

1 MRI Study of the Psoas Major Muscle and its Attachments to
2 the Lumbar Intervertebral Discs: Can a Partial or Absent
3 Attachment of the Psoas to the Disc Trigger Herniation of the
4 Disc?

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8 **Abstract**

9 Background: The Psoas Major muscle attaches to the discs from its origin until the level of
10 L4-L5 disc. It rarely attaches to the L5-S1 disc, and the absence of attachment of the psoas to
11 the L4-L5 disc is frequently seen. Likewise, disc herniation occurs more often at these two
12 lower lumbar discs L4-L5 and L5-S1. Hypothetically, by attaching the disc, the psoas may
13 provide support to the fibrous annulus and prevent herniation of the nucleus pulposus. That
14 may explain the higher incidence of herniation of the lower lumbar discs where the psoas
15 attachment is frequently absent.Purpose: 1) To search for the location of disc herniation in
16 the lumbar spine, 2) To determine whether the site of the disc herniation coincides with a
17 partial or a total absence of psoas major (PM) attachment to the disc. Materials and
18 Methods: One hundred and seventy-five magnetic resonance imaging (MRI) lumbar spine
19 examinations from Rashid Hospital, Dubai, UAE were reviewed. There were 89 females, and
20 86 males, twenty-four East Asians and 151 Arabs, mean age 53.2 (range 21-75) years.
21

22 **Index terms**— psoas major muscle, anatomy, disc herniation, MRI.
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31 Purpose: 1) To search for the location of disc herniation in the lumbar spine, 2) To determine whether the site
32 of the disc herniation coincides with a partial or a total absence of psoas major (PM) attachment to the disc.

33 Materials and Methods: One hundred and seventy-five magnetic resonance imaging (MRI) lumbar spine
34 examinations from Rashid Hospital, Dubai, UAE were reviewed. There were 89 females, and 86 males, twenty-four
35 East Asians and 151 Arabs, mean age 53.2 (range 21-75) years. The participants were selected by one physician.
36 The inclusion criteria were presence of low back pain, paresthesia, radiculopathy. All selected participants
37 underwent MRI spine examinations. All MRI examinations were performed with the same sequences. The MRI
38 images were read by three Radiologists who were blinded to the clinical examination results such as level of
39 dermatomes and side of symptoms. The location and prevalence of nonattachment of the psoas to the three
40 lower discs were assessed. The association of psoas nonattachment to the disc and disc herniation was calculated
41

4 B) MRI EXAMINATION OF THE LUMBAR, SEQUENCES AND IMAGING PARAMETERS

42 using the Pearson Chi Square test with 95% confidence interval (CI), and two-sided p value <0.05 for statistical
43 significance.

44 Results: At the L5-S1 disc, 16 (9.1%) patients presented with partial attachment of the PM; and 75% of them
45 had disc herniation. One hundred and fifty-nine (90.8%) patients had nonattachment of the PM to the L5-S1
46 disc; amongst them, 60% suffered from disc herniation. At the L4-L5 disc, partial attachment and nonattachment
47 of the PM to the disc was detected in 77 (44%) patients. Disc herniation was seen in 45 (79.2%) of them. At
48 L3-L4 disc, 12 (6.8 %) patients presented with partial attachment of the PM to the disc. Disc herniation was
49 present in 58.3% of them. The PM's partial attachment and nonattachment to the disc was more common in
50 females at all three disc levels, the highest incidence being at L4-5 level in 60.7% of females compared to 26.7 %
51 of males, p=.0001.

52 There was a higher prevalence of disc herniation at L5-S1 in the older age group (76.1%), compared with
53 the younger age group (52.4%), p=.003. The presence of disc herniation associated with nonattachment of the
54 PM muscle to the disc was higher at L4-L5 disc among the younger age group (47.6%) compared with the older
55 age group (23.9%), p=0.003 Conclusions: The partial attachment or nonattachment of the psoas muscle to the
56 lumbar disc may trigger disc herniation with a higher incidence in females and in the younger age group.

57 1 I. Introduction

58 anatomically, the psoas major (PM) muscle attaches to the lumbar intervertebral discs, to the vertebral bodies and
59 to the transverse processes (1). At the discs level the PM adheres to the fibrous annulus on both sides. In most
60 individuals, the muscle connects to the disc at its anterolateral borders, although it may occasionally extend
61 to the posterior border close to the lateral recess (1,2). Anatomical variants such as partial attachment and
62 nonattachment of the PM to the discs exist; although their prevalence is unknown. Previous reports mentioned
63 the frequent absence of attachment of the PM to the L5-S1 disc and the occasional partial attachment to the
64 L4-L5 disc (3).

65 The attachment of the PM to the lumbar discs remains enigmatic both from a biomechanical standpoint and
66 from a Radiological perspective. Hypothetically, the PM's attachment to the disc provides support to the fibrous
67 annulus and therefore would prevent extrusion of the nucleus pulposus. Likewise, it can be speculated that the
68 lack of attachment or partial attachment of the PM to the lower lumbar discs L3-L4, L4-L5 and L5-S1, can be
69 a contributing factor in the advent of disc herniation or extrusion. This is a hypothetical thought that has not
70 been thoroughly investigated.

71 In the general population, the higher incidence of herniation occurs at the lower lumbar discs L4-L5 and L5-S1
72 (4,5), where the nonattachment of the PM muscleis frequent. This can be a cause-effect phenomenon which
73 has not been demonstrated neither biomechanically nor radiologically. The aim of this study is to assess the
74 prevalence of disc herniation in patients with low back pain and search for possible association with the PM
75 muscle's partial attachment or non attachment to the affected disc.

76 2 II. Materials and Methods

77 3 a) Selection of participants and collection of clinical data

78 This is a retrospective study. The material consists of magnetic resonance imaging (MRI) examinations of the
79 lumbar spine performed from October 2015 to April 2016. The images were retrieved from the picture archiving
80 communication system (PACS) of our Institution. All patients were referred to the Radiological Department by
81 their attending physician because of low back pain of variable duration and paresthesia in the lower extremities
82 originated from the three lower lumbar nerve roots.

83 During the selection of the material, the criteria set to participate in the study included: a) history of low back
84 pain of long or short duration, b) presence of clinical symptoms -paresthesia, motor deficit, or neurological deficit
85 -suggesting presence of lumbar disc herniation, c) a complete MRI examination of the lumbar spine which included
86 the three lower lumbar discs in axial and sagittal planes. The patients with primary or secondary malignancies,
87 history of trauma, congenital disease affecting the musculoskeletal system such as muscular dystrophy, previous
88 spinal surgery with hardware, history of infection (spondylodiscitis) with destruction of the disc and endplates,
89 were excluded from the study. The demographic data (age, gender, ethnicity), clinical and radiological data of
90 each participant were collected from the electronic Archive system of the same Institution. One hundred and
91 seventy-five patients were selected for the study. Their age ranged from 21 to 75 years, with a mean of 53.8
92 years. They were 89 females, and 86 males. Among them there were twenty-four East Asians and 151 Arabs.
93 All participants underwent MRI examination of the lumbar spine with the same imaging protocol.

94 4 b) MRI examination of the lumbar, sequences and imaging 95 parameters

96 All selected MR examinations contained images in sagittal and axial planes with cross-sectional slides of at least
97 the three lower lumbar discs from L3 to S1. The images were obtained from a 1.5 Tesla GE imager. The series
98 of images were acquired with the following sequences: a) turbo spin echo (TSE) T1Weighted (T1W) in sagittal
99 plane, b) TSE T2Win sagittal plane, c) short Tau-Inversion Recovery (STIR) in sagittal plane, and d) TSE T2W

100 in axial plane. With a slice thickness of 3 millimeters, a field of view (FOV) of 200, a matrix of 416x288, the
101 number of signal average (NSA) of 1-3, a repetition time (TR)=T1W of 580 milliseconds (ms), T2W (4660ms),
102 STIR(2860ms), echo time (TE)=T1W (11.9ms), T2W(82.19ms), STIR(33.92ms), inversion time (IT) =125, echo
103 train (ET) of T1W =3, of T2W=24, of STIR=12, the examination time would not exceed thirty minutes.

104 **5 c) Analysis of MR images and assessment of the PM attachment 105 to the disc**

106 The images were analyzed by two experienced Radiologists, as the decisions were reached by consensus. The
107 results were supervised by two senior Radiologists.

108 The analytic process was three-fold: a) search for disc herniation in the three lower lumbar discs, with emphasis
109 of its location central or lateral, 2) assess the attachment of the PM muscle to both sides of the disc, and verify if
110 the attachment was present, partial, or absent (nonattachment), and 3) verify whether there was disc herniation
111 and partial or absent attachment of the PM muscle to the same disc. To facilitate the assessment of the PM
112 muscle adherence to the disc's borders, and to correctly locate the herniated disc, the disc's surface was divided
113 into four quadrants of equal size. The four quadrants were obtained by drawing two perpendicular lines at the
114 center of the disc (Figure 1). The quadrants were named: right anterolateral, left anterolateral, right posterior,
115 and left posterior. When the muscle fascicles adhered to the disc in all four quadrants, it was considered as
116 complete attachment (Figure 1). The lack of contact of the PM muscle fascicles with the disc border in one, or
117 two, or three quadrants was defined as partial attachment (Figure ??a). The lack of contact of the PM muscle
118 fascicles to the disc in all four quadrants was defined as total absence of attachment or nonattachment (Figure
119 2b).

120 The PM muscle's attachment to the discs were assessed on the TSE T2W axial images. The presence of
121 lumbar disc herniation was assessed at the last three lower lumbar levels, on both sagittal and axial images. The
122 herniation site was defined as: diffuse, right, central, or left. The disc was considered as herniated when it bulged
123 more than 2 mm from the vertebral margin.

124 For comparison purposes, the population was sub-classified, based on age, into two sub-groups: group I (21-45
125 years) and group II (46-75 years). There were two other sub-groups based on gender: male and female; and based
126 on ethnicity: East Asians and Arabs. The data were collected on Excel spread sheets prior to statistical analysis.

127 **6 d) Statistical analysis**

128 The data was processed with a SPSS software (IBM) version 20 and different categorical variables were tabulated
129 for frequency and percentages separately. For analyzing the association between two categorical variables we
130 cross tabulated variables and used Pearson Chi Square test to see the significance of association between two
131 variables. With 95% confidence interval (CI), two-sided p value <0.05 was considered statistically significant.

132 **7 III. Results**

133 **8 a) Prevalence of disc herniation**

134 Out of 175 patients, disc herniation most frequently occurred at L4-5 level in 126 (72%). This was followed by
135 L5-S1 level, in 108 (61.7%) patients; and then by L3-L4 level in 87 (49.7%) patients. The most common patterns
136 of disc herniation and their prevalence at the three disc levels L3-L4, L4-L5, and L5-S1 are presented in Table
137 ??.

138 **9 b) Prevalence of PM's partial attachment and nonattachment 139 to the discs associated with disc herniation at the three levels**

140 At the L5-S1 disc level, none of the 175 patients presented with a complete PM attachment to the disc. However,
141 16 (9.1%) patients presented with a partial attachment of the PM muscle to the disc; while 159 (90.8%) patients
142 had nonattachment of the PM muscle to the disc.

143 Amongst the 16 patients with PM partial attachment to the disc, 75.0% had disc herniation. From the 159
144 patients with nonattachment of the PM muscle, 60% suffered from disc herniation (Figure 3). Statistically, the
145 difference in the prevalence of disc herniation in patients with partial attachment and those with nonattachment
146 was insignificant, p=0.371.

147 At the L4-L5 disc level, there was the highest prevalence of partial attachment and nonattachment of the PM
148 muscle to the disc. It was seen in 77 (44%) patients. Out of the 77 patients with partial and nonattachment, 45
149 (79.2%) showed disc herniation (Figure 4); compared with 37 (66.3%) patients out of 98 patients with complete
150 psoas attachment and disc herniation, showing a trend of significance, p value = 0.059.

151 At the L3-L4 disc level, only 12 (6.8 %) patients presented with partial attachment of the PM muscle to the
152 disc. Out of the 12 patients, disc herniation was present in 58.3%, compared with 49.1% patients with complete
153 PM attachment to the disc, which was not statistically significant, P value for Chi Square =.536.

154 **10 c) Prevalence of side (right / left)of PM muscle partial
155 attachment only at the three discs L3-L4, L4-L5 and L5-S1**

156 When the PM partial attachment to the disc was analyzed separately at each disc level, at L5-S1 disc more
157 patients were seen with partial PM attachment to the right side of the disc compared with the left side, 15 (8.5%)
158 and 7 (4%) respectively.

159 At the L4-5disc, the PM was partially attached in sixty-seven (38.2%) patients on left side of the disc compared
160 with 63(36%) patients where the PM was partially adhered to the right side of the disc (Fig. 4).

161 At the L3-L4 disc level, eight (4.5%) patients had partial attachment of the PM on the left side of the disc;
162 and 8 (4.5%) patients had partial attachment on the right side of the disc.

163 **11 d) Prevalence of disc herniation and complete PM**

164 attachment to the disc at the three levels At L5-S1 disc level, none of the participants had complete PM
165 attachment to the disc. However, disc herniation was seen in 60.1% of patients with nonattachment of the
166 PM to the disc.

167 At L4-L5 disc level, disc herniation was observed in 66.3% of patients with complete PM attachment to the
168 disc.

169 At L3-L4 disc level, disc herniation was seen in 49.1% of patients with bilateral complete PM attachment to
170 the disc.

171 **12 e) Prevalence of disc herniation in the two age groups,
172 genders and ethnic groups**

173 Based on age, the population was divided into subgroups. There were 104 patients in the younger group (age
174 21-45 years) and seventy-one patients in the older group, (age 46-75 years).

175 At L5-S1 disc level, disc herniation was detected in 52.4% of the patients from first age group, compared with
176 76.1% of patients from older age group, being the difference statistically significant, p = .003.

177 At L4-L5 disc level, among the younger age group of 104 patients, there was a higher prevalence of disc
178 herniation and nonattachment of the PM muscle to the disc, 45 (47.6%) patients compared with 23.9% of
179 patients from the older age group, p value =0.003.

180 At L3-L4 disc level, the difference in prevalence of disc herniation between the two age groups was less
181 important. The prevalence was 40.2% in the younger population compared with 58.6% in the older population.

182 When the two gender groups (female and male) were considered, there was a higher prevalence of disc herniation
183 in females compared to males especially at the level of L4-L5 disc, although not significant. The prevalence of
184 disc herniation in the two age groups, genders and the ethnic groups at all three disc levels is shown in Table ??I.

185 **13 f) Prevalence of partial attachment and nonattachment in
186 the two age groups, the two gender groups and the two
187 ethnic groups**

188 The analysis of the two age groups revealed a higher prevalence of the PM's partial attachment and nonattachment
189 to the discs in the older population. This difference was more accentuated at the two lower discs. At L4-L5 disc,
190 the partial and nonattachment of the PM (D D D D) D muscle to the disc was seen in 49.3% in the older group
191 compared to 39.8% in the younger group. At L5-S1 disc, the partial and nonattachment of the PM muscle to
192 the disc was detected in 12.7% in the older group compared to 6.8% in the younger group.

193 When the two genders groups were considered, the PM' spartial attachment and nonattachment to the disc
194 was more common in females compared to males, at all three disc levels. The incidence was highest at L4-5 level,
195 in 54 (60.7%) females, compared to 23 (26.7 %) males, p= .0001.

196 Among the 24 participants from East Asia, 12 (50%) of them presented with partial attachment of the PM
197 to the disc at L4-L5, compared with the Arabs. However, among the 151 Arabs, 11 (7.3%) of them had a partial
198 attachment of the PM at the L3-L4 disc compared with a lower incidence among the East Asians.

199 The prevalence of PM's partial and nonattachment to the discs in the two age groups, gender groups and
200 ethnic groups is presented in Table III. Table ??I: Prevalence of disc herniation in the two age groups, genders
201 and the ethnic groups at all three disc levels.

202 **14 IV. Discussion**

203 On magnetic resonance (MR) cross-sectional images, the PM muscle emits a moderate signal intensity compared
204 to other muscles. The sagittal images are less useful to evaluate the PM, while the axial slicespermit a fair
205 appreciation of the PM's attachment to the lumbar intervertebral discs and the anatomical variants. In this
206 study, the authors aimed to analyze the relationship between the pattern of attachment and nonattachment of
207 the PM to three lumbar disc and the possible impact on the herniation of the disc.

208 In previous studies, several conditions such as abnormal posture (6), increased intradiscal pressure (7,8) have
209 been mentioned as causative factors of lumbar disc herniation. The partial attachment or nonattachment of the
210 PM to the disc had not been considered as possible influential factors to disc herniation. Neither the differences
211 in the prevalence of these anatomical variants with regards to demographics have been subject to investigation.
212 Hypothetically, we postulated that individuals with anatomical variations of the PM attachment to the disc may
213 suffer from a higher risk of herniation, assuming the PM's attachment to the disc would provide support to the
214 fibrous annulus and therefore prevent annulus tear and extrusion of the nucleus pulposus.

215 At the L4-L5 disc, we found the highest prevalence of partial attachment and nonattachment of the PM muscle
216 to the disc in 77 (44%) patients. Of them, 45 (79.2%) suffered with low back pain and disc herniation. This
217 finding pointed toward a possible cause and effect phenomenon that has not been previously considered. In our
218 study, a population of 175 subjects was evaluated. The highest prevalence of disc herniation (72%) was detected
219 at L4-L5 level, which concurred with previous reports (4,5,8).

220 The PM's nonattachment to the L5-S1 disc has previously been reported (8, ??), and considered as
221 anatomically normal, since it occurs in most individuals. In our study, the nonattachment was seen in 159
222 (90.8%) subjects with a high prevalence of herniation (60% of them). Of the rest -16 (9.1%) subjects-, who
223 presented with PM's partial attachment, 75% had disc herniation. Such high occurrence of disc herniation at the
224 two lower discs and the high prevalence of the PM's partial and nonattachment to the disc may be related.

225 From the study's results, the demographic factors -age and gender-seemed to have some influence on the
226 advent of disc herniation in individuals with partial or nonattachment of the PM to the disc. We found that
227 a higher frequency of disc herniation at L4-L5 level and L5-S1 level in the younger individuals with partial or
228 nonattachment of the PM to disc. The difference in prevalence was more accentuated at L4-L5 disc, 47.6% versus
229 23.9% with statistical significance (p=0.003). This further emphasizes the role of muscle attachment pattern in
230 inducing herniation of the disc, with a possible stronger influence among younger subjects.

231 Also, a significant association between the PM's muscle nonattachment to the disc and disc herniation was
232 found with a higher frequency in females (60.7%) compared to males (26.7%), especially at the L4-L5 disc. This
233 difference has not been described previously. The selected population was represented by two different Ethnic
234 groups: Eastern Asians (24 subjects) and Arabs (151 subjects). Because of the discrepancy in the numbers (24
235 versus 151) no significant comparative data could be obtained for the two ethnic groups; which constitutes a
236 limitation of the study.

237 A study with a larger population with larger diverse ethnic groups may be necessary to better understand
238 the correlation between ethnicity, PM's attachment to the disc and disc herniation. Likewise, the statistical
239 difference between genders and different age groups for PM's attachment to the disc and disc herniation deserve
240 further investigation. To our knowledge, no previous study had focused on the PM muscle attachment to the
241 disc as a possible contributing factor in disc herniation in relation with demographics.

242 In conclusion, the PM muscle's partial attachment and nonattachment to the lower lumbar discs may be a
243 triggering factor for initiating disc herniation especially in younger age groups and in females. Further prospective
244 studies with larger population are needed to confirm this hypothesis. ^{1 2 3 4}

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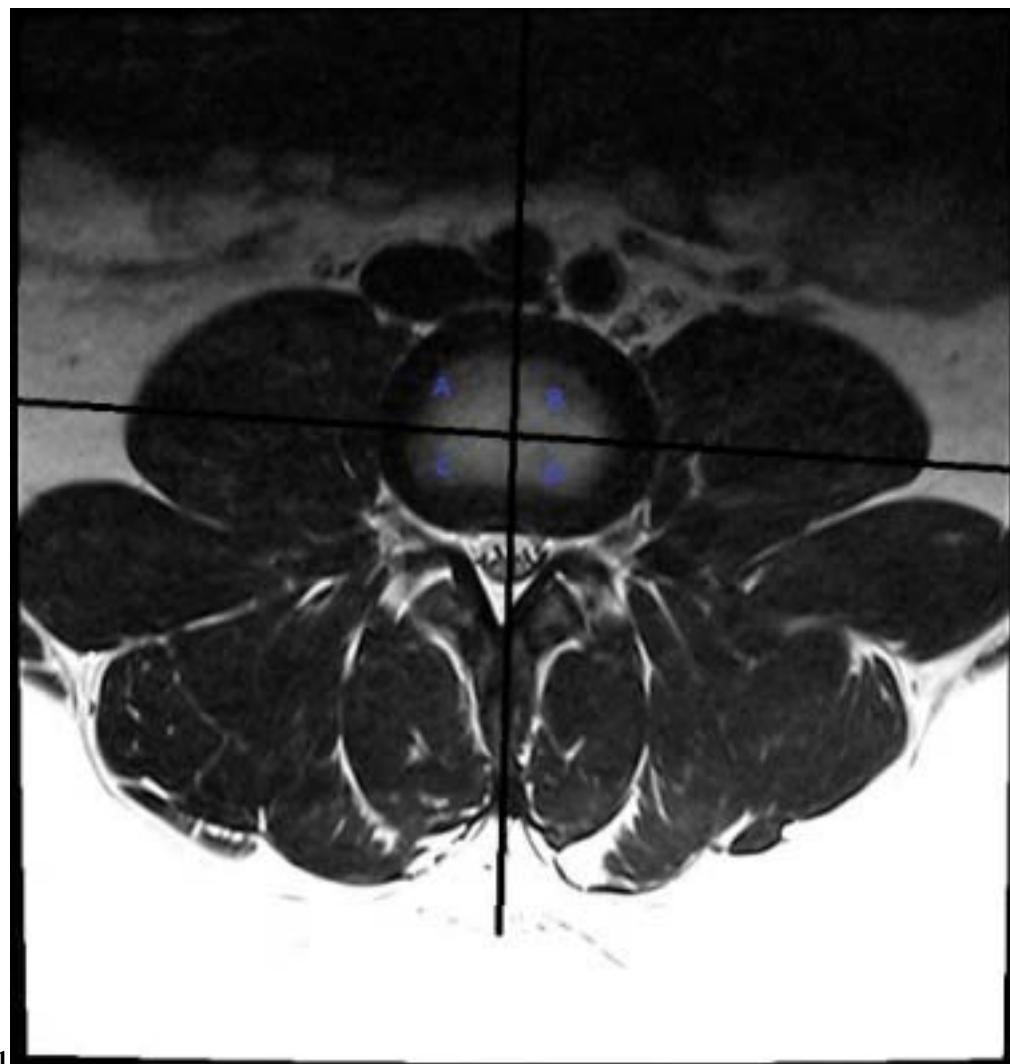


Figure 1: Figure 1 :

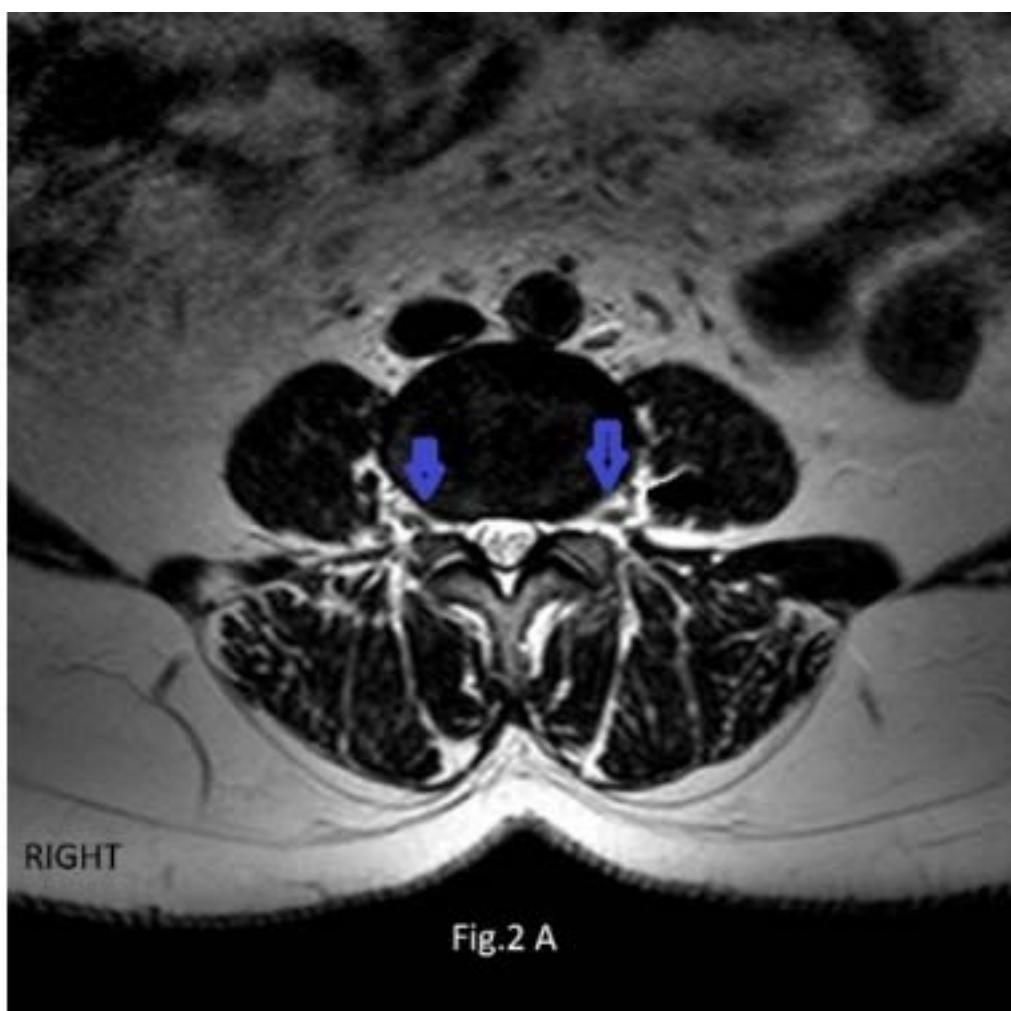


Figure 2: Figure 2B :



Figure 3: Figure 3 :

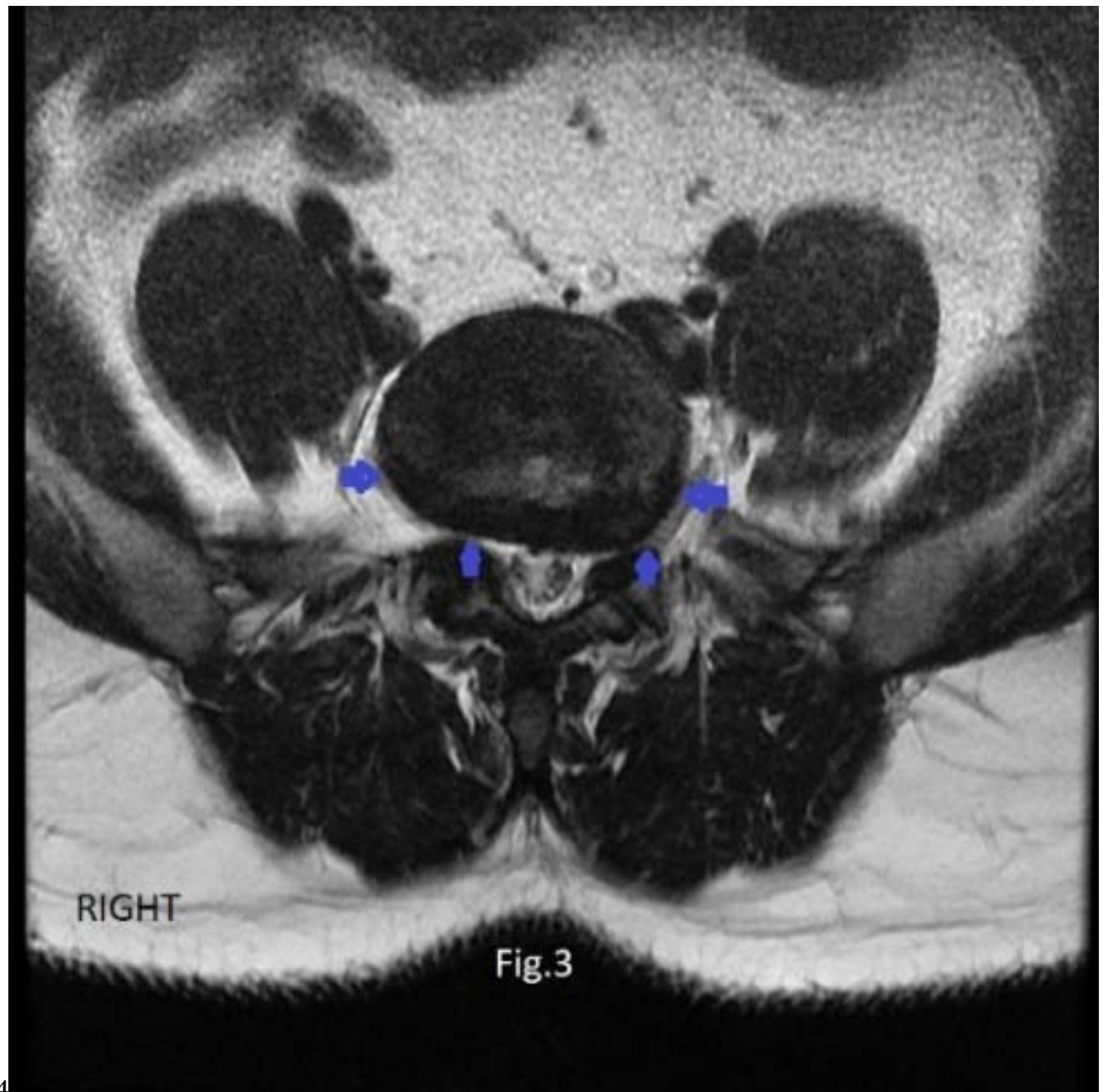


Figure 4: Figure 4 :

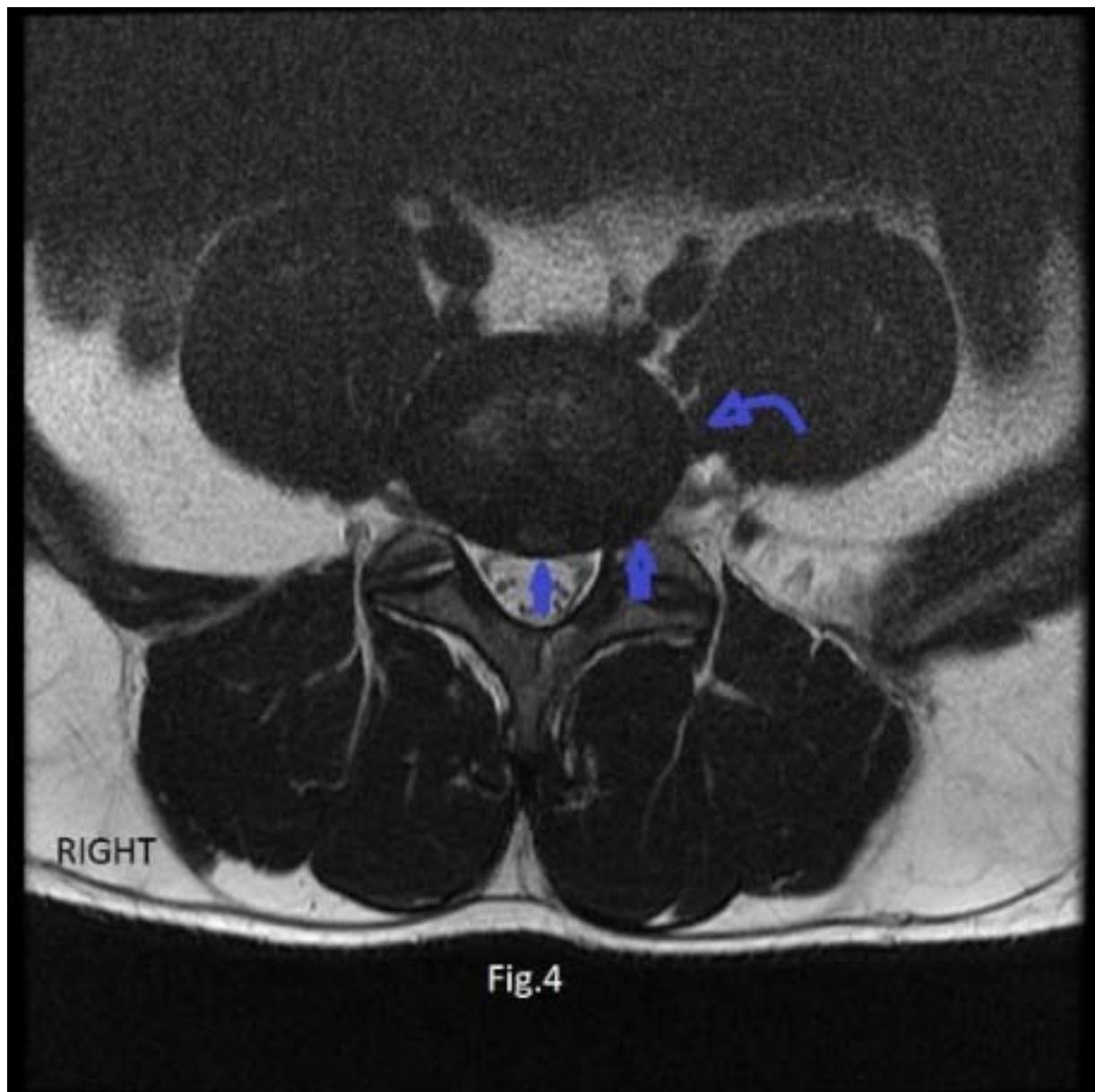


Figure 5:

III

LEVELS	21-45 YEARS	46-75 YEARS	MALES	FEMALES	EAST ASIANS	ARABS
L3-L4	3.9%	11.3%	2.3%	11.2%	4.2%	7.3%
L4-L5	39.8%	49.3%	26.7%	60.7%	50.0%	43.0%
L5-S1	6.8%	12.7%	8.1%	10.1%	16.7%	7.9%

Figure 6: Table III :

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