The occurrence of anular tears and their relation to lifetime back pain history: A cadaveric study using barium sulfate discography
The Occurrence of Anular Tears and Their Relation to Lifetime Back Pain History: A Cadaveric Study Using Barium Sulfate Discography

Tapio Videman, MD, MSc,* and Markku Nurminen, DPH, PhD†

Study Design. The occurrence of anular tears and general disc degeneration of the lumbar spine was studied in relation to the lifetime frequency of back pain.

Summary of Background Data. Although anular tears and ruptures are common targets for diagnostic and therapeutic approaches, the relationship between disc findings and back pain has been weak or nonexistent.

Methods. The data comprised barium sulfate discograms of lumbar spine levels from 157 male cadavers. The extent of “anular tears” and “general disc degeneration” based on posterior-anterior and side views were evaluated separately using a 4-point scale. Lifetime history of back pain occurrence and work were obtained from the families of 86 cadavers. To assess whether the risk of back pain changed with the severity of findings or the level of disc, we applied trend tests and proportional-odds logistic models for occurrence data.

Results. In early adulthood, the risk of anular tears was 0.6 to 0.7, whereas at retirement age, tears were practically unavoidable. The risk of full anular tears with barium sulfate leaking (“leaking” tear) was estimated to be 0.10 and 0.35 among the men in the age groups of 20 to 49 and 50 to 59 years, respectively. The risk of “leaking” tears was greatest at the L5–S1 levels. There were less severe degenerative findings associated with sedentary occupation but no differences between driving and physically light and heavy occupations. Overall, the risk of any anular tears and any general degeneration as defined was similar. The frequency of back pain had a highly significant relation to the occurrence of tears (model-based $P = 0.0009$). With a “leaking” tear, the model-based estimate of the risk of frequent lifetime back pain was 0.42, with an “outer” tear the risk was 0.20, and with no tears or “inner” tears the risk was 0.10 (the observed prevalence was 0). The effect of occupational loading was of borderline significance ($P = 0.045$).

Conclusion. Anular degeneration of the lumbar discs appear earlier and are more clearly related to back pain than previously thought, most probably due to the better sensitivity of the BaSO₄ discography method to detect tears.

Key words: adolescence, anular tears, autopsy study, back pain, disc degeneration, discography, physical loading, occupation. Spine 2004;29:2668–2676

Among different phenomena in disc degeneration, anular tears and especially radial anular ruptures are common targets for diagnostic and therapeutic approaches, because the outer anulus is the only innervated structure of a healthy disc. For more than 70 years, anular ruptures have been the pathologic finding underlying disc herniations, but recently they have also been shown to have an important role in nerve root inflammation caused by exposure to substances within the nucleus pulposus. In addition, the ingrowth of granulation tissue into the nucleus pulposus, one likely mechanism resulting in back pain, may require full anular rupture.

A commonly held view is that repeated mechanical loading, usually work related, leads to disc degeneration. This explanation has been supported by the observation that the peak rate of sciatic pain distribution, a clinical sign associated with anular ruptures, occurs after about 20 years of working, or at about the age of 40 years. In the past 2 decades, however, several studies have reported that back problems are common even in childhood. Magnetic resonance imaging (MRI)-documented disc pathology in adolescence has also been reported to reach a risk of 0.35 among asymptomatic and 0.57 among symptomatic patients by the age of 20 years. The risk of disc pathology among asymptomatic 11 year olds was found to be 0.09 (Smith F, Jeffrey J, Porter RW, unpublished data). Signal intensity of the disc, adjusted for the signal intensity of cerebrospinal fluid, has been shown to change faster in the early years than in later adulthood in a population sample ranging in age from 9 to 77 years. In addition, in an autopsy study using histology, Boos et al verified tears in the anulus in a group of 11 to 16 year olds and degenerative findings in disc endplate cartilage even among children 3 to 10 years of age.

Overall, the risk of anular tears in published studies varies markedly. In a sample of 60 20-year-old to 50-year-old asymptomatic patients, 67% had disc protrusions, 33% had high signal intensity zones, and 18% had disc extrusions based on MRI. In another sample of 98 asymptomatic adults and 27 adults with back pain history, 27% had protrusions, whereas only 1% had extrusions. These discrepancies in results between similar
studies would most likely depend on the different examination methods or classification criteria used or both.

In a study of 33 patients by Osti et al., the risk of anular tears was 30% lower in MRI than in discography, although all discs with abnormal MRI had altered patterns of discography. In a cadaver study using MRI discography with contrast medium and anatomic inspection of the specimens as a reference, radial, transverse, and concentric anular tears were recorded in 100%, 57%, and 21% of discs, respectively.17

Because an anular tear can circulate 3-dimensionally, commonly ending at the vertebral rim, there is a challenge in identifying tears “from end to end” with methods based on 2-dimensional slices, such as macroscopy, histology, computed tomography (CT), or MRI. A thin string of low-density contrast medium used in vivo examinations can be missed even on CT. Forced injection of contrast medium could likely identify discs in which contrast medium clearly leaks outside the disc and its ligaments, as was shown by Southern et al., but smaller leaks are likely to be diluted and missed in vivo.18 Yet all current clinical methods will likely miss a portion of full anular ruptures and, in particular, smaller and older anular tears that may contain granulation tissue. In addition, it would not be realistic to use 5-level CT discograms in a large population study.

Due to these methodologic shortcomings, both the development and the appearance of anular tears and ruptures are unclear. Knowledge of when anular tears begin to appear, factors associated with their occurrence, and whether they relate to back pain history would provide new insights into the pathogenesis of disc degeneration and back pain and could be useful for primary prevention, which has so far failed.19 Probably the best available method for identifying radial tears and ruptures extending through the anulus would be discography performed by injecting the discs of cadaver spines under pressure with high-density contrast medium, such as barium sulfate (BaSO₄). Radiography would provide information about the distribution of BaSO₄ in the whole disc and possible “leaking.” However, tears extending from the outer part of the anulus but not through the inner anulus would be missed.

Our primary goal was to explore the occurrence rate of lumbar anular tears by age through BaSO₄ discography of the spines of cadavers. We expected that the true occurrence rate of anular tears is higher in all age groups than rates that have been published. An additional goal was to do extended analysis of lifetime back pain frequency (available from the families of a subset of cadavers) by discographic findings that have a theoretically different role in pain production. We hypothesized that tears reaching at most to the inner anulus would not be related to discogenic pain, that tears extending to but not beyond the outer anulus would have a weak relation, and that full anular ruptures or “leaking” tears would be highly related to discogenic pain. Further, we hypothesized that back pain coming from other structures than the disc would decrease possible relationships.

### Data and Methods

We had access to a database of BaSO₄ discograms of the 5 lumbar spine levels (L1–S1) from 157 male cadavers, which were selected by occupation, and they had to be employed before death and were below the mandatory retirement age of 65 years (the mean age was 52 years and the range 21–64). Exclusion criteria were chronic illness, hospitalization or infectious disease, and cancer. Most deaths in our subject matter were from cardiovascular complications. The discography was performed by inserting a 20-gauge needle from the anterior into the center of the disc using finger pressure. The end point was either resistance or, in case of leaking, no more than 5 mL of the contrast medium was injected. The lumbar spine was then x-rayed from posterior-anterior and lateral directions. Because some upper lumbar discs were missing and in some cases “leaking” discs had contaminated lumbar structures on other levels, we reduced the number of discograms used in the analyses to 53, 122, 138, 136, and 120 for the spine levels L1–L2, L2–L3, L3–L4, L4–L5, and L5–S1, respectively. Anular tears and general disc degeneration were evaluated separately from posterior-anterior and side views of discograms using BaSO₄. The discograms were classified according to how far the contrast medium reached from the nucleus as follows: no tear for an intact anulus; inner tear when the tear extended through the inner anulus to the middle of the anulus; outer tear when the tear extended from the inner to the outer anulus, but did not leak; and full anular rupture where the BaSO₄ was uncontained and leaked outside the disc (“leaking” tear) (Figure 1). Barium sulfate usually reached the anterior upper rim of the lower vertebra, but was not clearly “leaking” beyond the longitudinal ligament as happened in the posterolateral region of the discs.

General degeneration describes how much the contrast medium covers the disc and was classified as none, slight, moderate, and severe. In severe general degeneration, the contrast medium covered the disc up to but not beyond the outer anulus in both posterior-anterior and side views (Figure 1). The anular tear and general disc degeneration scores are highly correlated, but in rare cases identify anomalies such as slight general degeneration with a leaking tear or a disc with severe general degeneration but no leaking tear (Figure 1B). Because of a missing axial view, we did not have full topographic information of the discographic patterns. The classification used was applied in an earlier study that had different goals and used a set of 86 cadavers from the same database, for whom back pain histories had been obtained from the men’s families. The questions posed to the families were: “Did he have back pain? If so, how often?” The response alternatives were: “No back pain,” 38%; “Sometimes—less than once a year,” 26%; and “Often—at least once a year,” 36%. The lifetime risks of
back-related conditions were: frequent pain (at least once a year), 0.30, and disability lasting over 1 month, 0.08. Data on the physical demand of jobs held for at least 5 years were also used: 34% were classified as sedentary, 17% as light, 24% as professional driving, and 24% heavy.

The risk or probability of the occurrence of anular tears in the lumbar spine was estimated as an incidence proportion (ranging from 0 to 1) comparing the relative frequency of the observed tears in a given classification by age and disc level to the total number of discs. The probability of general disc degeneration was estimated similarly. To display the probability, classified by the level of intervertebral disc and the extent of the rupture, we fitted a smooth curve to the scatterplot data using a nonparametric regression function. We used the statistical S system function LOWESS, short for a locally weighted scatterplot smoother, with locally linear polynomial fits. This algorithm weights points that are inside a span of data so that nearby points get the most weight. The local fitting is used with a robustness feature that guards against distortion by statistical outliers (i.e., data points that lie far outside the estimated curve). The fitted LOWESS curves used all the data points and were banked by an aspect ratio (i.e., the height of the data divided by the width) of 1. The fits of the curves to the 4-variate data were acceptable in spite of very few numbers in some age groups under 45 years. The LOWESS curve provides more stable and realistic estimates of the probabilities than do arithmetic mean values.

In the graphical presentation of the probability of anular tears, where the unit of observation was a disc, the probabilities in the displays were estimated from the 157 cadavers with observations of 569 discs that are not statistically independent. This approach should be distinguished from the risk calculation in which the unit of observation was a cadaver.

To assess whether the risk of frequent back pain increased or decreased with the extent of the findings or the level of the disc, we used the exact Cochran-Armitage trend test for age-stratified data with an exact one-sided $P$ value as implemented in the program StatXact. Because it is inconceivable that anular tears could prevent the experience of back pain, the statistical testing of the null hypothesis—that anular tears do not cause back pain—against the alternative, one-sided hypothesis—that anular tears cause back pain—is legitimate. The same test was applied in the case of general disc degeneration. To test the hypothesis that the 4 occupational groups are identically distributed according the severity of anular tears and general disc degeneration, we used the exact linear-by-linear association test for a doubly ordered $4 \times 4$ contingency table with scores derived from the data.

Finally, we considered the probability of the frequency of back pain (never, sometimes, often) in relation to the severity of anular tears and the burden of occupational physical loading. Because the outcome is ordinaly scaled, we modeled these data using a proportional-odds logistic regression model as implemented in the MASS library in S-PLUS. Anular tear and occupational loading were also entered in the model as ordinal variates. Age was included as a continuous variate. The significance of terms was evaluated by deleting them stepwise one at a time from the model, and the significance was tested by a $\chi^2$ test, with a 2-sided $P$ value.

The approval for the collection of this database was provided by the Ethical Committee of the Institute of Occupational Health, Helsinki, Finland.

Results

For the 157 cadavers, the probability of any anular tear was very high at 0.76 (95% confidence interval [CI] 0.69–0.82), showing only a slight rise with age in the span from 21 to 64 years (Figure 2A). However, when differentiated by the severity of the tear, minor changes (inner tear) occurred in earlier years, whereas severe changes (outer and leaking tears) increased substantially.
Figure 2. A, a scatterplot of the probability of anular tear in the L1–S1 discs of the lumbar spine against age given the severity of the finding, with a fitted local regression curve. The data points are based on 785 discs. Age is grouped as follows: 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, and 60–64 years. B, a scatterplot of the probability of general degeneration in the L1–S1 discs of the lumbar spine against age given the severity of the finding, with a fitted local regression curve. The data points are based on 785 discs. Age is grouped as follows: 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, and 60–64 years.

Figure 3. A scatterplot of the probability of anular tear in the L1–S1 discs of the lumbar spine against age given the level of intervertebral disc, with a fitted local regression curve. The data points are based on 785 discs. Age is grouped as follows: 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, and 60–64 years.
The risk of inner tear decreased from 0.54 in the group aged 55 to 59 years to 0.24 in those aged 20 to 49 years. In contrast, in the same age groups, the risk of an outer tear increased from 0.05 to 0.26, and the risk of a leaking tear increased from 0.10 to 0.36. The severity of tears also depended partly on the disc level. Inner tears decreased from higher (L1/L2) to lower (L5/S1) discs, whereas outer and leaking tears increased (Figure 3). Also, if the severity of the annular tears was ignored, the trend in the probability for all the discs was remarkably uniform at 0.26 (95% CI 0.22–0.30) over the entire age range (Figure 4A).

The risk of general disc degeneration in the L1–S1 discs in patients aged 30 to 49 years was 0.71 to 0.75, whereas in those aged 50 to 59 years, the risk was 0.83 to 0.86 (Figure 2B). If the severity of the general disc degeneration was ignored, the trend in the probability for all discs was similarly uniform at 0.27 (95% CI 0.22–0.33) over the entire age range (Figure 4B). Overall, the probability of general disc degeneration was similar to that of annular tears; the correlation coefficients between the outcomes at the L2–L5 levels were from 0.75 to 0.82, but at the L1 level, there was no correlation.

In the subset of 86 cadavers with data on back pain and occupational physical loading, the increase in the severity of annular tears and general disc degeneration in L3–S1 discs was associated with increasing heaivness of work (exact one-sided $P = 0.0006$ and $P = 0.009$, respectively; age-adjusted). Most of the clear differences in leaking tears and severe general disc degeneration in L3–S1 discs were seen between sedentary and the 3 other groups (Table 1). When the cases were classified solely by worst tear and worst general degeneration, 60%, 65%, 79%, and 82% of sedentary, light, driving, and heavy groups had leaking tears, respectively (exact one-sided $P = 0.15$; age-adjusted), whereas 50%, 70%, 43%, and 75% of the same work classifications had severe general disc degeneration (exact one-sided $P = 0.04$; age-adjusted).

Under the proportional-odds model, the effects of annular tears, occupational loading, and age on the frequency of back pain, quantified in terms of $P$ values, were 0.0009, 0.045, and 0.4, respectively. This modeling result indicates convincingly that, of the 3 simultaneously considered risk factors, annular tears bore a highly significant relation to the frequency of back pain, whereas the effect of occupational loading, which was just statistically significant, was inferior to the effect of annular tears. The effect of age was not significant. The model-based risk estimates of back pain history indicate that the frequency of back pain had a trend relation to the occurrence of tears; the risk for frequent back pain was 0.42 (95% CI 0.15–0.70) with leaking tear, 0.20 (95% CI 0.0–0.40) with outer, and 0.10 (95% CI 0.0–0.19) with inner tears in a etiologic model (pain regressed

Table 1. The Proportion of Discs With Annular “Leaking” and “Severe General Disc Degeneration” of the L1–L3 and L3–S1 Lumbar Spine Discs in Four Occupational Groups

<table>
<thead>
<tr>
<th>Spine Level</th>
<th>Sedentary</th>
<th>Light</th>
<th>Driving</th>
<th>Heavy</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1–L3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaking tear</td>
<td>0.11</td>
<td>0.04</td>
<td>0.06</td>
<td>0.19</td>
</tr>
<tr>
<td>Severe degeneration</td>
<td>0.12</td>
<td>0.16</td>
<td>0.00</td>
<td>0.20</td>
</tr>
<tr>
<td>L3–S1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaking tear</td>
<td>0.24</td>
<td>0.52</td>
<td>0.44</td>
<td>0.45</td>
</tr>
<tr>
<td>Severe degeneration</td>
<td>0.25</td>
<td>0.40</td>
<td>0.27</td>
<td>0.44</td>
</tr>
</tbody>
</table>
by tear) (Table 2). In a diagnostic model (tear regressed by pain), obtained by the Bayes rule, the risk for at least one leaking anular tear in someone with a history of frequent back pain was 0.92, and without such a history it was 0.45. The risk trends for frequent back pain by occupational loading are similar for the “heavy” and “driving” categories (higher risk for pain) as well as for the “light” and “sedentary” categories (lower risk for pain) (Table 3).

Discussion

In this study, we used BaSO4 discography in cadaver material to explore theoretically and clinically relevant anular pathology and the pathogenesis of lumbar disc degeneration. In our earlier study based on 86 cadaver samples, we reported that aging seemed to have no effect on the risk of anular leaks. The effect of 10 years of aging as a term in a logistic regression analysis was not significant, although risk of anulus rupture was increased by 40%. The rather large scatter of the leaking annuli in all age groups (Figure 2A) may have hindered the effect to become significant in the parametric regression function has the advantage that it guards against distortion by outlying observations. The non-parametric curve gives a more incisive visual description of the broad nature of the relation as well as a perception of how the risk of rupture changes according to its extent and at different levels of disc.

The cause of death of these cadavers was dominantly from cardiovascular disease and its complications. If we assume that disc and vascular degeneration might have in part the same determinants as those for cardiovascular disease, it could lead to slightly higher occurrence rates of disc degeneration than in the general population, where only about 50% of mortality is due cardiovascular diseases.

Due to different examination methods and classification criteria, it is difficult to adequately compare our risk estimates with those found in earlier studies. Our occurrence rates were many times higher than those of Jensen et al13 based on MRI, but closer to those of Weishaupt et al14 among symptomatic patients, where one-third had high signal intensity zones, and 18% had disc extrusions, comparable to our outer anular tears and leaking tears. Powell et al showed that disc degeneration was present in over one-third of women aged 21 to 40 years.27 Considering that male discs are more degenerated than female discs at most ages based on macroscopic cadaver data and that our method for anular tears is sensitive, the occurrence rate of anular tears in our study is not unrealistic.28 Overall, the progression of anular pathology seems to be slow, but the severity of the findings in all age groups varied significantly between cadavers. The marked variation in discographic findings is similar to that seen in the lumbar spine MRIs, where a 69-year-old man could have fewer structural changes than a 35-year-old one.29 The additional effect of occupational loading in the adult years beyond the physical loading included in routine everyday living on anular tears based on BaSO4 discography assessed by MRI is concordant with the very modest effect of physical loading on overall disc degeneration.29

Due to missing discography data from younger age groups in the current study, we cannot determine precisely the age at which first anular tears appear. From our data, we do know that the youngest person, aged 21 years, already had inner tears at levels L1–L3. However, we cannot expect that the risk for any anular tears increases vertically from none to 0.5 to 0.6 in the age group of 30 to 34 years. Moreover, the substantial genetic influences in most degenerative disc findings suggest that those who are genetically predisposed develop disc pathology significantly earlier than the rest and that the role of occupational physical loading is modest in those disc degeneration parameters assessed by MRI.29 Thus, we can project the curve of any tears to predict that anular tears develop as early as adolescence. The risk of any tear can be as high as 0.50 or greater at the age of 20 years, with the most probable prediction being 0.65 (Figure 5). These predictions would also be supported by earlier results of degenerative signs seen in histologic examination of discs below the age of 10 years.13 However, it must be stated that the projection is very uncertain and is based on an extension of the LOWESS curve from 30 to 44 years to 20 years. The view that disc degeneration begins early in life is also concordant with the beginning of other degenerative processes, such as atherosclerosis, which has been documented in childhood.30,31

The associations between back pain and structural changes in discs have been weak or nonexistent in clini-

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**Table 2. Logistic Model-based Risk Estimates of Back Pain History by Severity of Anular Tears**

<table>
<thead>
<tr>
<th>Severity of Anular Tears</th>
<th>No Back Pain</th>
<th>Sometimes</th>
<th>Often</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner</td>
<td>0.75 (0.56–0.94)</td>
<td>0.16 (0.06–0.26)</td>
<td>0.10 (0.0–0.19)</td>
</tr>
<tr>
<td>Outer</td>
<td>0.55 (0.25–0.85)</td>
<td>0.25 (0.15–0.35)</td>
<td>0.20 (0.0–0.40)</td>
</tr>
<tr>
<td>Leaking</td>
<td>0.30 (0.05–0.54)</td>
<td>0.28 (0.25–0.31)</td>
<td>0.42 (0.15–0.70)</td>
</tr>
</tbody>
</table>

* Mean probability in the class (95% confidence intervals).

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**Table 3. Logistic Model-based Probability Estimates of Back Pain History in Four Occupational Groups**

<table>
<thead>
<tr>
<th>Occupational Group</th>
<th>No Back Pain</th>
<th>Sometimes</th>
<th>Often</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary</td>
<td>0.53 (0.23–0.84)</td>
<td>0.26 (0.13–0.38)</td>
<td>0.21 (0.16–0.27)</td>
</tr>
<tr>
<td>Light</td>
<td>0.57 (0.30–0.83)</td>
<td>0.25 (0.13–0.37)</td>
<td>0.19 (0.04–0.33)</td>
</tr>
<tr>
<td>Driving</td>
<td>0.24 (0.03–0.45)</td>
<td>0.27 (0.24–0.30)</td>
<td>0.49 (0.26–0.72)</td>
</tr>
<tr>
<td>Heavy</td>
<td>0.22 (0.08–0.37)</td>
<td>0.27 (0.24–0.31)</td>
<td>0.51 (0.33–0.68)</td>
</tr>
</tbody>
</table>

* Mean probability in the class (95% confidence intervals).
cal studies due to several obvious reasons. Primarily, structural changes are the sum of a lifetime progression in pathogenesis, but back pain is highly varying. Also, in addition to the unresolved methodologic challenges associated with measuring disc pathology and back pain, other causes of back pain are likely. However, possible inaccuracy of our pain (or anular) parameter cannot increase the relation with structural pathology. It could also be speculated that pain data from family members could filter less significant symptoms and reflect more chronic or severe lifetime back pain, or both.

Based on our knowledge of disc innervation and possible adverse reactions in innervated structures of and around the disc produced by substances from the nucleus, the relationship among anular leaking and no or inner tears with the risk of frequent lifetime back pain in this study were concordant with our alternative hypothesis. However, the finding that the model-based estimate of the risk of frequent back pain among those with an intact outer anulus was 0.10 (the observed prevalence was 0), whereas the risk was 0.42 when the anulus was fully ruptured and leaking after adjusting for age and occupational loading is new. The association between back pain and the severity of anular pathology appeared surprisingly clear. Our explanation for the results is that the discographic method using BaSO4, which can be used in autopsies, is more accurate than the methods and protocols used in earlier studies. Autopsies have provided the key to understanding many other diseases, yet spine pathology has not historically received such attention in autopsy studies. Based on experience from clinical pathology, the chance that discography would produce the leaks in anulus is practically nonexistent.

There were no clear differences among the light, driving, and heavy groups in respect to severe degenerative findings. These findings support recent results suggesting that driving does not damage the disc (Table 1).

In conclusion, more than half of the cadavers at the age of 20 to 34 years showed some degenerative anular findings, indicating that identifiable structural change within the lumbar discs begin in early adulthood or earlier. It follows that any primary preventive intervention related to spinal disorders would need to begin early in life. The finding that the risk of leaking anular tears in the lumbar discs increased from about 0.10 at 20 to 39 years to 0.35 at 50 to 59 years of age implies that pain-related disc pathology exists in one-third of middle-age men.

The results suggest an important role of the disc in back pain, which is plausible, although it has been questioned in the past. However, the results do not confirm the mechanism of pain, but full anular rupture is required that substances from the nucleus pulposus can expose nerve tissues and cause inflammation as well as for
ingrowth of granulation tissue into the nucleus pulposus, both likely causes of back pain. Significant false-negative rates obtained by clinical methods used to detect anular leaking in earlier studies may explain the differences observed in this study; namely, that there is a markedly high risk of anular pathology even at younger ages, and that there is a clearly stronger relation between leaking anulus and lifetime back pain than observed earlier.

Finally, we note that the findings of the present study are novel but still tentative, and consequently should be evaluated as instructed by Bacon: “Read not to contract and confute, nor to believe and take for granted, nor to find talk and discourse, but to weigh and consider.”

Key Points
- Identifiable structural changes of the lumbar disc likely begin in adolescence.
- There is a large variation in the occurrence of anular tears at all age groups.
- A full anular tear with leaking contrast medium is highly associated with the history of frequent back pain.
- Heavy physical loading has a minor effect on disc degeneration but is an exacerbating factor for back pain.
- Current diagnostic techniques using MRI may not be adequate to detect or fully distinguish ruptured or leaking anular tears.

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