Percutaneous lumbar spine fusion

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Since the introduction of percutaneous nucleotomy at Balgrist in 1979, a stepwise growing concept for the treatment of different forms of lumbar disc affections evolved. Four years before, in 1975, Hijikata (1) had published in Japan for the first time about this minimally invasive percutaneous alternative for the treatment of lumbar disc herniation. The original procedure, performed from one side with small calibrated cannulas made some difficulty to get sufficient decompression in the posterior range of the intervertebral discs. So a biportal approach using somewhat larger sized cannulas was developed in 1980/81. In 1982, after further modifications of the instrumentation, for the first time the complementary introduction of a modified arthroscope became possible in order to control the intradiscal manipulations (12). By this helpful complement, later also approved by other authors (2) and some further instrumental improvements, the range of application of percutaneous nucleotomy with discoscopy became standardized (10, 11); so the reoperation rate could be reduced from over 50% in the year 1980 to less than 10% in the year 1991 (6). In the first ten years, the percutaneous nucleotomy with discoscopy markedly impressed also by its its minimal invasivity against musculoligamentary and neurologic structures (4). So it is well to understand, why this sparing approach was soon further investigated also for the treatment of segmental malfunction. In 1988, the introduction of the percutaneous fusion with temporary percutaneous pedicular fixation gave raise to a new field in percutaneous lumbar disc treatment that since then has been stepwise standardized (3, 6, 10).

Technical evolution

After several years of experience with the percutaneous approach for contained disc herniation first steps to percutaneous intervertebral restabilization were realized already in 1986/87. Several instruments were conceived in order to get more radical preparation of the adjacent vertebral plates. In 1988 an adapted set of instruments then made possible deeply spongious abrasion of the vertebral plates for local bony ingrowth of autologous bone grafts. The posterolateral percutaneous approach avoids considerable damage to the functionally stabilizing musculoligamentary structures; moreover, also for this indication, the percutaneous approach avoids mechanical irritation of the epidural space and so optimally prevents often cumbersome peridural scar formation. Since its introduction in 1988, the indication for this percutaneous interbody fusion were strictly limited to monosegmental instabilities. These may be of degenerative origin, cases with spondylolysis, patients with postdiscotomy monosegmental dysfunction, or as mild, nonerosive forms of inflammatory segment collapse. In any case, free epidural sequesters still remain excluded for this technique. So preoperative screening includes also a contrast-discomanometry study that is routinely completed with a "discoscan." Minor foraminal stenosis in presence of degenerative protrusion is not a basic contra-indication. The discogenous thrust then is reduced by the percutaneous subligamentary discharge and the foramina are somewhat enlarged by the segmental distraction obtained with the preoperatively already placed external pedicular external fixation device (8). The screening of monosegmental dysfunction for operative therapy is one of the most challenging tasks beside of the selection of the appropriated surgical technique. Subsequent to patient's anamnesis and clinical findings, the native radiographs with segmental interbody narrowing and increased range of motion in functional radiographs give the first pattern. Also in these cases, conservative therapies with active lumbar stabilization, eventually with complementary elastic lumbar bandage are to be exhausted at least for 8–12 weeks. In case of insufficient effect, a more rigid external fixation with a probatory cast brace is applied for at least 2 weeks. When so successful, now a percutaneous external pedicular fixator is applied. This has to confirm the relevant clinical effects of the monosegmental fixation with additional segmental distraction, realignment and correction of intervertebral lordosis. When under such conditions and functional activity of the patient, full relief of symptoms is obtained, the percutaneous interbody fusion can be

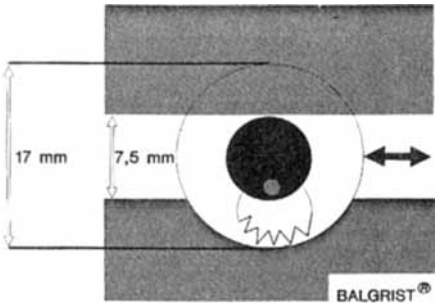

Figure 1. Drawing of our excentrically abrasive cutter introduced in the cannula (black). Its denticulated head rotating on an excentrical axis reaches som 4–5 mm laterally of the cannula and so deeply abrades the vertebral plates.

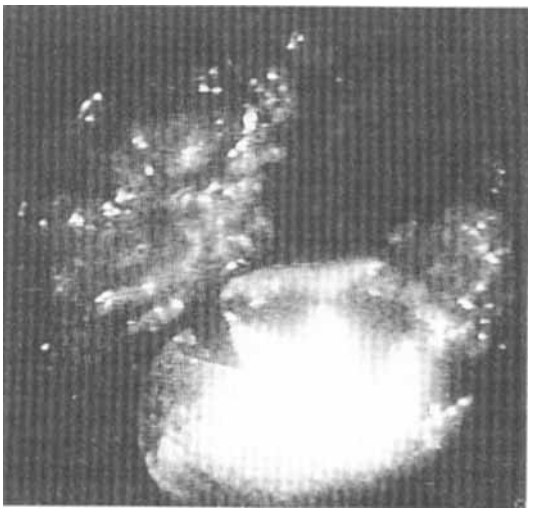

Figure 2. Discoscopic control of the intervertebral preparation: the denticulated head of the cutter can be recognized eroding the vertebral plates down to the spongious bone. By tilting the guide cannula some 70% of the vertebral surface can be reached also in the central concave zone.

performed preserving the successful interbody position by means of the remaining external pedicular fixator. Routinely, the external fixator remains for 3 months. In special cases, e.g. with perifusional monosegmental degeneration, at the end of the percutaneous interbody procedure, the external fixator can be switched to an internal subcutaneous fixation for a longer period, still respecting the musculoligamentar apparatus.

Operative technique. A determining step of every type of interbody fusion remains the preparation of the adjacent vertebral plates. As we established with our preliminary experience in 1986/1987, without deep opening of the cortico-cartilagineous transition, solid interbody fusion cannot be achieved (3, 9). So also for percutaneous fusion best possible abrasion of the corticospongious transition of the vertebral plates is mandatory. This aim, since 1988, can be attained under discoscopic control by use of our standardized bilateral working-cannulas (11). Their diameter of 7 mm corresponds approximately to the height of the distracted intervertebral space. The abrasion of the plates then has to ground into the often degeneratively sclerotic vertebral bone. So considerable forces has to be transmitted laterally to the axis of the cannula. This can be reached by a specially developed eccentrically abrasive milling cutter that reaches about 5–7 mm depth to each side of the cannula (Figure 1). With such a large mechanical exposure (≥60%) of the bleeding spongious bone of the vertebral bodies (Figure 2), optimal conditions for bony ingrowth of the subsequently impacted autologous bone grafts can be reached.

In the practical procedure, as the first step of percutaneous interbody fusion, the external pedicular fixator will be put in place under general anaesthesia. Intraoperatively we strive already for optimal interbody distraction and/or realignment. With this interbody correction the patient is mobilized the same day without restriction of physical activity. In the following 2 to 3 days, whenever necessary, the correcting effect of the external fixator can further be modified until patient's most comfortable position is reached. Stable clinical success during 24 hours of active mobilization confirms the indication for the complementary second operative step, the percutaneous interbody fusion. This step, comparable in its operative approach to the percutaneous nucleotomy with discoscopy, is performed in prone position with unchanged external fixation. The cannulas are positioned from each side pointing now somewhat more to the center of the intervertebral space, in order to reach the maximal possible surface of the plates. To prevent possible bending during wedge-like impaction in the degenerative altered space, the walls of the cannulas are somewhat stronger than the ones used for decompressive nucleotomy. So when full restitution of intervertebral height has not been completely realized by the external pedicular fixator, further interbody opening can be reached with these distractive wedge cannulas. The tip design of the cannulas is conceived with a prismatic grind that, stepwise overslipping each cannula by the next caliber, smoothly penetrates the anulus fibrosus without cutting effect. So the crossed annular fibers are just temporarily stretched and after the procedure can realign themselves. So a kind of "inborn" containment for the autologous bone graft is maintained that prevents accidental backfall of bony fragments outside of the anulus in the extraforaminal area with potential mechanical irritation of the root. As soon as the work-

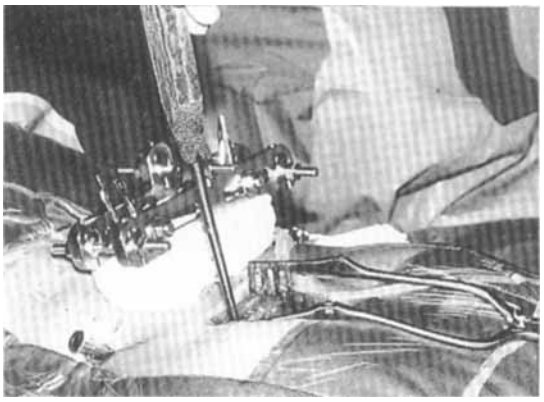

Figure 3. Intraoperative site: After preparation of the end-plates, fresh autologous bone is taken from the posterior iliac crest. The external fixator does not handicap the biportal cannular approach some 9–11 cm lateral of the midline.

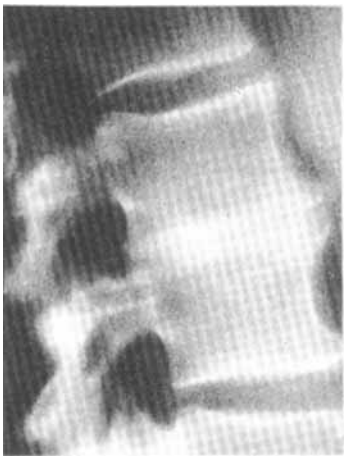

Figure 4. Lateral tomography 3,5 years after percutaneous intervertebral fusion at L1–2. A large intervertebral bony fusion is achieved. The patient is asymptomatic. At the L2 pedicle, more than at L!, some reactive sclerosis at the site of the former Schanz-screws can be recognized.

ing 7-mm cannula is put in place, the degenerative altered and often already fragmented discal tissue can be progressively removed. For this job adapted rongeurs and suction-punches are engaged. Some posteromedial and ventral disc rests towards the anulus fibrosus, since 1990, are further shrunk and denaturalized with topic Holmium-Yag-laser (2100 nm) application under discoscopic control (5). This can help to eliminate best possible the osteoinhibitive activity of residual disc tissue. When deep spongious preparation of the vertebral body with the eccentrically abrasive cutter is then accomplished and documented also in fluoroscopy. Fresh autologous bone chips, harvested directly from the iliac crest (Figure 3), are immediately reimpacted through the cannulas from both sides. Best homogenous interbody filling is obtained by means of adapted impactors and again by slight tilting motion of the cannulas during the stepwise impaction. The postoperative management starts with patients mobilization right in the evening of the day of the interbody intervention. The physical activities are increased while an isometric physiotherapeutic program is absolved during the first postoperative week. With ongoing wound healing at the two cannular entry points and the 5 cm skin incision above the iliac crest, the sutures are removed and a protective, fenestrated cast brace is applied. The main aim of this brace is shielding of the percutaneous fixator. With this protection the patient is discharged and can move around without hooking up even lying in his standard bed. The periodic desinfection of the pintracts remains under the control of the family doctor. Routinely a prophylaxis with trimetoprim-sulphomethoxazole is given in the first 6 weeks. After removal of the pedicular fixation at 12 weeks, a light flexible corset is given for smoothly lumbar remobilization associated to an active muscular stabilizing program. So a progressive reintegration in a normal way of life is soon achieved.

Results

Between October 1988 and January 1991 a percutaneous interbody fusion was performed in 33 patients; 21 women and 12 men. The interventions were localized between the first lumbar vertebra and the sacrum; 24 cases were operated on the level L4/5. The mean age at the intervention was 46 years. The indications included monosegmental instability of which degenerative in 16 cases, postoperative in 8 cases, spondylolysis in 6 cases and postinflammatory collapse in 3 cases. The follow-up was 22 (8–45) months after percutaneous interbody fusion. In 5 cases of the early series, we noticed an early reabsorption of the interbody grafts, so that three of them later had a conventional reintervention with posterolateral interbody fusion and internal pedicular fixation. In another patient, the graft only became integrated caudally, so that he could not get away from his lumbar brace. Six of the patients with radiographic consolidation nevertheless had to reduce their professional activity. A radiographic interbody consolidation was obtained in 28 cases (Figure 4.). The primary gain of segmental distraction was maintained to at least 70% in 18 cases. A relative lost of initial gain in distraction of 30–50%

is evident in 6 cases. Nevertheless, in the 28/33 cases (84%) with solid fusion, there was no significant correlation between functional tolerance of the lumbar spine and the finally maintained percentage of segmental distraction. The external pedicular fixation was accepted by the patients and their socioeconomic surroundings without specific problems. In 2 cases, a temporary pin tract irritation was successfully managed with intensified local care and short period of antibiotics. In younger and more active patients, we noticed some temporary muscular contractions and "pinning" in the area of the former Schanz-screw after stressing physical activities, lasting over several weeks after removal of the fixator. We consider that as due to the local adhesions after muscular transfixation. An important advantage of this minimal invasive technique, beside the facilitated functional rehabilitation, is that no metallic implant remains that might bother e.g. CT- or MRI-studies or has to be removed later on with another damage to the posterior muscular apparatus. Moreover, this technique of spondylodesis is routinely performed without any blood transfusion, which favor economy and respects increasing patients concern about possible risks of transfusion related contaminations (13). The overall operation time with 2.5–3 hours is competitive with conventional open surgery. Further long-term studies will have to investigate whether the functional gain for the musculoligamentar compensation of the adjacent vertebral segments pays also in longer absence of supra/sub-fusional degeneration.

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