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The Effects of Age, Gender, Ethnicity, and Spinal Level on the Rate of Intervertebral Disc Degeneration. A review of 1712 Intervertebral Discs

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Abstract

Study Design—A gross anatomical and magnetic resonance imaging (MRI) study of intervertebral disc (IVD) degeneration in fresh cadaveric lumbar spines.

Objective—The purpose of this study was to find the rate of IVD degeneration.

Summary of Background Data—Age, sex, race, and lumbar level are among some of the factors that play a role in IVD degeneration. The rate at which IVDs degenerate is unknown.

Methods—Complete lumbar spine segments (T11/12 to S1) were received within 24 hours of death. The nucleus pulposus, annulus fibrosus, cartilaginous and bony end-plate, and the peripheral vertebral body were assessed with MRI and IVD degeneration was graded by two observers from grade 1 (nondegenerated) to grade 5 (severely degenerated) based on a scale developed by Tanaka et al. The specimens were then sectioned and gross anatomical evaluation was performed according to Thompson et al.

Results—433 donors and 1712 IVDs were analyzed. There were 366 Caucasians, 47 Africans, 16 Hispanics, 4 Asian. There were 306 males and 127 females. The age range was 14–81 years, (average 60.5+/-11.3). For donors greater than age 40, the L5/S1 IVD degenerated at a significantly faster rate of 0.043/year compared to 0.031, 0.034, 0.033, 0.027 for L12, L23, L34, L45, respectively. For donors younger than 40, L5/S1 IVD degenerated at a significantly faster rate of 0.141/year compared to 0.033, 0.021, 0.031, 0.050 for L12, L23, L34, L45, respectively. Multiple regression analysis revealed that gender had no significant effect on IVD degeneration whereas African ethnicity was associated with lower Thompson score at L12, L23, L34, L45 when compared to Caucasians.

Conclusions—The relatively early degeneration at L5-S1 in all races and lower Thompson grade in donors of African ethnicity needs further investigation. Factors such as sagittal alignment, facet joint arthritis, and genetics potentially play a role in IVD degeneration.

Keywords

Intervertebral disc; degeneration; ethnicity; age; rate

Introduction

Intervertebral disc (IVD) degeneration is believed to begin as early as the second decade of life, and is viewed by most as an inevitable consequence of ageing [1–3]. The IVD is comprised of a centrally located nucleus pulposus (NP) core, the peripherally located multilaminar annulus fibrosus (AF), and cartilaginous endplates.

It has been shown that IVD degeneration originates in the NP, with a decrease in proteoglycan content and type II collagen synthesis, while there is an increase in denaturation of type II collagen and synthesis of type I collagen [4–8]. As the NP loses its osmotic properties, which leads to fibrosis, the NP cannot transmit forces efficiently, thus initiating the degenerative cascade that affects the AF and the whole disc.

Several authors have shown IVD degeneration to be associated with ethnicity, smoking, and vertebral level [9–15]. Intervertebral disc degeneration is commonly graded by using the Thompson classification, which uses a 5-category grading scheme for assessing gross morphology of mid-sagittal sections of human lumbar IVD [16]. Tanaka et al have shown a high correlation between magnetic resonance (MR) images of IVD degeneration and the Thompson grade on gross morphological inspection with the reported kappa value as high as 0.9 [17]

There are multiple reports which correlate age with disc degeneration [1,5]. However; there are no studies reporting the *rate* at which each IVD level degenerates in people with no prior history of spinal problems. Knowing the rate of IVD degeneration has an important prognostic value. Furthermore, having a non-invasive means of assessing IVD degeneration, which closely correlates with the gross morphologic grade, would further enhance the usefulness of such a diagnostic examination. The purpose of this study was to find the rate of IVD degeneration at each lumbar level by using MR imaging and gross macroscopic evaluation.

Material and Methods

Donor population

Spine segments were harvested by and received from the Gift of Hope Organ and Tissue Donor Network after obtaining consent from the families. All the individuals had died of acute causes such as acute trauma, acute poisoning, cerebral bleeding, sepsis or myocardial infarction. None of the individuals had a history of a relevant back problem (e.g., previous in-hospital treatment, surgery, or invalidity) in their medical reports (available at autopsy). Furthermore, the donors' families were questioned regarding any spine related history. Specimens with a prior history of spine related problems were excluded from this study. Demographic data including age, gender, and ethnicity as well as the donors' cause of death were obtained. The Gift of Hope Organ and Tissue Donor Network uses an observation based 3-point scale to assess donor weight. Donors are classified as under weight, normal, or overweight.

Donor samples—Complete lumbar spine segments (T11/12 to S1) were received within 24 hours of death of the donor. The segments included the entire spinal column as well as the surrounding muscles and ligaments. Each of the lumbar segments subsequently underwent MR imaging. Specimens that were found to have fractures, excessive osteophytes (precluding opening of the joint), or other signs of a pathologic process were excluded from this analysis. The vertebral column was then sectioned with a saw in a sagittal plane 5mm from the midline. The NP, AF, cartilaginous and bony end-plate, and the peripheral vertebral body were evaluated macroscopically by two observers.

Sample analyses

Gross Specimen Evaluation—The NP, AF, cartilaginous and bony end-plate, and the peripheral vertebral body were assessed macroscopically and IVD degeneration was graded by two observers from grade 1 (nondegenerated) to grade 5 (severely degenerated) based on a scale developed by Thompson et al [16].

Magnetic Resonance Image Evaluation—MR images were taken using a Siemens Magnetom Vision at 1.5 T. The operational modes employed were T1-weighted spin-echo sequences (TR 500ms, TE 20ms) and T2-weighted spin-echo sequences (TR 3200ms, TE 160ms). The NP, AF, cartilaginous and bony end-plate, and the peripheral vertebral body were assessed by MRI and IVD degeneration was graded by two observers from grade 1 (normal), grade 2 (mild disc degeneration), grade 3 (moderate disc degeneration), grades 4 (severe) and 5 (severe with osteophytes >2mm) using a modification of the scale developed by Thompson et al [16]. Any discrepancy between the MR imaging-based grade and the macroscopic Thompson grade was recorded and those samples showing a different grade by these two methods were excluded from this study.

Statistical analyses

Age, gender, and ethnicity of the donor and degeneration grade for each IVD were recorded and used for statistical analysis. Statistical analysis was performed using simple and multiple linear regression as well as simple mean comparisons using analysis of variance and student t-tests. Simple comparisons using student t-test and analysis of variance were used to establish the differences between age (independent variable) and IVD degeneration in males and females, and various ethnicities. The donors were also grouped according to decades. Linear regression was used to establish the rate of IVD degeneration for each level, as well as, to analyze the differences in IVD degeneration between the various decades. The observational weight scale was not used for statistical analysis.

Results

Cadaveric lumbar spine segments of 433 donors and 1712 IVDs were used for analysis. There were 366 Whites, 47 Blacks, 16 Hispanics, 4 Asian, among the donors of which 306 were males and 127 were females. The age range was 14–81 years, average age was 60.5 ± 11.3 years (Table 1).

The average Thompson grade by age and spinal level is presented in Table 2. Degeneration grade increased as one proceeded caudally down the spinal column. There was a statistically significant difference between L1/2 and L4/5 ($p < 0.0001$)

There was a statistically significant difference in Thompson grade observed between L2/3 and L4/5 ($p < 0.0001$); between L3/4 and L4/5 ($p < 0.0001$); between L4/5 and L5/S1 ($p < 0.034$) and between L1/2 and L3/4 ($p = 0.023$).

The average Thompson grade by decade is presented in Table 3, and the differences in Thompson grades between decades are presented in Table 4. Increase in the degeneration grade was observed with increasing age of the donor, and statistically significant differences were found between every pair of age-groups compared, except for decades V and IV, II and III, III and IV and III and V.

The average Thompson grade by spinal level and decade is presented in Table 5. There was no statistically significant difference in IVD Thompson grade between spinal levels within any decade.

Rate of age-related IVD degeneration per spinal level (Table 6)

Regression analysis revealed that age indeed predicted deterioration at all lumbar levels; however the rate of degeneration was dependent on the level of the IVD in the spinal column. For donors over the age of 40, the L5/S1 IVD degenerated at a significantly faster rate of 0.043/year when compared to 0.031, 0.034, 0.033 and 0.027 for L1/2, L2/3, L3/4 and L4/5, respectively. There was no statistical difference in the rate of IVD degeneration when comparing L1/2, L2/3, L3/4 and L4/5. For donors under the age of 40, the L5/S1 IVD degenerated at a significantly faster rate of 0.141/year when compared to 0.033, 0.021, 0.031 and 0.050 for L1/2, L2/3, L3/4 and L4/5, respectively. There was a statistically significant difference in the rate of IVD degeneration between donors under 40 years old and those over 40 years old at the L2/3, L4/5, and L5/S1 level.

Gender and IVD degeneration relationship for each spinal level

Gender, age, and Thompson grade are presented in Table 7. The comparison in Thompson grades between males and females for each spinal level is presented in Table 8. There was no statistical difference between males and females in degeneration grades at any lumbar level ($p>0.05$).

Ethnicity and IVD degeneration relationship for each spinal level

Age, ethnicity, and mean Thompson grade are presented in Table 9. Comparison between ethnicities and mean Thompson grades revealed a significant difference between Caucasians and Africans, as shown in Table 10. There was no difference between the remaining ethnicities-Caucasian/Asian; Caucasian/Hispanic; African/Asian; African/Hispanic; Asian/Hispanic. There was a statistically significant difference between Caucasian and African ethnicities in IVD degeneration at the L2/3 ($p=0.021$), L3/4 ($p=0.006$), and L4/5 ($p=0.013$) levels, with African ethnicity being associated with having a lower Thompson grade. There was no difference between the ethnicities in the Thompson grades at the L1/2 ($p=0.0507$) and L5/S1 ($p=0.39$) levels (Table 12).

Discussion

In this study we were able to correlate IVD degeneration based on MR imaging and gross morphological examination with the age, gender, and ethnicity of the donor as well as the position of the IVD in the lumbar spine. We demonstrated a direct relationship between the age of the donor and the grade of IVD degeneration, and determined the rate of degeneration in IVDs of each level of the lumbar spine. Interestingly, the rate of degeneration per year was faster in the L5/S1 IVD relative to other lumbar segments. The difference was even more profound in the 14–40 age group, although the sample size was small.

One of the reasons that the rate of IVD degeneration is highest at the L5/S1 motion segment is secondary to the high magnitude of compressive forces seen at the lumbosacral junction [18]. Furthermore, anterior shear forces at the L5/S1 motion segment increase proportionally

with increasing sacral angle [18,19]. Anterior and posterior disc postural loads, which are balanced at T8–T9, show the greatest difference at L5/S1 [19]. Intervertebral disc degeneration in the lumbar spine has been shown to be associated with motion [17]. Furthermore, it has been shown that the proliferation of IVD cells, the formation of clefts and tears, and both mucoid and granular matrix degeneration, are statistically associated with aging and/or IVD degeneration [3,7,8]. There is a direct correlation between IVD matrix metalloproteinases (MMP) expression and age, with aging IVDs containing more MMP-producing cells [3]. These IVDs may therefore show a higher breakdown of collagenous matrix molecules [3]. The increased compressive loads seen at L5/S1 may trigger a more robust increase in MMPs leading to an increased rate of IVD degradation. Thus, we propose that it is because of all the above mentioned factors that L5/S1 IVDs showed a statistically higher rate of degeneration when compared to other levels. Reporting on pooled data from 3 studies using the Nachemson scale, Ashton-Miller et al reported no difference in degeneration grades between the L3/4, L4/5, and L5/S1 levels [20,21]. The authors also reported that the L5/S1 disc does not degenerate before the L3/4 disc. In contrast to the present study, the donors' clinical history was not available in the Ashton-Miller review. Therefore, no conclusions about the natural history of intervertebral disc degeneration can be made.

It would appear that there is a direct linear relationship between IVD degeneration and age after the 5th decade. Multiple regression analysis demonstrated that IVD degeneration plateaued during the 3rd and 4th decades and then increased steadily after the 5th decade. This relationship was observed at every level. Antoniou et al demonstrated that synthesis of type II collagen in the NP tissues dropped with aging and increasing grade of degeneration [5]. Adult degenerative NP cells produced significantly higher amounts of proteoglycans, collagens, and aggrecan when compared to adolescent cells. These findings suggest that human NP cells are involved in repairing and replacing diminishing ECM during age-related degeneration [5,6]. It can therefore be postulated that after the 5th decade, IVD cannot repair and replace the ECM as efficiently as IVD in the 3rd and 4th decades leading to a progressive, linear degeneration in the NP.

To the best of our knowledge this is the largest series of cadaver spines that underwent both MR imaging and gross morphological evaluation at a single institution. It should be noted that there was no history of spinal conditions in any of the donors allowing us to report on the natural history of IVD degeneration.

There are many studies that assess IVD degeneration using MR imaging. This is a safe and reproducible way of judging not only IVD degeneration but also neural compression. MR imaging closely reflects the degenerative changes noted in the IVD on gross morphological examination. Previously, Tanaka et al evaluated both MR images and cryomicrotome sections using Thompson's classifications, and found no statistical difference between the IVD degeneration grades based on the two types of images [17]. However, 13 of 14 discs that were assigned to grade I based on cryomicrotome sections were assigned to grade II based on MR images. The authors concluded that MR images reflect the morphologic changes in degeneration of the IVD except for early grades I and II.

Using a 5 grade scale, based on T-2 weighted sequence MR imaging, Boos et al prospectively observed 46 asymptomatic individuals during a 5-year follow-up period, and reported that IVD degeneration progressed in 17 (41.5%) of 41 patients [13]. In a cross-sectional MR imaging study of lumbar IVD degeneration in 200 healthy individuals age 30–55, Kanayama et al reported that age was a significant risk factor when examining any disc level except L5/S1 [22]. Over half of the subjects had moderate IVD degeneration at baseline at the L4/5 and L5/S1 levels. Other parameters (episode of low-back pain, smoking

status, BMI, and hours of standing/sitting) were not found to be significantly related to disc degeneration. In our study we noted a significant correlation between IVD degeneration and age at every level, with L5/S1 demonstrating the highest rates and grades of IVD degeneration.

Smoking data was not available in this analysis, however some authors reported that smoking has not been shown to have an effect on the prevalence of IVD degeneration [13,22]. Other authors found both smoking, and obesity as detrimental factors for lumbar IVD degeneration [9–12]. All of these studies evaluated subjects in a narrow age range. Battie et al used MR imaging to study pairs of identical twins highly discordant for cigarette smoking, and reported 18% greater mean IVD degeneration scores in the lumbar spines of smokers than nonsmokers [9]. Liuke et al, also studied the association between being overweight and having lumbar IVD degeneration in 129 working middle-aged men and showed that BMI ≥ 25 kg/m² increased the risk of lumbar IVD degeneration [12]. These authors excluded L1/2 and L5/S1 from their analysis and used one examiner to review all the available images.

One of the drawbacks of this study was related to the harvesting technique, which often sectioned the spine through the L5/S1 disc space reducing the amount of L5/S1 IVDs available for analysis to 80. This was especially evident when samples were analyzed by decade and there were no L5/S1 specimens in the 31–40 age range available for analysis.

In this study, IVD degeneration was influenced by ethnicity at L1/2, L2/3, L3/4, and L4/5 levels, but not at the L5/S1 level. Although IVD degeneration is multifactorial, genetics certainly plays a role [23]. The Tt and the tt genotypes of Taq I polymorphism of the vitamin D receptor gene have been associated with IVD degeneration [14,23,24]. This association was shown in a Finnish study examining 85 pairs of monozygotic twins between the ages of 39 and 69 years [24]. In a Japanese study examining 205 Japanese volunteers and patients between age 20 and 29 years, the Tt genotype was more frequently associated with multilevel disc disease, severe disc degeneration, and disc herniation than the TT genotype [14]. The frequency of this “risk t-allele” is significantly different between the three major ethnic populations, and is found in 8% of Asians, 31% of Africans, and 43% in Caucasians [25]. Gruber et al demonstrated a relationship between ethnicity and IVD cell proliferation, with advanced age and Middle Eastern ethnicity resulting in poorer proliferative ability of cultured cells [15]. We suspect that the lack of difference in grades of IVD degeneration between ethnicities at the L5/S1 level is a result of the high forces that this motion segment sees in all ethnic groups. The higher frequency of the “risk t-allele” in Caucasians may partially explain the higher IVD grades seen in this population in our study.

Conclusion

The rate of IVD degeneration in donors with no history of spine problems was highest at L5/S1, most likely due to the high forces seen at this motion segment. The relatively early degeneration at L5/S1 in all ethnicities needs further investigation. Other factors such as sagittal alignment, facet joint arthritis, and genetic predisposition play a role in IVD degeneration.

Key Points

The rate of IVD degeneration was highest at L5/S1.

The rate of IVD degeneration was higher at L5/S1 for donors younger than 40 than those older than 40.

Donors of African ethnicity had a lower rate of IVD degeneration when compared to Caucasians.

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Table 1

Donor Demographics

Total donors	433
Males	306
Females	127
Average Age Males	59.13+/-12.5
Average Age Females	61.02+/-10.6
Age Range	14–81
IVD analyzed	1712
Overweight	93
Normal weight	340
African Ethnicity	47
Asian Ethnicity	4
Caucasian Ethnicity	366
Hispanic Ethnicity	16

Table 2

Average Thompson Grade and Age by Spinal Level

Level	Mean Thompson Grade	Mean Age	Number of IVD
L1/2	2.79+/-0.85	60.3+/-11.7	401
L2/3	2.80+/-0.84	60.5+/-11.5	433
L3/4	2.86+/-0.81	60.4+/-11.5	435
L4/5	2.99+/-0.86	60.2+/-11.7	363
L5/S1	2.93+/-0.97	61.0+/-11.8	80

There was a statistically significant difference between L1/2 and L4/5 ($p<0.0001$)

There was a statistically significant difference between L2/3 and L4/5 ($p<0.0001$)

There was a statistically significant difference between L3/4 and L4/5 ($p<0.0001$)

There was a statistically significant difference between L4/5 and L5/S1 ($p<0.034$)

There was a statistically significant difference between L1/2 and L3/4 ($p=0.023$)

Table 3

Average Thompson Grade by Decade

Decade	N	Mean Thompson Grade	Std Dev	Std Err Mean	Lower 95%	Upper 95%
II	4	1.38	0.91	0.45	-0.06	2.84
III	6	1.83	0.54	0.22	1.26	2.40
IV	12	2.17	0.27	0.08	1.99	2.34
V	46	2.28	0.48	0.07	2.13	2.42
VI	129	2.72	0.56	0.04	2.63	2.82
VII	142	3.00	0.65	0.05	2.90	3.11
VIII	91	3.32	0.60	0.06	3.20	3.45

Table 4

Comparison in Thomson Grade between Decades Using Student-t

Decade (1)	Decade (2)	Difference in Mean Thomson Grade	Std Err Diff	Lower CL	Upper CL	p-Value
VIII	II	1.94	0.30	1.34	2.53	<0001*
VII	II	1.62	0.30	1.03	2.21	<0001*
VIII	III	1.49	0.24	1.00	1.98	<0001*
VI	II	1.34	0.30	0.74	1.93	<0001*
VII	III	1.17	0.24	0.68	1.66	<0001*
VIII	IV	1.15	0.18	0.80	1.51	<0001*
VIII	V	1.04	0.10	0.83	1.25	<0001*
VI	III	0.89	0.24	0.40	1.38	0.0003*
V	II	0.89	0.30	0.28	1.49	0.0041*
VII	IV	0.83	0.17	0.48	1.18	<0001*
IV	II	0.78	0.34	0.11	1.45	0.0225*
VII	V	0.72	0.10	0.53	0.92	<0001*
VIII	VI	0.59	0.08	0.44	0.75	<0001*
VI	IV	0.55	0.17	0.20	0.90	0.0019*
VI	V	0.44	0.10	0.24	0.64	<0001*
V	III	0.44	0.25	-0.05	0.95	0.0830
III	II	0.44	0.38	-0.30	1.19	0.2445
IV	III	0.33	0.29	-0.24	0.91	0.2553
VIII	VII	0.31	0.08	0.16	0.47	<0001*
VII	VI	0.27	0.07	0.13	0.42	0.0001*
V	IV	0.10	0.19	-0.26	0.48	0.5692

Table 5

Average Thompson Grade by Spinal Level and Decade

Level	10-20	21-30	31-40	41-50	51-60	61-70	71-80
L1/2	1.25+/- 0.5 (n=4)	1.91+/- 0.66 (n=12)	2.0+/- 0.0 (n=11)	2.21+/- 0.55 (n=39)	2.7+/- 0.83 (n=115)	2.87+/- 0.80 (n=135)	3.19+/- 0.79 (n=86)
L2/3	1.5+/- 1.0 (n=4)	2.0+/- 0.42 (n=12)	2.0+/- 0.0 (n=11)	2.11+/- 0.48 (n=42)	2.68+/- 0.78 (n=127)	2.90+/- 0.80 (n=144)	3.23+/- 0.74 (n=94)
L3/4	1.5+/- 1.0 (n=4)	2.25+/- 0.62 (n=12)	2.18+/- 0.4 (n=11)	2.22+/- 0.60 (n=42)	2.73+/- 0.72 (n=127)	2.95+/- 0.76 (n=144)	3.29+/- 0.79 (n=93)
L4/5	1.5+/- 1.0 (n=4)	2.25+/- 0.75 (n=12)	2.33+/- 0.5 (n=9)	2.41+/- 0.68 (n=33)	2.83+/- 0.79 (n=112)	3.16+/- 0.80 (n=120)	3.27+/- 0.87 (n=72)
L5/S1	1.00+/- 1.0 (n=1)	2.0+/- 1.41 (n=2)	(n=0)	2.22+/- 0.44 (n=9)	2.56+/- 0.79 (n=24)	3.13+/- 0.86 (n=23)	3.54+/- 0.96 (n=22)
	17	50	42	165	505	566	367

There was no statistically significant difference in Thompson grade between L1/2, L2/3, L3/4, L4/5, and L5/S1 for any decade.

Table 6

Regression Analysis of Rate of Intervertebral Disc Degeneration by Level and Age

Level	Rate of IVD Degeneration/Year in Donors 14–40 years old	Rate of IVD Degeneration/Year in Donors 41–80 years old	Number of IVD
L1/2	0.033(n=27)	0.031(n=404)	401
L2/3	0.021(n=27)	0.034* (n=406)	433
L3/4	0.031(n=27)	0.033 (n=405)	435
L4/5*	0.050(n=25)	0.027*(n=345)	363
L5/S1*	0.141(n=3)	0.043*(n=77)	80

The difference between L4/5 and L5/S1 was significant for both the 0–40 group and the 41–80 group ($p<0.05$). The difference between the 0–40 group and the 41–80 group was significant at L2/3, L4/5, and L5/S1 ($p<0.05$).

Table 7

Age, Sex, and Thompson Grade

Sex	N	Mean Age	Std Dev	Mean Thompson Grade	Std Dev
F	127	59.13	12.5	2.81	0.70
M	306	61.02	10.6	2.87	0.67

p>0.05

Table 8

Grade of Intervertebral Disc Degeneration by Sex and Level

Level	Thompson Grade in Males	Thompson Grade in Females	Number of IVD
L1/2	2.77 $\pm$ 0.83	2.71 $\pm$ 0.82	401
L2/3	2.81 $\pm$ 0.83	2.76 $\pm$ 0.81	433
L3/4	2.88 $\pm$ 0.8	2.79 $\pm$ 0.82	435
L4/5	2.99 $\pm$ 0.82	2.91 $\pm$ 0.94	363
L5/S1	2.92 $\pm$ 0.91	2.8 $\pm$ 1.10	80

Table 9

Ethnicity, Age, and Mean Thompson Grade

Ethnicity	N	Mean Age	Std Dev	Mean Thompson Grade	Std Dev	Std Err Mean	Lower 95%	Upper 95%
African	47	59.6	9.0	2.60	0.56	0.08	2.4	2.7
Asia	4	54.0	22.0	2.48	1.03	0.51	0.8	4.1
Caucasian	366	60.7	11.1	2.89	0.68	0.03	2.8	2.9
Hispanic	16	59.6	13.9	2.72	0.77	0.20	2.2	3.1

Table 10
Comparison between Ethnicities and Mean Thompson Grade

Ethnicity (1)	Ethnicity (2)	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
Caucasian	Asian	0.41	0.34	-0.26	1.08	0.23
Caucasian	African	0.28	0.10	0.070	0.50	0.0094*
Hispanic	Asian	0.24	0.38	-0.51	1.00	0.52
Caucasian	Hispanic	0.16	0.18	-0.19	0.53	0.37
African	Asian	0.12	0.35	-0.57	0.82	0.72
Hispanic	African	0.12	0.20	-0.29	0.53	0.56

p>0.05 for Age

Table 11

Grade of Intervertebral Disc Degeneration by Ethnicity and Level

Level	Thompson Grade in Caucasians	Thompson Grade in Africans
L1/2 *	2.80+/-0.82 (n=334)	2.54+/-0.84 (n=42)
L2/3 *	2.84 +/-0.84 (n=362)	2.54+/-0.70 (n=46)
L3/4 *	2.91+/-0.80 (n=361)	2.56+/-0.73 (n=46)
L4/5 *	3.01+/-0.86 (n=303)	2.65+/-0.62 (n=38)
L5/S1	2.98+/-0.97 (n=63)	2.50+/-0.70 (n=13)

* statistically significant difference (p<0.05)