each disc level.

PP showed great variability with respect to the type, site, and degree of pain. Since it was not considered worthwhile to subdivide these phenomena all of which are essentially subjective in nature and the purpose of this study was mainly to analyze whether PP depends on intradiscal deterioration, only the following two broad categories were considered.[10, 25]

1. Similar PP (S-PP) : pain response similar to the individual's pre-study clinical pain.
2. Dissimilar PP (D-PP) : some kind of pain response present but differing from the individual's pre-study clinical pain.

The induction of these two types of PP was studied with respect to the following items(Figure 1 to Figure 9):

1. Sex, age, and examined level (Figure 1)
2. Intradiscal deterioration
 1) Grade of general degeneration (GD) according to the Dallas Discogram Description[30]: Grade 0; no change, Grade 1;local,<10%, Grade 2;partial, <50%, and Grade 3;total,≧50% (Figure 2)
 2) Grade of anular disruption (AD) according to the Dallas Discogram Description[30]: Grade 0; none, Grade 1; into the inner anulus, Grade 2; into the outer anulus, Grade 3; beyond the outer anulus (Figure 3)
3. Clinical Diagnosis
 1: Discs showing herniated nucleus pulposus (disc herniation) on CTD according to Muro's classification[27] (Figure 7, 8, 9)
 2: Discs associated with spinal canal stenosis
 3: Discs demonstrating degenerative spondylolisthesis
 4: Discs associated with isthmic spondylolysis and/or -olisthesis
 5: Discs showing posterior osteophytes
 6: Discs with Schmorl nodes
 7: Discs with persistent epiphyseal separation

To observe the state of PP as related to each of the above items the pain provocation ratio (PPR) of the two reactions was determined, and the rates of appearance of S-PP and D-PP designated as S-PPR and D-PPR respectively. For statistical analysis, the Krauskal-Wallis H test was used for comparisons of the total distributions of the reaction, and the chi-square test for comparisons between two groups. Statistical significance was defined as $p<0.05$.

RESULTS

【1】PPR of the entire 1477 discs

S-PPR was present in 23.6% (349 discs) and D-PPR 14.5% (214 discs). No pain provocation was noted in 61.9% (914 discs).

【2】PPR according to sex, age, and examined level

No difference in PPR was seen between the sexes ($p>0.95$) (Figure 1-(1)).

No difference in PPR was seen between the patients in the second to fifth decades, with markedly higher values found in patients <50 years as compared to those ≧50 years ($p<0.01$). S-PPR was higher at approximately 30% in the patients from the second to fifth decades, while D-PPR averaged about 15% in all age groups except for that≧70 years. S-PPR was higher than D-PPR in the younger age groups (Figure 1-2 (2)).

PPR was clearly higher at L4-L5 and L5-S1 than at L2-L3 and L3-L4 ($p<0.01$), with no difference found between L4-L5 and L5-S1. S-PPR was approximately 35% at L4-L5 and L5-S1 and D-PPR 18% at these levels. S-PPR showed higher values at L4-L5 and L5-S1 than D-PPR (Figure 1-(3)).

【3】PPR according to intradiscal deterioration

1) PPR according to the DDD grade of GD

Of the 1477 discs the GD Grade according to the DDD was GD-0 in 322 discs(21.8%), GD-1 in 326 (22.1%), GD-2 in 216 (14.6%), GD-3 in 611 (41.4%), and undefined in 2(0.1%).

PPR was extremely low in the GD-0 discs ($p<0.01$). In the GD-1 and GD-2 discs, S-PPR was higher than D-PPR, while in the GD-3 discs D-PPR increased, with the difference between it and S-PPR tending to become smaller (Figure 2).

2) PPR according to the grade of AD

The AD grade according to the DDD of the 1477 discs was AD-0 in 322 discs(21.8%), AD-1 in 106 (7.2%), AD-2 in 184 (12.5%), AD-3 860 (58.2%), and undefined in 5 (0.3%).

S-PPR was significantly high in the AD-3 discs ($p<0.05$). D-PPR also increased with increasing grade of AD, although to a lesser extent than S-PPR (Figure 3).

【4】PPR according to clinical diagnosis

{ 1 } Herniated nucleus pulposus (Disc herniation)

1) Six hundred and two of the 1477 discs (40.8%) showed clear evidence of herniated nucleus pulposus on CTD. However, degenerative bulging of the anulus fibrosus including herniation of the anulus fibrosus was

excluded from this category. Of 602 herniated discs, there were 403 discs responsible for signs and symptoms, 207 of which were operated on, and 199 discs undergoing intradiscal therapy that were clearly demonstrated on CTD. Below, GD(+) denotes the GD grade of herniated discs and GD(-) that of non-herniated discs. Also, since the AD grade of the herniated discs was AD-3 in all cases, only the AD-3 discs were divided according to the presence/absence of disc herniation into AD(+)-3 and AD(-)-3 respectively.

2) Grade of GD(+) and GD(-)

(a) As compared to GD(-), both S-PPR and D-PPR were higher in GD(+) with the exception of GD-0. In particular, S-PPR was high in the GD(+) discs (Figure 4).

(b) With regard to PPR according to the GD(+) grade, GD(+)-1 showed higher values than GD(+)-2 and GD(+)-3 ($p<0.05$), with no difference found between GD(+)-2 and GD(+)-3 ($p>0.1$). S-PPR was high in GD(+)-1 (62.1%), with no difference found between GD(+)-2 and GD(+)-3 (46.2% vs. 46.6%). D-PPR was approximately 20% in all grades, and showed some tendency to increase with increasing grade, although these differences were not statistically significant (Figure 4-(1)).

(c) With regard to PPR according to the GD(-) grade, in GD(-)-0 clearly lower values were found ($p<0.01$). Both PPRs were markedly lower in GD(-)-1, GD(-)-2 and GD(-)-3 with no difference seen in either S-PPR or D-PPR according to the GD(-) grade (Figure 4-(2)).

3) Grade of AD(+) and AD(-)

(a) PPR was markedly higher in AD(+)-3 than in AD(-)-3 ($p<0.01$). S-PPR was high in the herniation group (51%), while D-PPR was about 20% in both groups with little difference seen between them (Figure 5).

(b) The PPR of AD(-)-3 was similar to that of AD-2 (Figure 3 and 5).

4) Analysis of various factors at the herniated disc

a) PPR according to herniation type

Judging from the diagnostic imaging (395 discs) and operative

findings(207 discs), 195 (32.4%) discs showed protrusion, 197 (32.7%) subligamentous extrusion, 199 (33.1%) extraligamentous extrusion, and 11(1.8%) sequestration.

Of the herniation types, PPR was highest in sequestration and extraligamentous extrusion followed by subligamentous extrusion and protrusion in decreasing order ($p<0.01$). The differences in S-PPR were marked. In contrast, D-PPR was highest in protrusion followed by subligamentous extrusion, extraligamentous extrusion, and sequestration in decreasing order, although the differences between types were small ($p>0.01$) (Figure 6).

b) PPR according to protrusion grade

When the protrusion grade on CTD was judged according to the classification of Muro[27], 234 discs (38.9%) showed Grade 1 (slight), 219 (36.4.%) Grade 2 (moderate), and 120 (19.9%) Grade 3 (marked), and 29 (4.8%) Grade 4(severe).

PPR showed increasingly high values as the protrusion grade increased (Grade 1 < Grade 2 < Grade 3 < Grade 4) ($p<0.05$). S-PPR showed clear increases with increasing grades, while conversely D-PPR decreased with higher grades (Figure 7).

c) PPR according to maximum protrusion site

The maximum protrusion site[27] of the 602 herniated discs was the central portion (central 1/3 of the spinal canal) in 217 (35.7%), nerve root portion (external 1/3 of the spinal canal) in 323 (53.2%), intraforaminal portion in 40 (6.5%), and extraforaminal portion in 22 (3.6%).

PPR was highest in the group showing maximum protrusion to the nerve root portion followed by the central portion, and was markedly lower in the group showing maximum protrusion to the extraforaminal portion ($p<0.01$). S-PPR was high in the groups showing maximum protrusion to the nerve root and central portions, and low in that to the extraforaminal portion. D-PPR showed somewhat higher values in the group showing maximum

protrusion to the intraforaminal portion, although no clear differences were found between the various sites (Figure 8).

d) PPR according to herniation route

Observation of the posterior herniation route[27] on CTD of the 602 discs revealed a central type in 273 discs (45.3%), paracentral type in 104 (17.3%), intraforaminal type in 20 (3.3%), extraforaminal type in 28 (4.7%), postero-entire type in 64 (10.6%), multiple type in 101 (16.8%), and undefined type in 12 (2.0%).

There was little difference in PPR between the groups showing the central, paracentral and intraforaminal types, all of which showed clearly higer values than the group with the extraforminal type ($p<0.01$). This tendency was marked in the case of S-PPR, with only small differences in D-PPR found between the various routes (Figure 9).

{ 2 } Discs associated with other clinical conditions (Table 1)

Of the 187 discs associated with spinal canal stenosis, 9 (4.8%) showed S-PP and 24 (12.8%) D-PP, with the remaining 154 discs (82.4%) showing no reaction. Thirty-five discs demonstrated degerative spondylolisthesis, of which 3 (8.6%) showed S-PP and 8 (22.9%) D-PP. Eighteen discs were associated with isthmic spondylolysis and/or -olisthesis, of which 3 (16.7%) showed S-PP and 5 (7.8%) D-PP. Eighteen discs had posterior osteophytes, with S-PP found in one (5.6%) and D-PP in 5 (27.8%). Schmorl nodes were seen in 6 discs, with only D-PP found in 2 (33.3%). Persistent epiphyseal separation was found in 4 discs, with both S-PP and D-PP seen in one disc each (25%).

【5】Comment on D-PP

D-PP assumed various forms of provocation, and its clinical significance is difficult to evaluate. Furthermore detailed analysis should be required in another paper.

For example, in a case with left sciatica, CTD showed disc herniation at L4-L5 and L5-S1. Disc herniation was demonstrated on the left side at L5-S1, and on the right side at L4-L5. On L4-L5, PP was induced as right

leg pain and this PP was defined as D-PP in this study, because the right leg pain was different from the patient's usual complaint. However, as the image finding was consistent with the appearance of PP, this PP should be considered as S-PP essentially.

Because D-PP has such a contradiction, only an analysis of D-PP and S-PP between the responsible and nonresponsible discs with HNP was shown in Table 2.

DISCUSSION

The clinical significance of PP during discograpy has been controversial [3, 17, 35] since its first description in 1948 by Lindblom[22]. Some investigators have disputed it, while others have found PP useful in the diagnosis and selection of treatment of disc disease.[5, 6, 7, 12, 14, 19, 21, 25, 31] With respect to the occurrence of this phenomenon, the innervation of the disc and its surrounding area has attracted considerable attention,[15, 16, 38] with a number of theories proposed to explain the mechanisms involved. Such theories have attributed PP to increased intradiscal pressure and stimulation of the tissues surrounding the disc,[4, 22, 35] intradiscal deterioration,[1, 7, 13, 36] or stimulation of the spinal ganglions,[37] although the actual situation remains unclear. The clinical usefulness of PP in determining the responsible focus in disc herniation and other conditions affecting the disc has been highly rated.[6, 10, 19, 21, 25, 26] Hitherto, the relation between intradiscal deterioration demonstrated by conventional discography and PP has been discussed, with the association between the presence of radial fissures and PP emphasized,[1] and the low incidence of PP in both normal discs and those showing high-grade degeneration described.[1, 4, 8, 21]

In recent years, with the clinical application of CTD, it has become possible to obtain axial views of intradiscal deterioration, which hitherto had been feasible only in cadaver specimens, and to observe in greater detail intradiscal deterioration.[2, 20, 21, 27, 30, 34]

The relationship between CTD findings and PP has been addressed only in the single report of Vanharanta et al.[33] These authors found a significant relationship between intradiscal deterioration and PP, with S-PPR increasing with higher GD and AD Grades. Futhermore, they describe that while the GD and AD Grades parallel each other, the AD grade is higher than that of GD in younger subjects showing S-PP. However they do not comment on the clinical implications of these findings.

Based on the present analysis of the total of 1477 discs, these results indicating a significant relation between PP and age, examined level, and AD grade suggest that PP is more closely associated with a particular diagnosis (i.e. disc herniation) than with the degree of intradiscal deterioration.

Next, we examined the relation between PP and various clinical conditions. First, we analyzed what influence is exerted by the presence/absence of disc herniation on the relation between the Dallas Discogram Description grade and PPR.

With respect to the GD grade, it is summarized that in the relation between GD grade and PPR, the presence/absence of herniation is a more important factor than the GD grade itself.

With respect to the AD grade, PPR tended to increase with increasing degree of AD in the order of AD-0, AD-1, and AD-2, while AD(+)-3 PPR, especially S-PPR, showed extremely high values.

These findings demonstrate that excluding GD-0 and AD-0 (normal discs), the presence/absence of herniation is a major factor affecting PPR. These results have not been described elsewhere.

Further analysis of the discs showing disc herniation on CTD revealed that S-PPR is highest in discs showing the herniation types extrusion (extraligamentous) and sequestration, large protrusions, maximum protrusion site at the nerve root portion, and herniation routes passing through the central portion of the disc. These findings are inconsistent with those of Jackson et al[21]. who found high S-PPR in protrusion.

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PPR in disc herniation has been reported by numerous investigators, with S-PPR reported to show extremely wide variability in the range of 36.1%[20] to 82.4%[9]. In our analysis, S-PPR was 51.0%.

In the analysis of clinical conditions other than disc herniation, PP was virtually silent in discs associated with spinal canal stenosis, with the contribution of such discs to symptoms extremely small.[24] In degenerative spondylolisthesis, isthmic spondylolysis and/or -olisthesis, and discs showing posterior osteophytes[6], Schmorl nodes[18], or persistent epiphyseal separation, D-PPR tended to be somewhat high while S-PPR was low, suggesting that in these conditions there is little relation between symptoms and disc degeneration. However, high S-PPRs were found in each of these conditions when complicated by herniated nucleus pulpusus.

PP provides much clinically useful information, and is helpful in determining the diagnosis, responsible focus, indications for intradiscal therapy, and operative method in lumbar disc diseases. Colhoun et al[5] pointed out that the operative results were better in cases with discography provoked symptoms than when such symptoms were absent. The present results emphasize that S-PP correlates intimately with lesions around the disc, but not with intradiscal deterioration.

CONCLUSION

The concept of discogenic pain has been long recognized, with disc degeneration considerd to be one of its causes. However, the present analysis of the relation between intradiscal deterioration and PP revealed that, with the exception of normal discs in which little pain was provoked, there was little relation between PPR and the grade of GD or the grade AD with respect to intradiscal rupture, whereas in herniated discs PPR was high. These findings demonstrate that PP has little relation to intradiscal deterioration but a strong relation to the presence/absence of herniated nucleus pulposus.

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Table 1. Specific Conditions of the Spine and PP

	Total Number of the Disc	S-PP	D-PP
Spinal canal stenosis	187	9 (4)	24 (3)
Degenerative spondylolisthesis	35	3 (2)	8 (1)
Spondylolysis and/or -olisthesis	18	3 (2)	5 (2)
Posterior osteophytes	18	1 (1)	5 (3)
Schmorl nodes	6		2
Persistent epiphyseal separation	4	1 (1)	1 (1)

cf: ( ); Number of the disc with herniated nucleus pulposus

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Table 2. PP on the Responsible and Nonresponsible Discs with Herniated Nucleus Pulposus

	Total Number of the Disc	S-PP	D-PP
Responsible Discs	403 (100%)	279 (69.2)	54 (13.4)
Nonresponsible Discs	199 (100%)	28 (14.1)	69 (34.7)
Total	602	307	123

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Legends of Figures

Fig.1 Sex, Age and Examined Level, and PPR

Fig.2 General Degeneration of DDD and PPR

GD : General Degeneration of Dallas Discogram Description

0 : no change, 1 : local, <10%,

2 : partial, <50%, 3 : total, ≧50%

Fig.3 Anular Disruption of DDD and PPR

AD : Anular Disruption of Dallas Discogram Description

0 : none 1 : into inner anulus

2 : into outer anulus 3 : beyond outer anulus

Fig.4 General Degeneration With or Without HNP and PPR

Fig.5 Anular Disruption With or Without HNP and PPR

Fig.6 Type of Herniation and PPR

PT : protrusion

ES : extrusion (subligamentous)

EE : extrusion (extraligamentous)

SEQ : sequestration

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Fig.7 Protrusion Grading and PPR

Protrusion Grading

0 : none

1 : slight

2 : moderate

3 : marked

4 : severe

Fig.8 Maximum protrusion site of the Herniation and PPR

Fig.9 Herniation Route on CTD and PPR

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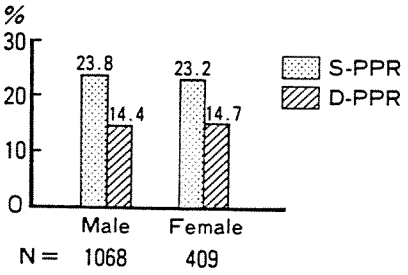
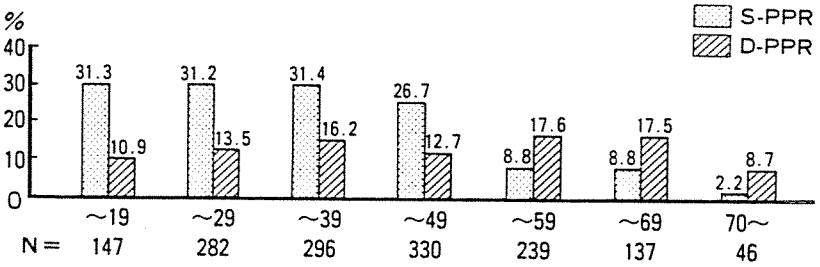
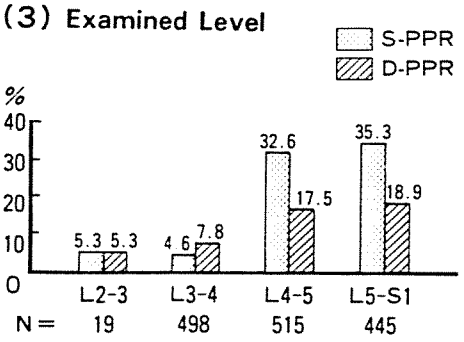
(1) Sex

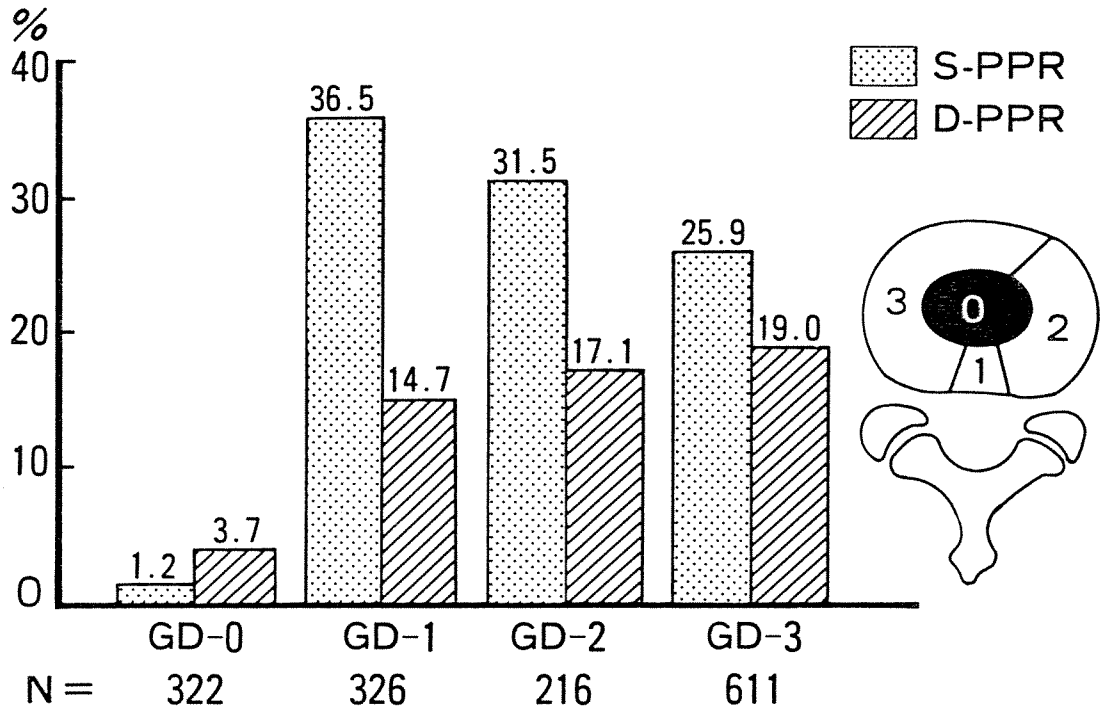


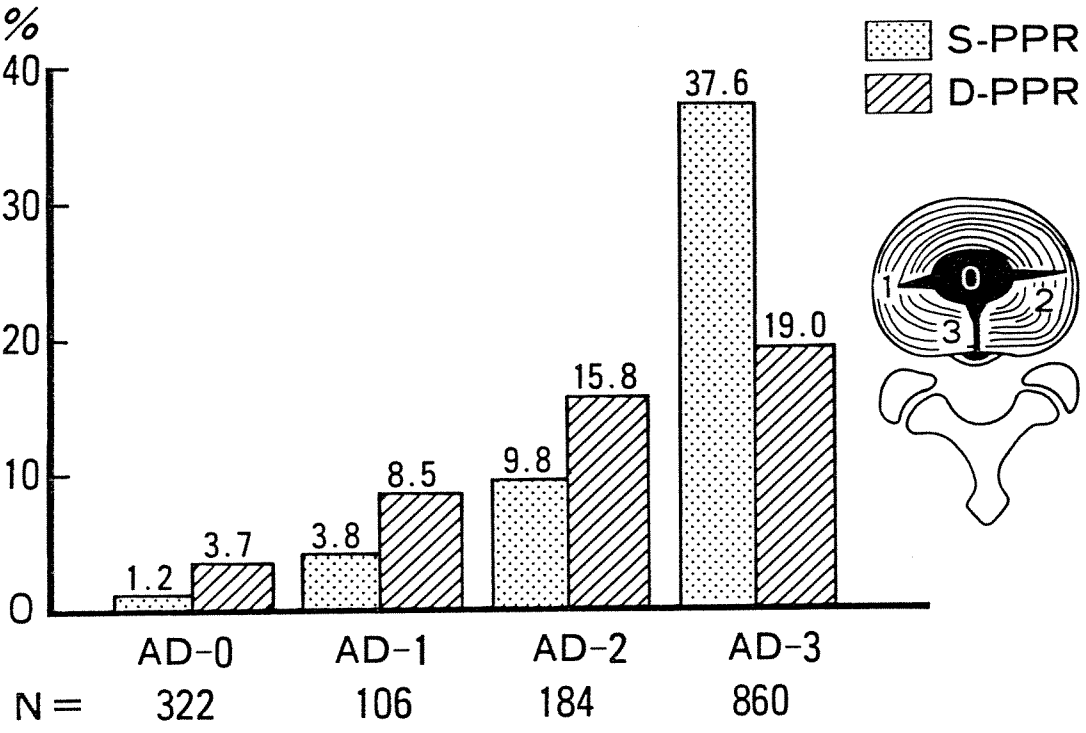
(2) Age



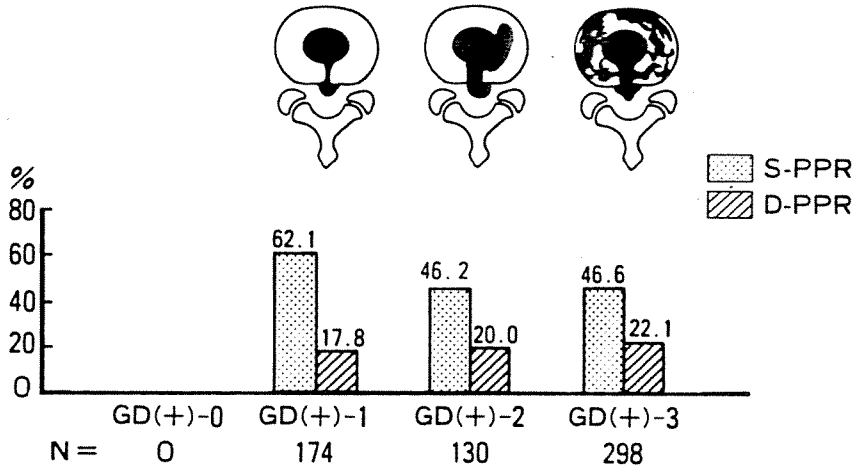
(3) Examined Level



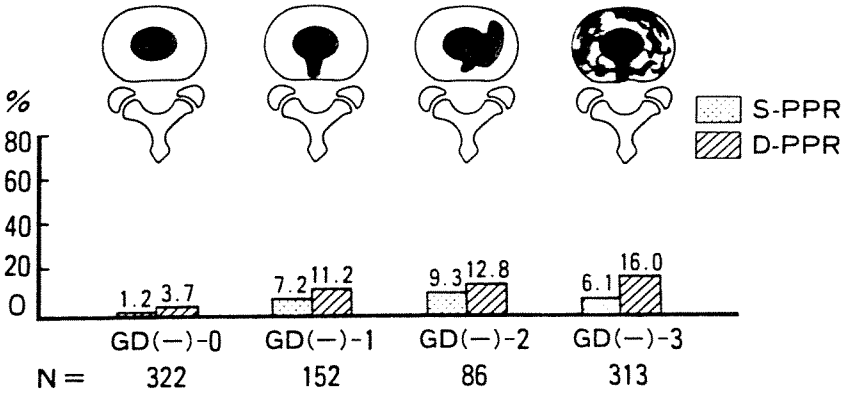

%
40
30
20
10
0
S-PPR
D-PPR
1.2
3.7
36.5
14.7
31.5
17.1
25.9
19.0
3
0
2
1
GD-0
GD-1
GD-2
GD-3
N＝
322
326
216
611

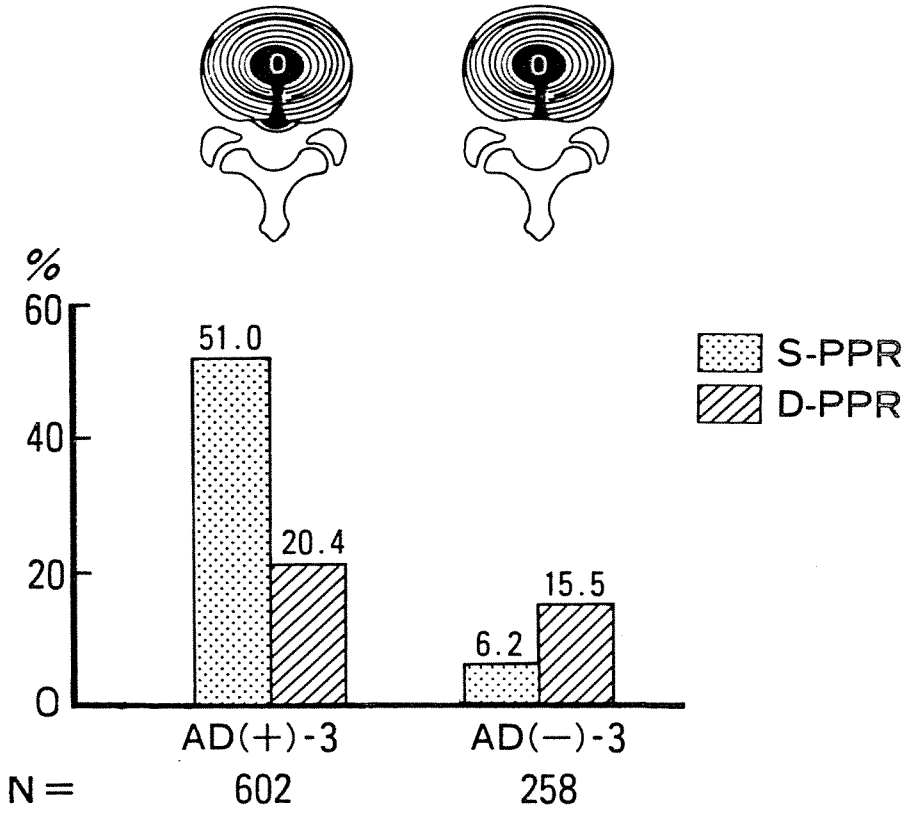

%
40
30
20
10
0
S-PPR
D-PPR
1.2
3.7
3.8
8.5
9.8
15.8
37.6
19.0
AD-0
AD-1
AD-2
AD-3
N =
322
106
184
860
0
1
2
3

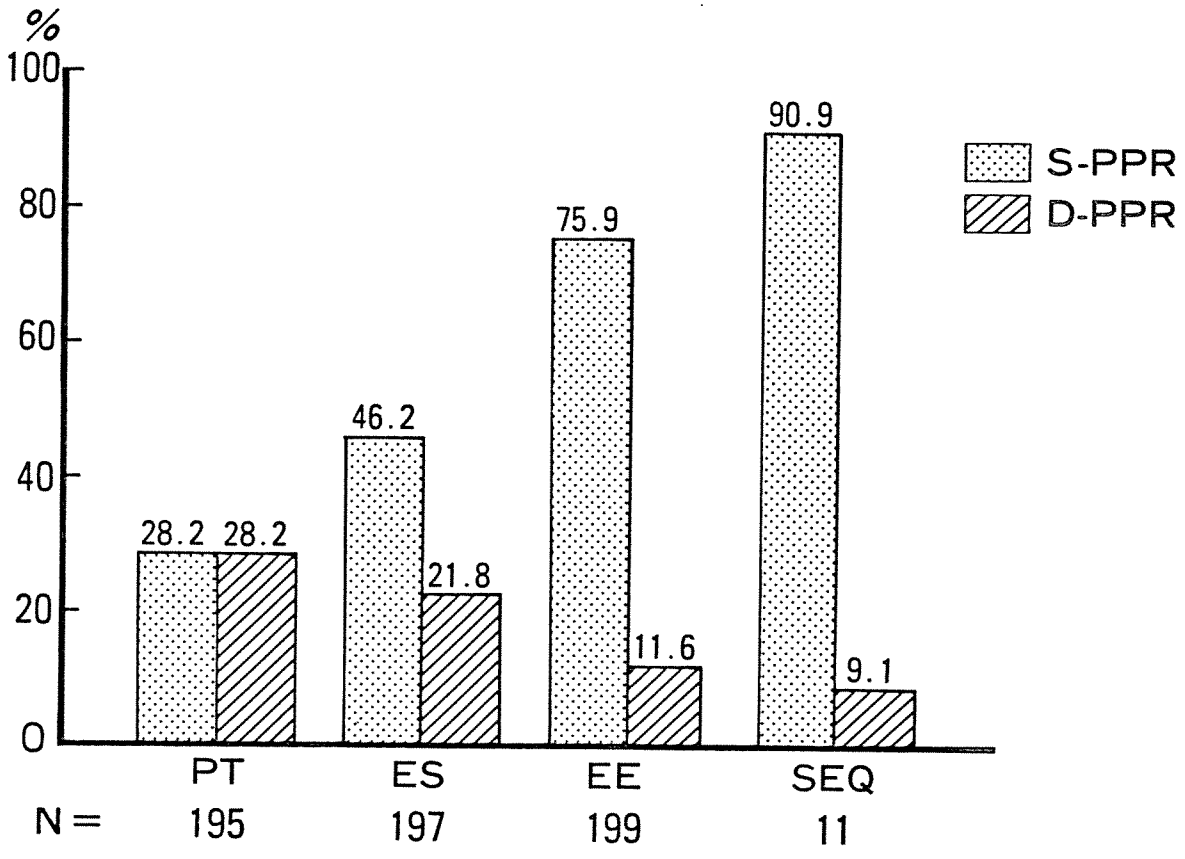
(1) With HNP

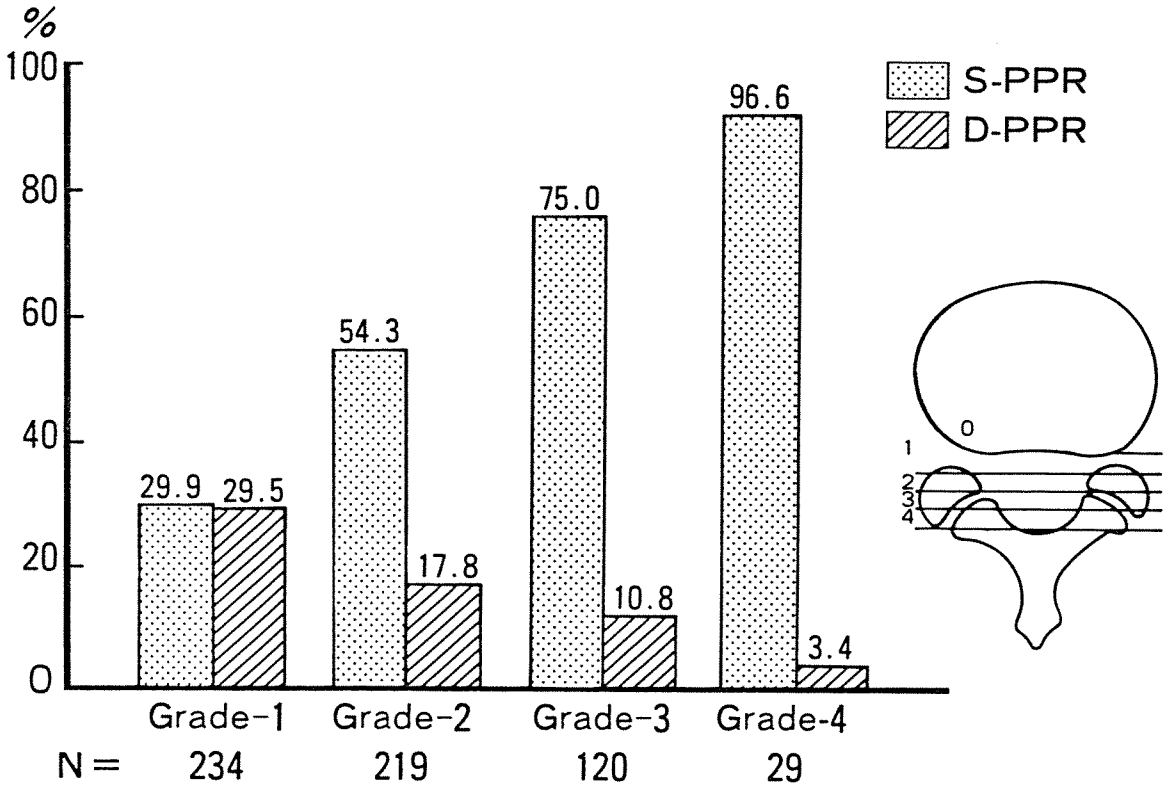


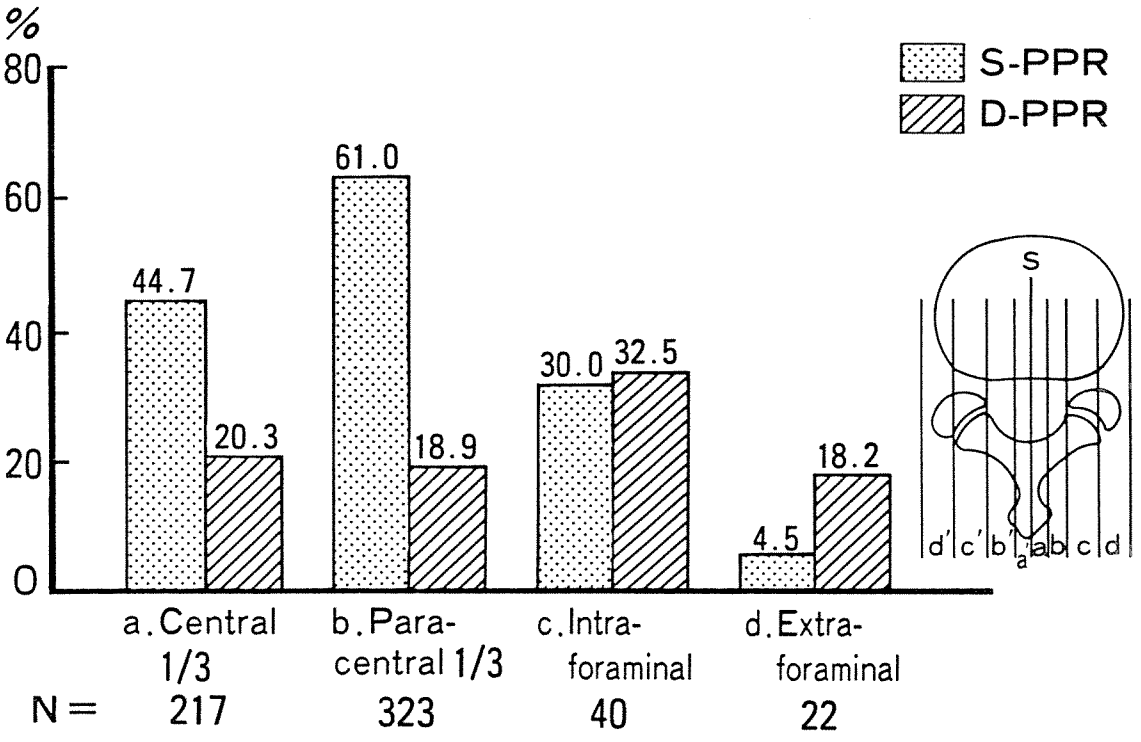
(2) Without HNP

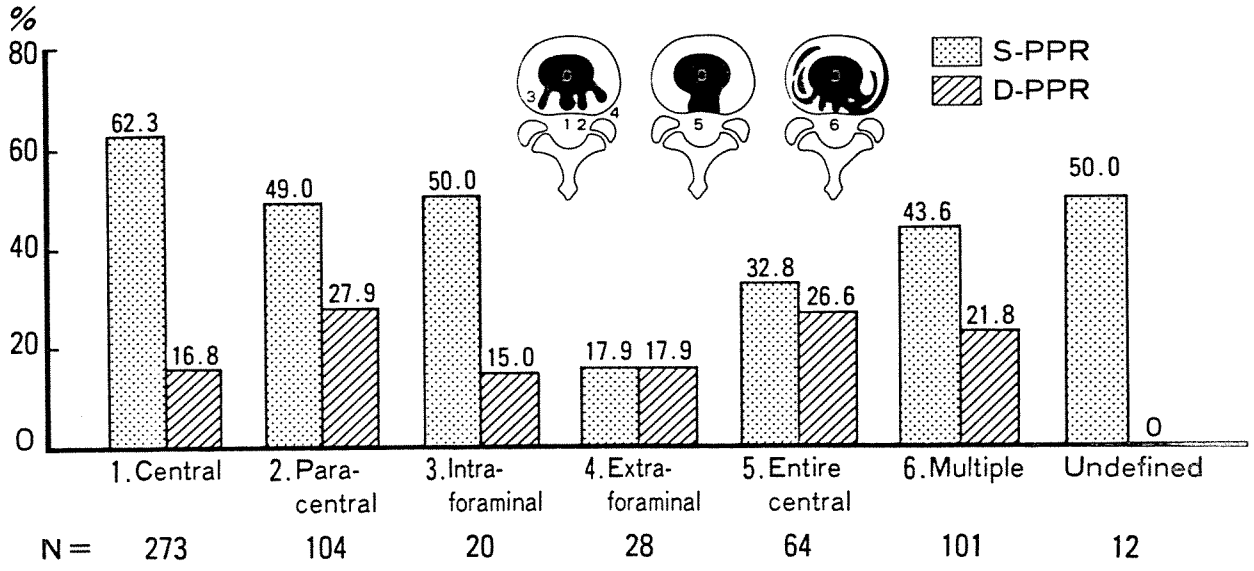



%
60
40
20
0
51.0
20.4
6.2
15.5
S-PPR
D-PPR
AD(+)-3
AD(−)-3
N=
602
258


%
100
80
60
40
20
0
28.2
28.2
46.2
21.8
75.9
11.6
90.9
9.1
S-PPR
D-PPR
PT
ES
EE
SEQ
N =
195
197
199
11


%
100
80
60
40
20
0
29.9
29.5
54.3
17.8
75.0
10.8
96.6
3.4
S-PPR
D-PPR
0
1
2
3
4
Grade-1
Grade-2
Grade-3
Grade-4
N=
234
219
120
29


%
80
60
40
20
0
S-PPR
D-PPR
44.7
20.3
61.0
18.9
30.0
32.5
4.5
18.2
S
d' c' b' a' a b c d
a. Central 1/3
b. Para-central 1/3
c. Intra-foraminal
d. Extra-foraminal
N =
217
323
40
22


%
80
60
40
20
0
S-PPR
D-PPR
3
1 2
4
5
6
62.3
16.8
49.0
27.9
50.0
15.0
17.9
17.9
32.8
26.6
43.6
21.8
50.0
0
1. Central
2. Para-central
3. Intra-foraminal
4. Extra-foraminal
5. Entire central
6. Multiple
Undefined
N=
273
104
20
28
64
101
12