A long-term outcome analysis of 984 surgically treated herniated lumbar discs

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This paper presents a long-term follow-up study of 984 patients operated on for a herniated lumbar disc between 1959 and 1991. It was possible to follow 98% of patients from the time of operation to the time of writing. The mean follow-up period was 10.8 years. The most common presenting complaint was back pain with sciatica in one leg; the most frequent neurological finding was impaired straight-leg raising. Myelography confirmed the diagnosis in 80% of patients, but more recently enhanced computerized tomography and magnetic resonance imaging have been the preferred studies. The operative procedure was either hemi-laminectomy or laminectomy with \( \times 3.5 \) magnification and fiberoptic lighting. Herniated lumbar discs involved L4-5 and L5-S1 with equal frequency (47%). The recurrence rate was 6%, one-third of which developed during the 1st year after operation. The complication rate was 4%; there were no intraoperative vascular or intestinal injuries. The Prolo Functional Economic Outcome Rating Scale was used to measure long-term outcome and the results were compared to those of Pappas, et al. Patients who did sedentary work and housewives had statistically higher total and economic Prolo scores (p < 0.01) than those who did strenuous work. The majority of patients with the “failed-back syndrome” had pending legal or Workers’ Compensation claims, or were at psychological risk for surgery. In 89% of patients the outcome was good — defined as a Prolo score of 8 in 10%, 9 in 19%, and 10 in 60%.

KEY WORDS • nucleus pulposus • lumbar spine • intervertebral disc • recurrence • grading systems • laminectomy

“Let nothing slip by you; the ordinary humdrum cases of the morning routine have been accurately described and pictured, but study each one separately as though it were new — so it is, so far as your special experience goes; and if the spirit of the student is in you the lesson will be there.”

— Sir William Osler

BECAUSE lumbar disc surgery is the most commonly performed neurosurgical procedure, considerable literature on this topic has evolved over the last 60 years. However, there are few long-term studies that describe the social and economic results in large numbers of patients.\(^6\),\(^10\),\(^14\) In a frequently cited monograph, Spangfort\(^23\) reviewed findings before and after lumbar disc surgery in 2504 patients with a short follow-up period. Until the recent introduction of the Functional Economic Outcome Rating Scale developed by Prolo, et al.,\(^19\) it was impossible to compare various surgical series because there has been no uniformity in reporting results. The present paper documents the functional and economic capacity of 984 patients followed for periods as long as 34 years, and can be compared with other studies by means of this outcome scale.

Clinical Material and Methods

Patient Population

Clinical information for 984 patients operated on between 1959 and 1991 was obtained by reviewing the office and hospital records of the Hospital of the University of Pennsylvania. There were 626 males (64%) and 358 females (36%), with an average age of 42 years (range 16 to 77 years). The average age of male patients was 41 years (range 18 to 77 years) and of female patients 43 years (range 16 to 77 years). Eight patients (0.8%) were less than 20 years of age and 42 patients (4%) were older than 64 years. Three hundred seventy-five patients (38%) did strenuous work, 461 (47%) were employed in sedentary occupations, and 148 (15%) were housewives. Strenuous work was defined as lifting, pushing, or pulling weights of 100 lb or
greater and frequent lifting and/or carrying weights up to 50 lb during an 8-hour workday. Sedentary work indicated lifting, pushing, or pulling weights up to 10 lb, occasionally lifting and/or carrying objects within this weight limit, and walking or standing for 2 hours in an 8-hour workday.

Operative Technique

All operations were performed by the author. The surgical procedure was either hemilaminectomy or laminectomy; spinal fusions were not performed for stabilization. After 1975, loupes with \( \times 3.5 \) magnification and fiberoptic lighting were used. The operative reports described whether the nucleus pulposus had herniated through the anulus fibrosus or if after a small incision it ruptured through a prominent budge of the anulus. If the nucleus pulposus had extruded into the extradural canal, its anatomical relationship to the nerve root was recorded. Patients with nerve root compression due to thickened ligamentum flavum, lateral osteophyte, or spinal stenosis were not included in this study. All patients were operated upon in the prone position under general anesthesia. Prophylactic antibiotics were given after 1979.

Follow-Up Methods

Follow-up evaluation was primarily via telephone interviews, office visits, or questionnaires. In addition, there were contacts with relatives, friends, and other treating physicians, inquiries at former places of employment, and access to the Medical Records Department of the Hospital of the University of Pennsylvania. Persistence of the investigator was facilitated by freedom from the time constraints of an ongoing practice. The telephone interviews and questionnaires were based on a specific set of questions posed by the Prolo scale. If patients considered their outcome to be poor, there was no lack of written or verbal candor, which minimized bias.

Prolo Functional Economic Outcome Rating Scale

The Prolo Functional Economic Rating Scale was used to determine outcome (Table 1). The total score represents the sum of the individual functional and economic scores. The outcome designation of poor was a total score of 5 or less, including “failed disc” or “decompensated back syndrome;” a moderate outcome was a score of 6 or 7, and a good outcome a score of 8 to 10, as suggested by Pappas, et al., for the purpose of standardization and convenient comparison between different studies.

Statistical Analysis

The SPSS mathematical program was used and the data were evaluated by the unpaired Student t-test. Significance was accepted at p less than 0.01. The z-test determined the difference of proportions in two populations.

Results

Follow-Up Data

Current follow-up information was obtained in 970 (98%) of 984 patients operated on between 1959 and 1991. The mean follow-up period was 10.8 years, and 494 patients (50%) were followed for 10 to 34 years. During the 34-year follow-up period, 79 patients (8%) died of unrelated causes; all were followed until the time of death.

Preoperative Neurological Complaints

All patients were interviewed and examined by the author. The most frequent neurological complaint was back pain with sciatic radiation in one leg, which occurred in 796 patients (81%). There were 98 patients (10%) who initially complained of back pain with radicular symptoms in both legs, and another 73 patients (7%) with unilateral sciatica only. Twelve patients (1%) had back pain without radicular symptoms, and two patients had pain in both legs without back pain. In addition, there were 721 patients (73%) whose symptoms were aggravated by coughing, sneezing, or an increase in intra-abdominal pressure. The mean duration of symptoms prior to surgery was 4.7 months, during which time a wide variety of nonoperative management techniques were used.

Preoperative Neurological Examination

The most common neurological finding was impaired straight-leg raising at 15°, or less; this was present in 746 patients (76%). This finding was most fre-
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quent when the disc herniation occurred at the L5–S1 level (37%), although it was observed in 34% of patients with disc herniation at L4–5. Contralateral leg pain with straight-leg raising was present in 19% of patients. An inability to flex the lumbar spine forward or laterally was noted in 83% (85%) of patients. An inability to stand prior to surgery. Inability to stand occurred with the same frequency whether the disc herniation was at the L4–5 or the L5–S1 level. No patient presented with paraplegia or paraparesis, and none had preoperative clinical bowel or bladder dysfunction.

A preoperative foot drop, loss of dorsiflexion of foot and toes to 2/5 strength or less, and eversion of the foot was found in 83% of patients (8%); in 50% of this group the herniated disc was located at L4–5. The mean preoperative duration of foot drop in patients who recovered from the deficit was 2.1 months and the mean postoperative recovery time was 3.0 months. Seven patients did not recover from foot drop; the mean preoperative duration of the deficit in this group was 1.57 months. There was no statistically significant difference between the mean preoperative symptom duration in these two groups. Three of the seven patients with a permanent foot drop had a myelographic block. In the 76 patients who recovered from the deficit, seven exhibited a myelographic block; in another seven the nucleus pulposus lay in the axilla of the nerve root.

Sensory loss was present in 377 patients (38%) and occurred with the same frequency in herniated discs located at L4–5 and at L5–S1. The knee jerk was absent or decreased in 222 patients (23%) when the disc herniation was at the L4–5 level, and the ankle jerk was absent or decreased in 49% of patients with a lesion at L5–S1. There were 352 patients (36%) with proximal motor weakness of 3/5 to 4/5 strength, and in this instance the disc herniation occurred at L4–5 or L5–S1 with the same frequency. Distal motor weakness was more common, being present in 582 patients (59%). This deficit resulted from a ruptured disc at L4–5 in 45% of patients and at L5–S1 in 48%.

Preoperative Trauma

There were 562 patients (57%) who sustained preoperative trauma; of this group, 283 (50%) were engaged in strenuous work, 228 (41%) had sedentary occupations, and 53 (9%) were housewives. Trauma as the cause of a herniated disc was most frequent in the 35- to 40-year age group. Of the 562 patients who had a history of injury, there was a tear in the anulus fibrosus in 391 patients (70%), although only 39 (7%) exhibited a myelographic block.

Initial Level and Description of Disc Herniation

Lumbar disc herniation occurred with the same frequency (47%) at L4–5 and L5–S1 and was rare at other levels. In 80 patients with a myelographic block, more than one-half were found at L4–5 (Table 2). There were 677 patients (69%) in whom the nucleus pulposus had ruptured through the anulus fibrosus, and this occurred with equal frequency at L4–5 and L5–S1. There were 79 instances (8%) in which a fragment of nucleus pulposus lay in the axilla of the nerve root; this finding was most frequent at L5–S1.

Recurrence of Lumbar Disc Herniation

During the 34-year follow-up period, there were 60 recurrences (6%) of lumbar disc herniation (Table 3). The mean time of recurrence was 4.3 years (range 2 weeks to 21 years). Recurrence developed most commonly during the 1st year after operation, when 19 patients required a second operation (Fig. 1). Thirty patients (50%) had a recurrence at the same level and on the same side as the original disc herniation. Another 16 patients had recurrence of disc herniation at a different level but on the same side as the initial operation. If patients with recurrence had originally been operated on by another surgeon, the time of recurrence and the anatomical level and side were confirmed by operative notes or by verbal or written reports from the previous surgeon. There were seven patients with recurrences of disc herniation who required stabilization procedures.
Preoperative Neuroradiological Findings

Neuroradiological studies were performed in all patients to confirm the diagnosis. Myelography was conducted in 786 patients (80%), of whom 27 (3%) had equivocal results. These patients were treated before the availability of computerized tomography (CT) and magnetic resonance (MR) imaging techniques and were operated on based on the neurological examination. Another 198 patients (20%) had enhanced CT-myelographic studies, MR images, or CT scans, all of which were positive and correlated with the surgical findings. Eighty patients (8%) exhibited a myelographic block, 42 of which occurred at the L4–5 level (Table 2).

Postoperative Complications

Postoperative complications developed in 40 patients (4%) (Table 4). The most common complication was a wound infection, which occurred in 25 patients (3%). Two infections were found below the fascia; all others were superficial. Paraparesis developed in one patient with deep wound infection; this resolved soon after surgery, but there was accompanying bowel and bladder dysfunction that did not resolve until 6 years after surgery. Six patients had postoperative cerebrospinal fluid (CSF) leaks that were closed surgically without resulting neurological deficit. Three patients developed postoperative paraplegia, two of whom had large disc herniation at L2–3. Prolonged intraoperative retraction and manipulation of nerve roots resulted in edema of the cauda equina in these two patients, but they recovered within 9 months. In the third patient paraplegia resulted from an extradural hematoma; the motor deficit resolved within 3 months. Each of these three patients had a total Prolo score of 9 at last contact. General complications included pulmonary emboli in two patients, myocardial infarction in one, a perforated diverticulum in one, and a lung abscess in one; none of these problems was fatal. There were no hospital deaths among the 984 patients, although one patient died from coronary artery occlusion 3 days after hospital discharge. There were no intraoperative intestinal perforations, damage to the ureter, or abdominal vascular injuries.

Surgical Outcome

Measured by the Prolo Functional Economic Outcome Rating Scale,19 the mean economic outcome score for all patients was 4.6 and the mean functional outcome score was 4.5. The mean total score was 9.1. These scores reflect outcomes over a mean follow-up period of 10.8 years. If the 34 years of follow-up review were divided into 5-year periods, there was no statistically significant difference from these three means. Total Prolo scores of 8, 9, and 10 were considered a good result,19 and the percentage of the 984 patients in each of these categories was 10%, 19%, and 60%, respectively. The percentage of patients in all outcome categories is shown in Table 5.

Prolo scores were also assigned to types of occupation (Table 6). The 375 patients (38%) who performed strenuous work had both mean economic and functional scores of 4.5. Of this group, a good result was present in 85%; 11% had a score of 8, 20% a score of 9, and 54% a score of 10. Among the 461 patients (47%) employed in sedentary work, the mean economic and functional scores were both 4.7. The distribution of a good result was 11% with a score of 8, 20% with a score of 9, and 63% with a score of 10. Another 148 patients (15%) were housewives. Their mean functional and economic scores were both around 4.6. Good results among housewives included 7% with a score of 8, 19% with a score of 9, and 63% with a score of 10. Patients who were housewives or did sedentary work had statistically higher total and economic Prolo scores than those who did strenuous work (p < 0.01).

Total Prolo scores of 5 or less were considered a poor result;19 there were 30 such patients (3%) (Table 7). More than one-half of these patients had pending legal or Workers’ Compensation claims at the time of their
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TABLE 5

Outcome in 984 patients surgically treated for a herniated lumbar disc.

<table>
<thead>
<tr>
<th>Economic Scale</th>
<th>Functional Scale</th>
<th>Total Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>Percent</td>
<td>Score</td>
</tr>
<tr>
<td>1</td>
<td>0.1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>15.2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>3.9</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>79.1</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>6.0</td>
<td>10</td>
</tr>
</tbody>
</table>

* Scores based on the Functional Economic Outcome Rating Scale of Prolo, et al.16

operation, and 10 were men who did strenuous work. In another six patients with persistent postoperative radiculopathy, three were operated on for recurrence of a herniated disc and failed to return to gainful employment. There were five patients at psychological risk or addicted to medication before operation. Postoperative degenerative changes in the lumbar spine were the cause of persistent low-back pain and postural limitation in three patients who had a poor outcome. In this group of patients with total Prolo scores of 5 or less there were none whose functional or economic capacities were limited by a neurological deficit.

Discussion

Literature Overview of “Follow-Up” Review After Disc Surgery

There is a wide discrepancy in the definition of “late results” and “long-term follow-up study.” Weber22 considered 4 years to be an adequate period for final postoperative evaluation, while other authors reported “late results” at 5 to 7 years6,22 and 10 to 17 years.6,13 The monograph of Jochheim, et al.,13 summarized surgical results in 13,452 patients reported by 35 authors and presented 107 surgical patients from their clinic, but made no comment on periods of follow-up evaluation.

Spangfort's statement, on page 55 of his report,22 that “information about the course of sciatic pain, as reported in medical records, later than 6 months after operation was discarded” represents a casual interpretation of long-term results. If Spangfort's criteria for follow-up evaluation were used in the present study, 75% of patients with a recurrent herniated disc would have been overlooked and reported as “relieved of sciatica and back pain.” The current study has also demonstrated that 4 years is an inadequate period in which to detect disc recurrences; if 4 years had been deemed sufficient in this series, 33% of patients who required a second operation would have been overlooked. With the exception of the Veterans Administration study by Nashold and Hrbuce16 and the report of Spurling and Grantham,24 the occasional follow-up study of more than 10 years6,14 had a response rate of 65% or less. By contrast, the present study provided follow-up information in 98% of patients over a mean of 10.8 years, which permitted an accurate assessment of the time and frequency of recurrence.

The longest follow-up period reported in the literature concerned one of the first patients operated on by William Jason Mixter in 1932; Frymoyer and Donaghy1 documented a 50-year follow-up review by Mixter, who commented to one of the authors, “K.N. is of particular interest as he is the first patient in whom a ruptured intervertebral disc was recognized as such and as the cause of sciatica. Therefore he is the man who started all this damn trouble.”

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Cases</th>
<th>Economic Score</th>
<th>Functional Score</th>
<th>Mean Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>strenuous work</td>
<td>375 (38%)</td>
<td>4.47 ± 0.05†</td>
<td>4.46 ± 0.04</td>
<td>8.94 ± 0.08‡</td>
</tr>
<tr>
<td>sedentary work</td>
<td>461 (47%)</td>
<td>4.68 ± 0.03</td>
<td>4.65 ± 0.03</td>
<td>9.34 ± 0.05</td>
</tr>
<tr>
<td>housewife</td>
<td>148 (15%)</td>
<td>4.69 ± 0.06</td>
<td>4.56 ± 0.06</td>
<td>9.25 ± 0.11</td>
</tr>
</tbody>
</table>

* Scores based on the Functional Economic Outcome Rating Scale of Prolo, et al.19 Data are expressed as mean ± standard error of the mean.
† Differences between economic scores for those engaged in strenuous work and the housewife and sedentary groups were significant: p < 0.01.
‡ Differences between total scores for those engaged in strenuous work and the housewife and sedentary groups were significant: p < 0.01.

**TABLE 7**

Analysis of total outcome scores of 5 or less

<table>
<thead>
<tr>
<th>Reason or Contributing Factor for Poor Outcome</th>
<th>Type of Occupation</th>
<th>Sex (M:F)</th>
<th>Total Cases</th>
<th>Mean Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workers’ Compensation</td>
<td>strenuous work</td>
<td>5:1</td>
<td>6</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>sedentary work</td>
<td>0:2</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>housewife</td>
<td>0:0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>legal claims</td>
<td>strenuous work</td>
<td>5:1</td>
<td>6</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>sedentary work</td>
<td>1:0</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>housewife</td>
<td>0:1</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>radiculopathy</td>
<td>strenuous work</td>
<td>1:2</td>
<td>3</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>sedentary work</td>
<td>2:1</td>
<td>3</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>housewife</td>
<td>0:0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>psychological risk or addiction</td>
<td>strenuous work</td>
<td>1:1</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>sedentary work</td>
<td>0:2</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>housewife</td>
<td>0:1</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>degenerative spine changes</td>
<td>strenuous work</td>
<td>1:0</td>
<td>1</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>sedentary work</td>
<td>0:1</td>
<td>1</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>housewife</td>
<td>0:1</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>totals</td>
<td></td>
<td>16:14</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

* Poor result, “failed disc,” or “decompensated back syndrome.”
Scores based on the Functional Economic Outcome Rating Scale of Prolo, et al.19
Comparison With the Study of Pappas, et al.

Pappas, et al.,18 reported 654 surgically treated patients followed for a mean of 9.7 months, with a recurrence rate of 11%. Although the patients in the current study were followed for a mean of 10.8 years, the percentage of all patients in the "good outcome" category (total Prolo score 8 to 10 as defined by Pappas, et al.) was moderately higher in the present series: 89% compared to 80% in the Pappas report. This difference probably reflects the high early recurrence rate in the Pappas study, as well as the number of surgeons who performed operations and differences in the type of operation. (There is an error in Pappas' Table 3: the percentage of patients with a total score of 10 should read "26.9%" rather than "10.9%", which enhances the outcome score.)

A parallel may be seen between the patients who suffered industrial accidents in the series of Pappas, et al.,18 and the strenuous-work group in the present study. It would appear that the mean total Prolo score of 8.94 in patients engaged in strenuous work is modestly higher than the mean score of 7.62 in the industrial category of Pappas, et al. This may result from the difference in follow-up periods, during which the patients in the latter group might be expected to return to work through rehabilitation and retraining, with a subsequent improvement in Prolo score. In the Pappas study, 61% of patients identified as having no industrial or legal claims had a total mean Prolo score of 8.61 and probably correspond to the group of 461 patients (47%) who performed sedentary work and had a total mean score of 9.34 as well as to housewives in whom the total mean score was 9.25. It would appear that there is a significant difference in these scores between the two studies. If Table 3 of the Pappas paper is compared to Table 5 of this one, there are 33% more patients in this report with a total score of 10. This variance may be due to the large number of economic scores of 5 assigned to older housewives and patients who continued to perform sedentary work after retirement.

A comparison of recurrence rates of 11% and 6% in these two studies, with different sample sizes and a wide variance in follow-up period, can be made by the z-test (z = 3.57, p < 0.001). It can be assumed that an 11% recurrence rate in 654 patients with a mean follow-up period of 9.7 months would not decrease with a longer follow-up period.

Surgical Failure, Neurological Recovery, and Complications

The causes of failure after disc surgery in this study agree with those of other authors:3,9,10,15 legal and Workers' Compensation claims were the most frequent deterrents to a good functional and economic outcome. Patients who are at psychological risk, those addicted to medication and/or opiates, and those with persistent postoperative radiculopathies or degenerative changes in the lumbar spine fail to have a good long-term outcome4,5 and should be treated by noninterventional methods at a pain and rehabilitation center according to the guidelines of Rosomoff and colleagues20,21 and Long, et al.13

The neurological history, examination, and confirmatory neuroradiological studies were the indications for operation in this series, and followed the criteria of other large studies.12,23 Reversal of postoperative neurological deficits, including three patients with postoperative paraplegia in this report, has been detailed by others.1 However, few studies other than that by Andersson and Carlsson1 have specifically addressed recovery from preoperative foot drop. These authors excluded the interval prior to surgery, rapidity of onset, operative findings, and patient age as causes that influence prognosis. In the present study three of the seven patients whose foot drop was irreversible had a myelographic block, which suggested that root compression may be a factor in recovery.

A conservative approach to the amount of disc tissue removed was followed in this series of patients, but the recurrence rate was comparable to that in other reports.10,14,22 Spangfort23 considered the degree of disc herniation to be the single most important factor in obtaining a good result. His contention is supported by the current study, because the nucleus pulposus had ruptured through the annulus in 70% of patients, which facilitated removal of disc tissue without aggressive exploration of the disc interspace. Recurrence of disc herniation is clearly preferable to potentially fatal abdominal, intestinal, or vascular injuries. With more frequent use of noninvasive neuroradiological techniques, postoperative CSF leaks can be avoided, but postoperative wound infections remain a problem. However, the incidence of wound infection in this study was lower than reported in comparable series18,23 and did not occur after the use of prophylactic antibiotics was instituted, although their role remains controversial.12

Conclusions

1. To evaluate adequately the result of surgery for herniated lumbar discs, the follow-up period should exceed the 4 years commonly suggested as adequate in the literature. If a 4-year follow-up period had been deemed sufficient in the present series, one-third of patients with recurrence would have been overlooked.

2. Of the 984 patients in this series, 970 (98%) were followed for a mean period of 10.8 years. Based on the Functional Economic Outcome Rating Scale of Prolo, et al.,19 89% of all patients had good outcomes (Prolo scores of 8, 9, or 10).

3. The recurrence rate was 6%, with one-third of herniations recurring in the 1st year after operation. The mean time of recurrence was 4.3 years (range 2 weeks to 21 years).

4. A postoperative complication rate of 4% is attainable, with wound infection being the major component. Operative injury to abdominal structures can be avoided by limiting removal of disc material at interspace depths beyond proper visualization.
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