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Optimal minimally traumatic approach for the SB Charité™ Artificial Disc

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Abstract The skin incisions and minimally traumatic approaches required for the optimal dissection of the intervertebral space and thereby for the correct implantation of the LINK® SB Charité™ Artificial Disc are described.

Keywords Skin incision · Approach · Double level

Introduction

Modern surgery aims at minimally traumatic approaches that bear the smallest possible risks. Patients expect surgery to exclude complications and produce a cosmetically acceptable scar. These objectives for surgery also apply to the minimally invasive approach used during implantation of the LINK® SB Charité™ Artificial Disc, which is described in this paper.

Preparation for surgery

The SB Charité™ Disc is implanted via an anterior retroperitoneal approach. The patient is placed supine on a level operating table. An operating table that can be adjusted during the operation to place the patient in hyper- or hypolordosis is preferred. Where the intervertebral space is extremely narrow or where bisegmental implantation is planned, such a table ensures that there is sufficient space for impacting the prosthesis.

Before antimicrobial preparation of the patient's skin, one should determine whether placing the C-arm at the appropriate angle will later permit intraoperative radiographs of the affected segment in a true anteroposterior

(AP) projection. The surgeon consults the AP radiograph to determine the topography of the affected disc in relation to the iliac crest, which usually is partially imaged. On the sagittal and transverse magnetic resonance (MR) images, the surgeon evaluates the abnormal findings that correlate with the patient's complaints and clinical symptoms, and inspects the level that will undergo surgery.

Variations of skin incisions

The LINK® SB Charité™ Artificial Disc can replace the entire lumbar disc in any of the segments from L2-3 through to the pre-sacral motion segment. The prosthesis with the greatest possible surface area should always be implanted. First and foremost, this requires choosing the optimum site for the skin incision. The incision for monosegmental implantation normally ranges between 5 cm and 7 cm, depending on the patient's body size and the thickness of the subcutaneous layer. For bisegmental implantation in two adjacent segments, the skin incision is approximately 8–9 cm long.

The surgeon traces the planned incision from the AP radiograph directly onto the patient and, after palpating the iliac crest, places this incision so that the affected L4-5

Fig. 1 Variations of the skin incisions. The *solid line* indicates the preferred incision

or L5-S1 segment lies directly in the middle of a skin incision carried from superior to inferior. When operating on the L2-3 or L3-4 segments, the skin incision is extended distally to gain distal access to the retroperitoneal space. Alternatively, when operating on the L2-3 or L3-4 segments or in patients who have undergone previous surgery, one may follow a modified procedure after exposing the posterior rectus sheath (see below). Of course, the position of the skin incision may also be determined on a lateral fluoroscopic image, where the surgeon simultaneously marks the skin.

Figure 1 shows the various options for making the skin incision. Pfannenstiel's incision is only suitable for the pre-sacral segment. We favour a median longitudinal incision along the linea alba inferior to the umbilicus. Depending on the affected level, the incision may be extended superiorly around the umbilicus. Alternatively, one may choose to make a straight or slightly curved transverse incision inferior to the umbilicus and directly anterior to the affected segment. The curved incision more closely follows the skin cleavage lines and may be expected to produce the most inconspicuous, cosmetically acceptable scar.

Surgical approach

After the skin incision is made, the subcutaneous tissue superficial to the linea alba is dissected longitudinally. In patients undergoing their first anterior spinal procedure, we expose the linea alba and then continue with a left lateral blunt dissection to expose the medial region of the anterior rectus sheath. This sheath is then incised longitudinally, approximately along the medial margin of the mus-

cle belly of the left rectus. Now the entire muscle belly is bluntly dissected laterally to the left as far as the junction between the anterior rectus sheath and posterior rectus sheath. Mobilizing the muscle belly may occasionally require dividing some of the medial tendinous intersections of the rectus abdominis.

The inferior margin of the posterior rectus sheath is exposed with the finger near its lateral junction with the anterior sheath. Then the peritoneum and visceral sac are carefully bluntly dissected medially and slightly superiorly away from the posterior aspect of the posterior rectus sheath. Taking care to protect the peritoneum, a longitudinal incision is made in the posterior sheath. The length of this incision depends on the affected segment. It is often not necessary to incise the posterior sheath for an implantation at L5-S1.

When implanting a prosthesis at L2-3 or L3-4, it is not necessary to expose the inferior margin of the posterior sheath. The posterior sheath can be slightly lifted directly adjacent to the lateral junction of the two sheaths with two blunt forceps and then carefully incised longitudinally. This immediately exposes the peritoneum, which, together with the visceral sac, is then mobilized off the posterior sheath and retracted medially. Now it is possible to gradually incise the posterior sheath longitudinally and continue on through the retroperitoneal fat tissue. This dissection is also successful where previous retroperitoneal surgery makes it impossible to expose the inferior margin of the posterior sheath and gain access to the retroperitoneum.

Further dissection in the deeper posterior planes is performed directly through the retroperitoneal fat tissue using blunt swabs or finger dissection. One should not dissect too far left and lateral through the retroperitoneal fat and connective tissue, as this increases the distance to the affected segment. To reach the affected segment directly, it is advisable to palpate the patient's iliac crest from time to time for better orientation and to avoid carrying the dissection too far inferiorly. After penetrating the retroperitoneal tissue, one can use the psoas muscle as a landmark. After it is reached, blunt dissection is continued to the right as far as the lumbar spine. Occasionally, the ureter will be visible (it typically will contract when palpated); it is always retracted to the right with the peritoneum.

In patients who have had previous retroperitoneal surgery in the left lower abdomen, the retroperitoneal approach may be made through the right lower abdomen. A transperitoneal approach can be chosen when a retroperitoneal approach in a previous procedure has caused adherence of fascial planes. In men, one should be aware of the risk of injury to the superior hypogastric plexus in the approach to the pre-sacral disc space, which could result in retrograde ejaculation.

Approach to L5-S1

After the sacral promontory has been identified by palpation, the dissection is continued with small swabs as far as the bifurcation of the major vessels. The tissue immediately superficial to the L5-S1 intervertebral disc is dissected off the disc toward both sides and superiorly to expose the median sacral artery and vein that course longitudinally across the L5-S1 disc. The number, position, and diameter of these vessels are highly variable. After sufficient exposure has been obtained, the medial sacral vessels are ligated and divided. Do not use cauterization in this area in male patients.

Further dissection is carried first to the left and then to the right to achieve the maximum possible lateral exposure of the disc. Special care should be taken to preserve the left and right common iliac vessels. Therefore, blunt dissection is performed with small swabs, beginning on the superior sacrum and extending to about 2 cm distal to the inferior margin of the intervertebral disc, and then laterally to the left and right. This makes it easier to mobilize the major vessels at the level of and superior to the intervertebral disc.

The surgeon begins the vascular dissection by bluntly mobilizing the left common iliac vein with small swabs and then the right common iliac artery together with the right common iliac vein that lies deep to it. All of these vessels are retracted laterally and occasionally slightly superiorly. The dissection should be carried to where the anterior surface merges with the lateral surface of the last lumbar vertebral body. Now four sharp Hohmann retractors or 3-mm Steinmann pins can be impacted into the adjacent vertebral bodies at a distance of approximately 1 cm to the superior and inferior margins of the disc. These retractors or pins are impacted nearly parallel to the vertebral endplates.

Each of the Hohmann retractors is placed such that its broad surface lies parallel to the course of the adjacent major vessels, taking care to ensure a broad area of contact between instrument and vessel to reduce the risk of thrombosis. If it hasn't been verified yet, the surgeon should check that the vertebral level is correct by fluoroscopy in the lateral view. If Hohmann retractors or Steinmann pins have not been impacted, a needle should be inserted into intervertebral disc L5-S1 to mark the site.

The intervertebral disc and anterior longitudinal ligament are vertically incised in the centre, and superior and inferior horizontal incisions are made close to the respective vertebral bodies. The two parts of the incised "H" shape of the annulus fibrosus are reflected laterally to the left and right like French windows to protect the vascular structures, and retaining sutures are passed through the raised flaps. Alternatively the flaps may be held with mosquito clamps. When the annulus fibrosus is later closed, the suture knot should lie between the major vessels.

Approach to L4-5 through L2-3

When implanting a prosthesis at L4-5, the surgeon, after first exposing the psoas muscle and digitally palpating the sacral promontory, exposes the lateral region of the L4-5 intervertebral disc directly at the medial margin of the left psoas by blunt dissection using small swabs. Usually, the sympathetic trunk is mobilized and partially dissected in the process. After identifying the intervertebral disc, which will appear as a prominent white structure in contrast to the vertebral body, one should verify proper location by fluoroscopy in the lateral view with a needle inserted into the disc.

The purpose of further dissection is to mobilize the major vessels, especially the left common iliac vein as far as its junction with the inferior vena cava, and to retract them as far laterally and to the right as possible without inducing vascular injury. Therefore, one first attempts to identify the left ascending lumbar vein, which lies directly on the vertebral body and communicates directly with the left common iliac vein. However, it is not possible to identify this vessel in every patient.

Where indicated, the left ascending lumbar vein is ligated and divided at a sufficient distance from the left common iliac vein. Ligation of this vein will be necessary where the surgeon finds the left ascending lumbar vein in the superior third of the L5 vertebral body or even at the level of the L4-5 disc. Occasionally, several small lumbar veins communicating with the left common iliac vein will be found in the superior portion of the L5 vertebral body. To prevent avulsion of these vessels from the left common iliac vein when that vessel is mobilized, they should be ligated and divided.

Then the soft tissue on the L4 vertebral body is mobilized from left to right, laterally, by blunt dissection in order to mobilize the major vessels for placement of retractors superior to the L4-5 disc space. Occasionally the lumbar vein and artery coursing transversely close to the vertebral body will have to be ligated and divided to allow sufficient mobilization of the major vessels to the right and lateral at the level of the disc. Using small swabs, one now carefully dissects the left common iliac vein anterior to the L5 vertebral body, proceeding laterally from left to right to where the anterior aspect of the L5 vertebral body and the L4-5 disc merges with the lateral aspect. Occasionally, venous bleeding from a small vessel in the L5 vertebral body will occur. This bleeding should be controlled by electrocautery or bone wax, taking care to protect the major vessels. Once the vessels have been sufficiently mobilized, a sharp Hohmann retractor or a 3-mm Steinmann pin is impacted into the L5 vertebra on the right. Then additional retractors or pins are impacted into L4 on the right, L4 on the left, and finally into L5 on the left if desired.

Dissection at the L3-4 and L2-3 intervertebral discs is performed in a similar manner. Our experience has shown

that no problems are to be expected with the left renal vessels, which lie further superiorly. Compared with the L4-5 and L5-S1 segments, the vascular anatomy and dissection at L3-4 or L2-3 are usually far easier to master. In most cases, it will only be necessary to ligate and divide segmental lumbar arteries and veins.

The intervertebral disc and the anterior longitudinal ligament at the L4-5, L3-4, and L2-3 levels are incised vertically at a left lateral location, and superior and inferior horizontal incisions are made close to the respective vertebral bodies. When the annulus fibrosus is later closed, the suture knot should lie in a left lateral position to avoid contact with a major blood vessel.

Double-level approach

In a bisegmental operation with implantation of prostheses in segments L4-5 and L5-S1, it is best to dissect L5-S1 and implant the prosthesis at this level first. However, where the L4-5 intervertebral space is particularly narrow in comparison to L5-S1, the prosthesis should be implanted at the L4-5 level first. Where both affected levels are narrow and bisegmental implantation appears difficult, we recommend first completing the entire dissection

of both levels before deciding which level should be treated first. The surgeon should implant the first prosthesis at the level that is narrower or more difficult due to the vascular anatomy. Usually the Hohmann retractors or Steinmann pins can be easily reinserted into the existing holes in the vertebral bodies after changing levels.

When levels L3-4 (or L2-3) and L4-5 are to receive implants, we recommend first implanting the prosthesis at L4-5, as the vascular dissection is usually more difficult at this level. When implants are to be placed at levels L3-4 (or L2-3) and L5-S1, one may complete the dissection of the disc spaces at both levels with the Hohmann retractors or Steinmann pins left in place and then decide where to implant the first prosthesis on the basis of how easily the respective intervertebral spaces can be distracted. Adjusting the operating table to induce lumbar hyperlordosis will facilitate initial insertion of the prosthesis. Final insertion should, however, be performed with the operating table level, to ensure that the prosthesis is implanted in a sufficiently posterior position.

The described skin incisions and minimally traumatic approaches are a prerequisite for the optimal dissection of the intervertebral space and thereby for the correct implantation of the LINK® SB Charité™ Artificial Disc.