A novel surgical treatment of lumbar disc herniation in patients with long-standing degenerative disc disease

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Object. In patients with long-standing lumbar degenerative disc disease (DDD) conventional surgical therapy of a herniated disc may worsen back pain due to further destabilization of the affected motion segment. In recent years, total-disc arthroplasty has been introduced to treat DDD while maintaining segmental mobility. To the best of the authors’ knowledge, this is the first report involving lumbar disc herniation and long-standing DDD submitted to combined anterior microdiscectomy with sequestrectomy and total-disc arthroplasty.

Methods. Fourteen patients with long-standing DDD and a recently herniated disc underwent total anterior lumbar microdiscectomy, with removal of the herniated disc, and total-disc arthroplasty. There were nine women and five men whose mean age was 39.6 years (range 22–56 years) in whom back and leg pain had been present for a mean of 75.4 (range 9–360) and 9.4 (range 0.33–36) months, respectively. Thirteen patients underwent L5–S1 and one underwent L4–5 surgery. In all cases the procedure and the postoperative courses were uneventful. After a mean follow-up period of 12.5 months (range 3.9–21.1 months), outcome was excellent in 11 and good in three patients.

Conclusions. The aforementioned surgical treatment of a recently herniated lumbar disc in patients with long-standing DDD yielded very favorable early results.

KEY WORDS • lumbar spine • degenerative disc disease • disc herniation • total-disc arthroplasty

The first description of lumbar disc herniations as an etiological factor in lumbar radiculopathy was reported by Mixter and Barr in 1934. Based on the literature, approximately 2 to 4% of all patients presenting with a lumbar disc herniation require surgical treatment. Surgical techniques have evolved from macroscopic discectomy to the gold standard of microsurgical treatment that involves a minimally invasive approach. With an overall success rate of 80 to 95%, after lumbar microdiscectomy there remains an important cohort of individuals with a failed–back surgery syndrome because of instability of the operated motion segment, eventually requiring internal fixation and fusion.

After having successfully treated patients with lumbar DDD by performing total–prosthetic disc replacement, we have begun extending this modality to patients with discogenic low-back pain due to long-lasting DDD who present with a recently herniated disc. It is well known that most of these patients will continue to complain of low-back pain if they undergo classic microdiscectomy and deterioration may even occur in secondary to further postdiscectomy destabilization. We describe treatment involving anterior microdiscectomy and sequestrectomy combined with total disc arthroplasty for this specific subgroup of patients.

Clinical Material and Methods

Patient Population

This study involves 14 (nine women and five men) patients whose mean age was 40 years (range 22–56.1 years). All patients suffered from long-standing lumbar discogenic pain due to DDD prior to disc herniation; in all cases there were radiculopathic signs and symptoms resistant to conservative treatment (Table 1). Special attention was paid to a lumbar pain pattern occurring and/or worsening during forward lumbar flexion as an indicator of pain evolving from the anterior weight-bearing axis (that is, the disc). Psychosocial or medicolegal issues were not involved, and no patient received Workers’ Compensation before or after surgery.

Radiological/Neuroimaging Assessment

All patients were referred to us after undergoing MR imaging, which revealed a large disc herniation, nerve root compression, and advanced DDD of the affected motion segment (Fig. 1). We paid special attention to the presence or absence of facet joint arthrosis and the DSH. Facet joint arthrosis was expected in cases in which there was radiological evidence of joint surface irregularities.
### TABLE 1

Summary of demographic, clinical, and operative data obtained in 14 patients undergoing total-disc arthroplasty for lumbar disc herniation and long-standing DDD*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>BMI (kg/m²)†</th>
<th>Preop Duration (mos)</th>
<th>Preop VAS Score‡</th>
<th>Affected Segment</th>
<th>Complications</th>
<th>LOS (days)</th>
<th>Postop VAS Score‡</th>
<th>Duration of FU (mos)</th>
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<tr>
<td>1</td>
<td>27, M</td>
<td>27.08</td>
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<td>4</td>
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<td>none</td>
<td>10</td>
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<td>2</td>
<td>45, F</td>
<td>21.30</td>
<td>36</td>
<td>36</td>
<td>8.1</td>
<td>L5–S1</td>
<td>none</td>
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<td>0</td>
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<td>27.61</td>
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<td>28.39</td>
<td>180</td>
<td>1</td>
<td>6.1</td>
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<td>radicular pain for 2 days</td>
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<td>7.9</td>
<td>L5–S1</td>
<td>none</td>
<td>7</td>
<td>0</td>
</tr>
</tbody>
</table>

| min      | 22       | 20.25        | 9                    | 0.33             | 4.7             | L4–5 in 1   | 6          | 0                 | 0                   | 3.9                 |
| max      | 56       | 31.22        | 360                  | 36               | 9.7             | L5–S1 in 13 | 14         | 3.8               | 1.5                 | 21.1                |
| mean ± SEM | 39.6 ± 10.2 | 24.83 ± 3.54 | 75.4 ± 97.5 | 9.4 ± 11.8 | 7.9 ± 1.3 | 6.9 ± 1.8 | 9.4 ± 2.0 | 1.4 ± 1.4 | 0.3 ± 0.6 | 12.5 ± 4.6 |
| median   | 40.5     | 24.41        | 36                   | 5                | 8.1             | 7.7          | 9.5        | 1.1               | 0                   | 13                  |

* BMI = body mass index; FU = follow up; LOS = length of stay; SEM = standard error of the mean; VAS = visual analog scale.
† Body mass index = weight in kilograms divided by square of body height in meters.
‡ Huskisson Visual Analogue Scale (0 = no pain, 10 = worst pain). See the article by Huskisson.
§ See text for definitions.
|| Comparison of VAS values by using the paired Student t-test (p < 0.05 considered to be statistically significant) before and after operation was performed.
and/or presence of a joint effusion. A loss of more than two thirds of the DSH was an exclusion criterion for total-disc arthroplasty because, in our experience, the prosthesis would not be functional because of excessive ligamentotaxis of the shrunken musculoligamentous apparatus of the motion segment. In each patient, we referred to a normally hydrated lumbar disc as a measure for physiological DSH. Dynamic lumbar extension–flexion radiography was performed to rule out major segmental instability.

**Indication for Surgery**

Anterior microdiscectomy and artificial disc–based arthroplasty were reserved for patients with disc herniation who suffered from long-lasting discogenic pain prior to the appearance of compressive radiculopathy. Patients in whom DDD led to mainly facet joint–producing pain (that is, pain generated and/or worsened by hyperextension and lateral bending of the lumbar spine) or who presented with other concomitant spinal diseases were excluded. In summary, the following inclusion and exclusion criteria were applied: DDD with long-standing low-back pain and compressive radiculopathy with: 1) pain generator within the anterior weight-bearing axis (the disc); 2) absence of facet joint arthrosis and/or facet-producing pain; 3) preserved DSH one third or more of the normal value; and 4) absence of major segmental instability on dynamic radiographic studies. Exclusion criteria included the following: DDD with long-standing low-back pain and compressive radiculopathy with: 1) pain generator in the facet joints; 2) the presence of facet arthrosis; 3) DSH loss of more than two thirds of the physiological value; and 4) the presence of major segmental instability on dynamic radiographic studies.

**Surgical Technique and Postoperative Measures**

The gastrointestinal tract is completely washed. After induction of general anesthesia, the patient is placed supine with the legs abducted and slightly lowered. A urethral catheter is introduced. Hyperlordosis of the lumbosacral junction is produced by bending the operating table and by using an inflatable bag that is placed beneath the patient’s low-back region. As reported elsewhere, we perform a left pararectal lower abdominal incision, open the rectal fascia, and dissect the transverse fascia caudal to the linea arcuata. Thereafter, we choose the extraperitoneal route to the lumbosacral spine by reflecting the peritoneal sac to the right side. The latter permits exposure of the ureter and the iliac vessels after blunt dissection. Retraction of the major vessels exposes the anterior longitudinal ligament and the intervertebral disc. As is the case in the well-known anterior approach to cervical herniated discs, discectomy is performed. It is important to remove both the nucleus pulposus and the anulus fibrosus as completely as possible. This can be difficult, mainly in the area of the lateral aspects of the anulus; however, additional cutting of the lateral anulus significantly improves mobility of the segment in these instances. By these measures adequate intervertebral mobility is obtained to allow physiological functioning of the prosthesis. Microsurgical techniques are mandatory to open the posterior longitudinal ligament to avoid neural injury and to search for dislocated disc fragments (we use the OPMI Pro Magis microscope [Carl Zeiss, Oberkochen, Germany]). Peridural vein bleeding can be safely controlled using this anterior approach. Thereafter, the total-disc prosthesis is implanted following a standardized operative procedure. The definite position of the prosthesis is fluoroscopically controlled in anteroposterior and lateral orientations. In all patients the operations were performed by the senior author (T.M.M.).

Postoperatively, normal food intake is resumed as soon as physiological peristalsis is noted. The patient is allowed to walk within the first 24 hours. There is no need for a

![Fig. 1. Case 4. Left: Sagittal T2-weighted MR image of the lumbar spine. There is significant herniation of the L5–S1 disc, reduced intervertebral distance, a “black disc” appearance because of dehydration and Modic sign because of long-standing dysfunction of the motion segment. Right: Axial T2-weighted MR image revealing the L5–S1 disc herniation with right-sided nerve root compression.](image)
jacket orthosis, and the sitting position is allowed. Because manipulation of major vessels is considered to put the patient at a higher risk for postoperative thrombosis formation, the patient him/herself administers subcutaneous low-molecular heparin for 1 month. Radiological examinations are performed after 6 and 12 weeks.

The Implant

We use the ProDisc II endoprosthesis (Synthes, Stratec Medical, Oberdorf, Switzerland). The device has a modular design concept. It consists of two forged cobalt-chrome–alloy plates. Each of them has a keel that anchors in the adjacent vertebral endplates for primary stability. The plasma-sprayed titanium surfaces of those plates enable osteointegration through its porosity and thus guarantees secondary stability. Physiological range of motion is obtained by introduction of an ultra–high molecular weight polyethylene core between the large surface plates. The core is constructed following a ball-and-socket joint principle and is permanently fixed on the lower plate by using a locking fit mechanism.

The implant is available in several sizes, which differ in the angle of lordosis, the height of the device (DSH), and the dimension of the plates. The prosthesis should restore the normal DSH, normal size of the neural foramen, normal function of facet joints, normal segmental stability, and restore the segment’s normal range of motion in all three axes. Axial compression is possible but limited and absorbed by the polyethylene core.

Evaluation of Results

The criteria for the evaluation of the results have been previously reported. Briefly, we used the following categories: excellent (normal working capacity in previous or comparable activity; no or only occasional residual pain), good (normal working capacity in previous or comparable activity; mild residual low back pain or lower-limb dysesthesia), satisfactory (reduced working capability; working in less heavy activity; and residual low back pain and lower-limb pain), moderate (incapable of work; low-back and lower-limb pain slightly improved), and poor (incapable of work; pain unchanged or worse).

Results

Table 1 provides a summary of demographic, clinical, and operative data. The mean durations of low-back and radicular pain before surgery were 75.4 and 9.4 months, respectively. There were no major intra- or postoperative complications. The mean operative duration was 120 minutes and mean blood loss was 300 ml. Excellent results were obtained in 11 patients and good results in three. The mean follow-up duration was 12.5 months (range 3.9–21.1 months).

Illustrative Case

Case 4

This otherwise healthy 45-year-old man had suffered from discogenic low-back pain since he was 15 years old. In addition to the deep-seated low-back pain that worsened during lumbar flexion, he complained of right-sided sciatica that was unresponsive to conservative measures for 10 weeks. There was a positive straight leg raising test at 45° and sensory loss in the area of the S-1 dermatome as well as a missing ipsilateral ankle jerk. He had no facet joint–based pain (that is, no pain generation in hyperextension or forced lateral bending of the lumbar spine). Magnetic resonance imaging revealed a black disc at the L4–5 level, which could have been additionally involved in pain generation, a large right-sided L5–S1 disc herniation, advanced DDD with moderate loss of DSH, and no facet joint arthrosis (Fig. 1). The lower L-5 endplate exhibited irregularities and an epichondral edema; however, we focused on the surgical treatment of the L5–S1 segment because of the MR imaging signs of active degenerative disc destabilization at that site and the high likelihood that the pain arose from the now-ruptured/herniated disc. Microdiscectomy, sequestrectomy, and disc arthroplasty were performed via the anterior approach. In the early postoperative period, the patient continued to complain of leg pain. Myelography as well as CT scanning investigations demonstrated the correct positioning of the implant and no neural compression (Fig. 2). After 2 days the patient fully recovered from radicular pain, which had most probably been caused by increased tension of the irritated nerve root after artificial disc implantation. The postoperative course was uneventful and the patient resumed work 3 months postoperatively. Low-back pain and radicular pain completely resolved.

Discussion

The notion of replacing the intervertebral disc with an implantable physiologically functioning device is an old goal in medicine. Finally, after many innovative ideas, the development of different devices, and after many dashed hopes and setbacks, we now have such prostheses at our disposal (for example, the ProDisc II, Link SB Charité III, and Maverick disc systems). After having gained experience with the anterior approach and microsurgical exploration of the posterior aspect of the intervertebral space and spinal canal in ProDisc II implantation procedures it became evident to our senior author (T.M.M.) that lumbar disc herniations could also be excised anteriorly.

Therefore, after April 2002, all 14 patients with long-standing discogenic pain due to DDD and a new disc herniation were able to undergo anterior microdiscectomy and prosthesis implantation. Another 270 patients underwent standard posterior microdiscectomy during the same period. Based on these figures, we believe that only approximately 4.9% of patients elected for surgical treatment because of their herniated lumbar disc are now possible candidates for arthroplasty.

We expect a lower incidence of the dreaded problems that may occur after conventional microdiscectomy alone; it is of particular interest that total discectomy eliminates the possibility of recurrent herniations and that the prosthesis restores stability, DSH, physiological motion, and normal facet joint function of the affected segment. In contrast, conventional microdiscectomy alone is associated with a herniation recurrence rate of approximately 5%3,4,19 and, calculated over a lifetime, with an even higher incidence of instability of the treated motion segment, requiring internal fixation.2,8,10
In our experience with the 14 patients and in another 18 cases in which arthroplasty was performed for discogenic low-back pain, we learned that the condition of the zygapophysial joints must be properly assessed. Facet joint arthrosis is probably the most significant contraindication for this procedure because the prosthesis reconstructs only the anterior portion of a lumbar motion segment, leaving the posterior articulating elements untreated. The anterior approach allows treatment of the majority of common disc herniations except far dislocated fragments. Epidural venous bleeding can be controlled using bipolar coagulation and/or temporary tamponade.

To our knowledge, there is only one report and one abstract available in the literature in which authors report long-term outcomes and one study in which investigators describe intermediate results after ProDisc-based arthroplasty. These articles and other contributions (Charité III), however, are focused on the treatment of low-back pain; there exist no published series involving arthroplasty-treated patients with a concomitant disc herniation. To date, the incidence of potential (late-onset) problems after arthroplasty can only be estimated. In our series there were no cases of extrusion, subsidence, debris wear, or fracture of the prosthesis. Likewise vascular or visceral lacerations, retrograde ejaculation, incisional hernia, infection, and significant hematoma formation were absent. One individual experienced self-remitting radicular pain for 2 days after surgery, probably secondary to increased nerve root tension due to the restoration of DSH.

Based on the aforementioned pros and cons, we believe that lumbar total-disc arthroplasty for long-standing DDD associated with a recent disc herniation is a valuable procedure that offers significant potential for further dissemination despite its increased operative and technical demands. Whether the increased initial costs, compared with classic microdiscectomy, will be outweighed by a reduced need for subsequent surgeries and by patients’ earlier return-to-work status remains to be shown by examination of long-term data.

Because of the small number of patients fulfilling the inclusion criteria for anterior microdiscectomy and arthroplasty (in the present series 14 [4.9%] of 284 requiring surgical treatment for lumbar disc herniations) there was no control group (that is, patients undergoing conventional microdiscectomy). Therefore, it is difficult to analyze our data in more detail. At the present time, however, significant patient cohorts for randomized controlled studies can only be obtained in a multicenter setting with the collaboration of a greater number of neurosurgeons already familiar with the anterior approach to the lumbar spine. Additionally, more patients and a longer follow-up period are required for definitive evaluation of the method.

References


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