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REVIEW ARTICLE

Infection and revision strategies in total disc arthroplasty

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Abstract
Purpose Our aim was to revise the different strategies for treating an infected disc arthroplasty.
Methods Despite recognition that disc replacement may reduce the incidence of adjacent-segment disease, the risk of potential complications associated with primary and revision total disc arthroplasty has diminished surgeon enthusiasm for the procedure. We performed a literature review of the different revision strategies for an infected disc arthroplasty.
Results The need for revision of lumbar total disc arthroplasty has been reported in a number of prospective, randomised trials (level I or II evidence). Suboptimal patient selection and/or surgical technique accounted for the majority of failed disc arthroplasties. Revision procedures include posterior stabilisation or anterior extraction and conversion to arthrodesis. The risk of injury to the great vessels and retroperitoneal structures is greater during revision than primary procedures. The use of a distant lateral, or transpsoas, approach to the anterior column may reduce these adverse events. Also, the use of adhesion barriers has been shown to reduce adhesions in abdominal and pelvic surgery and may be of benefit in revision disc arthroplasty.
Conclusion This review article provides an update on the various treatments for infected lumbar disc prosthesis and the different surgical approaches used in these difficult cases. It also describes potential options to avoid complications associated with the revision surgical approach.

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Introduction

Disc replacement arthroplasty is as effective as spinal fusion for treating single- or two-level lumbar degenerative disc disease [19–21], providing pain relief, maintaining segmental motion, and limiting adjacent-segment degeneration that occurs following fusion [4–7]. Anterior revision procedures are becoming more common due to an increasing number of patients with disc prostheses, an increase in anterior lumbar fusion, and treatment of adjacent-segment disease. Revision procedures of anterior disc arthroplasty are technically difficult, with a high risk of vascular injury. Revision of the anterior approach, especially at L4–L5, is complicated by scar tissue and adhesions of vessels previously mobilised during the index procedure. These elements must be taken into account in assessing the therapeutic choices. In some cases, vessel dissection and retraction is impossible. Some authors advise placing the polytetrafluoroethylene (PTFE) GORE-TEX patch over the implant during the index procedure to expedite re-exposure if a revision becomes necessary. Others recommend evaluating the vascular anatomy with computed tomography angiography (CTA) and/or magnetic resonance (MR) venography at L4–L5 or above [2, 3].

Late infection following disc replacement is a rare event, with only one case found in the literature published in 2010 by Spivak et al. [2]. Diagnosis can be made by radiographic studies that identify periprosthetic loosening, which can have many origins; however, when it is associated with

leukocytosis, an elevated erythrocyte sedimentation rate (ESR), and high C-reactive protein (CRP) value, it is strongly suggestive of infection [3]. Diagnosis can be made by aspiration of fluid from the periprosthetic area and re-aspiration of saline solution after an injection. [2, 3]. This literature review provides an update on the various treatments for infected lumbar disc prosthesis and the different surgical approaches used in these difficult cases.

Materials and methods

We reviewed the literature and found one case report, by Spivak et al. [2] in 2010, of revision of a lumbar disc arthroplasty following late infection. Tropiano et al. [1] published a commentary on this case and reported identifying another possible form of management. With the very small number of cases reported in the literature, it is impossible to establish an algorithm for managing these infections. However, several elements seem essential in the debate against this type of pathology. First, this complication is an infection of surgical hardware similar to that which may be found in a peripheral prosthetic joint. Numerous publications are available describing therapeutic management in these cases. However, those methods must be adapted to the specific circumstances involved in disc prosthesis infection. Treating this complication differs from other infections of hardware due to the anatomical position of the prosthesis and difficulty and risks of revision approaches. Revision of the anterior approach to the lumbar spine, especially at L4–L5, is complicated by scar tissue and adhesion of vessels that were previously mobilised during the index procedure. These elements must be taken into account in making a therapeutic choice. The case reported by Spivak et al. [2] involved a 35-year-old man who underwent uncomplicated two level total disc arthroplasty (TDA) at L4–L5, L5–S1. The authors used a left retroperitoneal approach with a transverse incision curved cephalad at its extension to the left. Eight months after surgery, the patient was complaining of acute onset of severe sharp back, abdominal, and left thigh pain. He was febrile, with nausea, vomiting and had eight days of loss of bowel movement. Biological markers showed leucocytosis of 16.2, ESR 101, and CRP 301. The clinical and biological presentation was suggestive of acute infection. CT scans showed a left psoas-based retroperitoneal abscess, which was drained by the interventional radiologists. The abscess cavity was injected with contrast media and found to communicate with the nearby L4–L5 prosthesis only. A pigtail catheter was left in situ until there was no drainage for two consecutive days. Blood cultures revealed *Staphylococcus aureus* and, at the abscess site, *Streptococcus intermedius*. Treatment was drainage of the abscess and a six week course of IV antibiotics followed by oral suppressive antibiotics. All clinical–biological parameters improved except the low-back pain. Initially, the author's recommendation to the patient consisted of antibiotics for four to six months. After identifying the organism and administering appropriate antibiotics, Spivak et al. [2] initially preferred nonsurgical management, as suggested by Kostuik [3] in 2004. However, understanding the risks of the procedure, the patient preferred revision with TDA removal followed by fusion and was thus revised five months following identification of the infection (13 months following his index procedure). Pre-operatively, a stent was not inserted into the ureter nor was a vena cava filter placed. Two different levels were used by the authors during their approach: a new oblique left anterolateral incision for L4–L5 and a Pfannenstiel incision in from the index procedure for L5–S1. At L4–L5, they started with L4 vertebral access in more normal tissue and continued to the L4–L5 disc space. They could not mobilize the vessels, so they used an anterolateral approach to the disc space, with lateral retraction of the left psoas muscle. An osteotomy was performed to expose the keel centrally. After implant removal, a fresh–frozen femoral shaft allograft was inserted, held in position with 6.5-mm screw and washer, and bone morphogenic protein (BMP)-2 was infused. At L5–S1, because of adhesions, the surgeon was unable to use the retroperitoneal approach and used, instead, a transperitoneal approach. At this level, they used a similar allograft and fixation and Infused BMP-2. Intraoperative cultures taken at both levels were negative. They then performed percutaneous posterior fixation. The patient had one complication—persistent retrograde ejaculation—after the revision. At the four year follow-up, the fusion had healed, with no sign of infection and with mild lower back pain.

Revising the guidelines for treating prosthetic joint infections [15, 16], the authors suggested debridement and IV antibiotics if the duration of clinical signs and symptoms is <3 weeks, the implant is in place, and soft tissues are in good condition. Antibiotic therapy is administered IV for two to four weeks, followed by oral treatment of up to six months. This is validated in the literature for other orthopedic therapeutic indications, with success rates ranging from 82% to 100% for *Staphylococcus* infections in the series of Zimmerli et al. [15]. This therapeutic approach should be discussed in view of the surgical risks encountered in the revision procedure, particularly the risk of vascular injury at level L4–L5 and the risk of retrograde ejaculation following the transperitoneal approach [18] due to sympathetic nervous system injury. To minimise risk, Tropiano et al. [1] proposes using the opposite side for retroperitoneal L5–S1, if possible, or the transperitoneal approach if this is not an option. However, the second approach is risky for the sympathetic plexus. For the L4–L5 and above, they propose an anterolateral retroperitoneal approach [17], with the introduction of ureteric catheter for all cases approached from the left. As emphasized by Tropiano et al. [1], the approach and dissection will be easier in the presence of an abscess, and there is no need to retract the vessels or expose the

prosthesis. Soft tissue irrigation is recommended for a week, followed by drainage for four days. Several samples must be taken close to the prosthesis and sent for cultures. If the duration of signs or symptoms of infection proceed beyond three weeks, Tropiano et al. [1] propose careful debridement, irrigation, prosthesis removal, and fusion of the infected level [3]. They recommend stopping all antibiotics 15 days prior to surgery and begining prophylactic probabilistic antibiotic therapy after intra-operative samples are collected. If the implant is removed, it is necessary to take tissue samples from the surface of the implant.

Discussion

The objectives of managing late disc prosthesis infection are to cure the infection and to improve the patient's pain. It is difficult to determine, in the case reported by Spivak et al. [2], whether pain originated from infection or the prosthesis. The author reported that the patient presented eight months after initial surgery complaining of severe, sharp back and left thigh pain of acute onset. The patient's clinical presentation was suggestive of acute infection. To treat this complication, Tropiano et al. [1] suggested referencing the algorithms developed for infections of joint prostheses: acute during the first three months after surgery, with virulent bacteria such as *S. aureus*; clinical presentation of fever, severe pain, nausea, and vomiting; with signs in relation to anatomical position, such as no bowel movement and formation of a deep abscess in the area. Chronic infections, later than three months with less virulent types of bacteria, appear with milder clinical signs of pain and the appearance of radiological signs such as prosthesis loosening.

There is a very little literature regarding infections of disc prostheses. Although such infections are similar to those in total joint prostheses, the environment of the intervertebral disc space is different from the space in other synovial joints, with the development of a biofilm bacterial material found at the site of the arthroplasty, as reported by Cavanaugh et al. [14]. To revise to the adjacent segments just above or below the previous surgery, a change in approach is recommended, as is the use of lateral or anterolateral approaches to lower the risk of vascular injury. Several articles were found regarding revision of uninfected TDA [8–12]. These studies emphasise avoiding repeated access to the abdomen and changing the approach to minimize vessel mobilisation. In 2005, Bertagnoli et al. [12] recommended TDA using a right-sided approach for the index surgery, thus preserving the left side for revision surgery. Spivak et al. [2] use the same recommendation for their approach L5–S1. Bertagnoli et al. [12] suggest placing an anti-adhesive membrane between the prosthesis and the large vessels during the index procedure.

Several authors recommend that revision surgery should be done in spine centres, which have considerable experience in the anterior approach [11–13]. In 2006, McAfee et al. [9] reported a series of anterior revisions of Charity prostheses. In 8% of these cases, they could access the disc space because they could not mobilise the vessels, with 16.7% of vascular injuries during these revisions. In 2006, Wagner et al. [8] reported a series of revisions in 21 patients: 14 needed staged removal of the prosthesis. For L4–L5 access, they proposed a transpsoas lateral approach and at L5–S1 a contralateral retroperitoneal approach. In 2008, Patel et al. [10] published a literature review on strategies for revision and referred to the ureteric and vascular complications that can occur in these approaches. The authors suggest that the far-lateral or transpsoas approach to the anterior column may reduce risks to retroperitoneal structures. As with Bertagnoli et al. [12], the authors recommend placing a membrane between prosthesis and vessels to facilitate dissection in the event of a revision.

Spivak et al. [2] describe removing the Pro-Disc prosthesis (Synthes-Paolia), which has a prosthetic keel, suggesting that the best approach is a direct anterior approach, which is feasible at L5–S1 but very difficult at L4–L5, with a high risk of vascular injury. In some cases, vessel dissection and retraction is impossible. An approach with an anterolateral retraction of the psoas and an osteotomy to remove the prosthesis at these levels is recommended by Spivak et al. [2]. Regarding fusion, Kostuik [3] and Tropiano [1] recommend a structural autograft rather than allograft in the infection phase. As highlighted in Tropiano's commentary [1], the addition of hardware in an infectious context must be avoided if possible because it promotes infection persistence or recurrence. Regarding posterior fusion, Spivak [2] opted for a percutaneous instrumentation without true fusion. In turn, Tropiano [1] suggest a posterior instrumentation with posterolateral fusion using autologous bone graft. Posterior fusion with instrumentation seems the most suitable option because it promotes treatment of infection with its stability and treats residual low back pain. As for the indication to treat two levels at a time, the two authors disagree. Spivak [2] preferred to treat both simultaneously, even if the injection of contrast into the abscess showed a single communication with the L4–L5. Complications are retrograde ejaculation due to injury to the sympathetic plexus by a transperitoneal approach. Trapiona [1] would not remove the prosthesis at L5–S1 given the risks of surgery and the lack of certainty about the infection. The authors would, by this time, have evaluated the outcome on lower back pain after infection eradication at L4–L5. It is true that if we consider this level as not being infected and only responsible for back pain, appropriate treatment would have been an instrumented posterior fusion [2]. Trapiona [1] suggests retaining the implant using debridement and irrigation for joint replacement infection lasting <3 weeks but removing

the prosthesis for situations lasting longer or for a prosthesis in an unacceptable position. However, it seems essential to take into account the time to onset of infection compared at the index procedure. If the revision is late or after two weeks, the risk of vascular, ureteral, and intestinal injury is high. In 2007, Leary et al. [11] reported a large case series of anterior revision surgery in patients who had complications following lumbar total disc replacement with the Charite artificial disc. For them, the choice of approach in revision anterior spinal surgery should be dictated by the time since the index procedure and the level to be revised. For early revision, within the first two weeks, they recommend the anterior retroperitoneal approach; for late revisions, at L5–S1, they recommend a right anterior retroperitoneal approach. At L4–L5 and above, they recommend an expanded left anterior retroperitoneal approach or a direct lateral transpsoas approach. In late revisions at ≥L4–L5, they recommend using vascular and ureteric stents. The authors believe that during the index procedure, placement of the PTFE GORE-TEX patch over the implant can expedite re-exposure if a revision becomes necessary. They experienced such benefits in a case in which the membrane had facilitated dissection of the iliac vessels from the implant. Other advice is to evaluate the vascular anatomy with CT angiography and/or MR venography at L4–L5 or above [1, 2].

In cases of infection, Kostuik et al. [3] raise the possibility of nonsurgical management if the culture is positive and the right antibiotic given. This is the same management initially decided upon by Spivak [2]. Kostuik [3] suggested that if infection persists or if there is a recurrence, it will be necessary to remove the implant, debriding and irrigating soft tissues, and fusing the discs with structural autograft. Neither Kostuik [3] nor Tropiano [1] recommend any hardware to support the allograft in a revision with infection. Regarding posterior fixation, Spivak [2] opted for a percutaneous instrumentation, whereas Kostuik [3] and Tropiano [1] recommend open posterior spinal instrumentation and fusion one week after revision surgery with a patient in antibiotic therapy.

Conclusion

Managing revision of a lumbar disc arthroplasty following late infection should use a multidisciplinary approach with a team of orthopaedic surgeons, infectious disease specialists, radiologists, microbiologists, and vascular surgeons to avoid complications and to decrease morbidity following the procedure.

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