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Percutaneous transpedicular discectomy and drainage in pyogenic spondylodiscitis

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Abstract The natural history of uncomplicated hematogenous pyogenic spondylodiscitis is self-limiting healing. However, a variable degree of bone destruction frequently occurs, predisposing the spine to painful kyphosis. Delayed treatment may result in serious neurologic complications. Early debridement of these infections by percutaneous transpedicular discectomy can accelerate the natural process of healing and prevent progression to bone destruction and epidural abscess. The purpose of this manuscript is to present our technique of percutaneous transpedicular discectomy (PTD), to revisit this minimally invasive surgical technique with stricter patient selection, and to exclude cases of extensive vertebral body destruction with kyphosis and neurocompression by epidural abscess, infected disc herniation, and foraminal stenosis. In a previously published report of 28 unselected patients with primary hematogenous pyogenic spondylodiscitis, the immediate relief of pain after PTD was 75%, and in the long-term follow-up, the success rate was 68%. Applying stricter patient selection criteria in a second series of six patients (five with primary hematogenous spondylodiscitis and one with secondary postlaminectomy-discectomy spondylodiscitis), all patients with primary hematogenous spondylodiskitis (5/5) experienced immediate relief of pain that remained sustained at 12–18 months follow-up. This procedure was not very effective, however, in the patient who suffered from postlaminectomy infection. This lack of response was attributed to postlaminectomy-discitis instability. The immediate success rate after surgery for unselected patients in this combined series of 34 patients was 76%. This technique can be impressively effective and the results sustained when applied in the early stages of uncomplicated spondylodiscitis and contraindicated in the presence of instability, kyphosis from bone destruction, and neurological deficit. The special point of this procedure is a minimally invasive technique with high diagnostic and therapeutic effectiveness.

Keywords Percutaneous transpedicular discectomy · Primary hematogenous pyogenic spondylodiscitis

Introduction

Pyogenic spondylodiscitis, particularly its primary form, may heal spontaneously or respond effectively to treatment with antimicrobial therapy. However, it is not uncommon that even while the patient is on antibiotics, the infectious process may become fulminant and serious complications may develop ranging from mechanical deformities (kyphosis-scoliosis) caused by massive bone destruction to catastrophic neurological deficit (paralysis-paraparesis) provoked by epidural abscess formation. Delayed treatment may lead to sepsis and organ failure associated with increased morbidity and mortality [4, 14, 22, 30]. Several predisposing factors such as smoking, malnutrition, a compromised immune system, etc. [2]. play a determining role in the gravity of the infectious process and in the development of complications. Obviously, early diagnosis and assessment of the aggressiveness of the infectious process, and prompt and suitable treatment should play a major determining role in the successful management of spondylodiscitis and prevention of its dreadful complications. CT-guided percutaneous drainage of infected intervertebral disc space as an adjunctive therapy to intravenous (IV) antibiotic therapy has been shown to be an effective tool [28, 29].

In an attempt to effectively decompress and control the infection process, we modified this approach using a technique common in arthroscopic knee surgery [3]. This is a well-established, minimally invasive procedure for joint infections [16, 17] that has also been successfully applied to intervertebral disc infection by means of percutaneous discectomy [8, 9, 10, 27, 31]. However, the reported studies using both CT-guided disc space drainage and percutaneous discectomy are small and not well controlled, and the state of the infectious process is not well documented.

In a previous study, we reported on the effectiveness of percutaneous transpedicular discectomy (PTD) in a series of 28 patients [12]. In this series of unselected patients, the success rate was 75%. Based on the heterogenous nature of the disease progress in these patients (including both early and late stages), we concluded that more appropriate selection criteria should yield a higher success rate. The goal of this paper is to revisit the effectiveness of the procedure by adding six more cases of spondylodiscitis with stricter patient selection criteria.

Material and methods

Thirty-four patients with pyogenic spondylodiscitis were treated by means of transpedicular discectomy from November 1994 to January 2002 in two different university centers. Six new cases that were treated from January 2000 to January 2002 (follow-up 1–3 years), were added to the initially reported cases of 28 patients treated between November 1994 and October 1996 [12]. Primary hematogenous pyogenic spondylodiscitis was present in all 28 patients in the initial series and 5/6 patients in the second series. In the remaining patient, the infection was secondary to postoperative laminectomy-discectomy surgery. There were 24 men and ten women ranging in age from 18 to 72 (mean 49) years. All patients presented with intractable back pain that required narcotic pain management and bed rest. In the first series, neurological deficit was attributed to either cord compression, causing spastic paraparesis in three patients (Frankel C), and cauda equina manifestation (L1-L2) in one patient (Frankel C), or to severe radiculopathy with drop foot and sciatica in four patients. Cord compression was caused by epidural abscess at T8-T9 in two patients, infected herniated disc at T7-T8 in one patient, and L1-L2 in another patient. Radiculopathy with drop foot (2–3 grades out of 5) was seen in four patients, two with foraminal stenosis (L4-L5 and L5-S1 stenosis and bone destruction) and two with neurocompression of the L5 nerve root by epidural abscess (L4-L5 and L5-S1 levels). In the second series, sciatica was present in two patients who suffered from primary hematogenous pyogenic spondylodiscitis and was caused by purulent epidural abscess that produced neurocompressive radiculopathy of the L5 nerve root (drop foot grade 3/5 and pain).

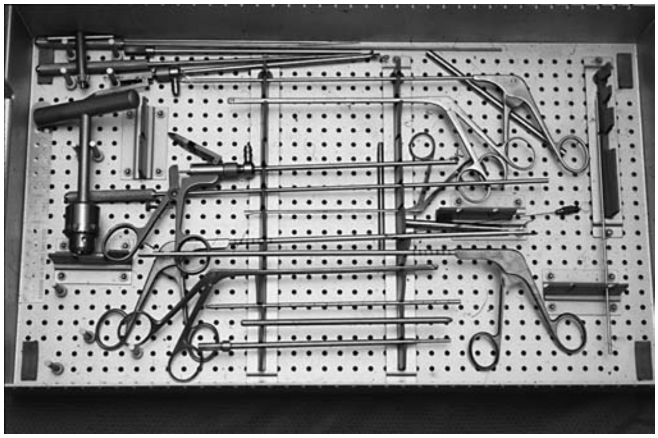

Fig. 1 Demonstrates the modified Kambin instrumentation to be used for percutaneous transpedicular discectomy (PTD) (Smith and Nephew, Memphis, TN, USA)

All patients had preprocedural routine laboratory tests for infections (CBC, ESR, CRP) and imaging studies with conventional radiographs, magnetic resonance imaging (MRI) and CT scans. Technetium (Tc^{99}) bone scan and Gallium citrate (Ga^{97}) scan were done in 27 patients. The imaging studies were consistent with the diagnosis. All patients received a 6-week intravenous course of suitable antibiotic therapy. In patients with brucella infection, antibiotic therapy was given for 6 months. Five infections were encountered in the thoracic spine and 29 in the lumbar spine. Pain and disability was assessed using pain drawings, pain visual analogues and the Oswestry disability questionnaire.

The operative procedure was performed under general anesthesia in 25 patients. Local anesthesia with conscious sedation by means of fentanyl citrate (dose range, 50–200 mg) and midazolam (Versed; Rate Laboratories, Nutles, NJ, USA: dose range, 1–5 mg) was used in nine patients who where considered as high risk for general anesthesia due to septic condition or other serious medical conditions.

Three patients underwent the procedure with the use of Tony Yang discectomy instrumentation (Wolfe Corp., Germany). In 14, patients the Kambing-Craig modified biopsy discectomy instrumentation (Smith and Nephew, Memphis, TN, USA) was used, and in the remaining 17 patients, a combination of Kambin-Craig modified instrumentation with the flexible automated nucleotome was used (Surgical Dynamics, Alameda, CA, USA) (Fig. 1). The excised pathological tissue was submitted for histopathologic and bacteriologic examination as previously described [19, 23].

Description of technique

The procedure can be performed under general or local anesthesia [13]. It is highly recommended that all aspects of the procedure be done with fluoroscopic guidance. With the patient lying prone, the operator introduces a percutaneous guide pin (2 mm Steinmann) into the pedicle caudal to the affected intervertebral disc. The pin tip is centered in the pedicle ‘bull’s eye” on an oblique fluoro-

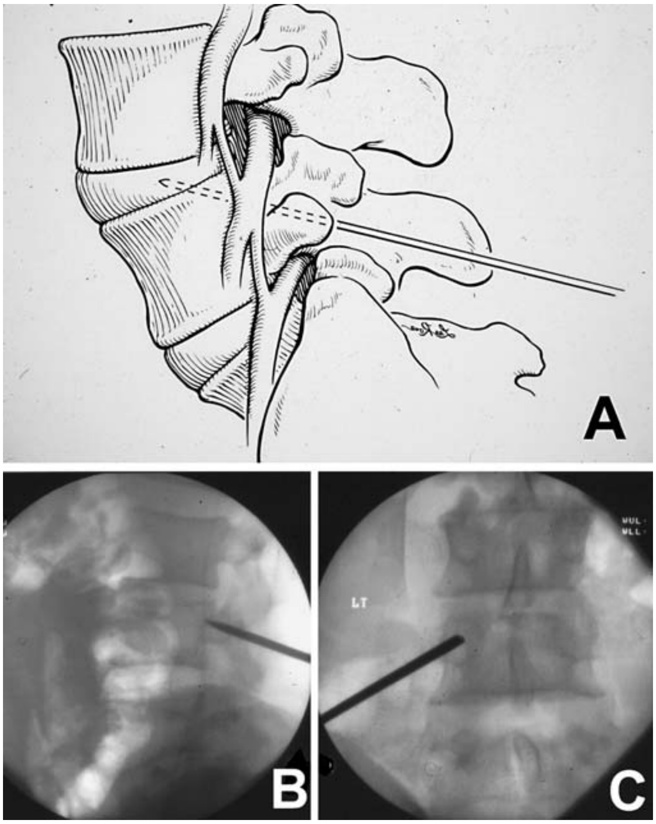

Fig. 2A–C Lateral view of diagrammatic representation of transpedicular access at L4-L5 level that shows the guide pin introduced into the intervertebral disc space though the caudally located pedicle (**A**). Hard copy reproduced from an image intensifier showing the position of the guide pin on the lateral view (**B**) and on an AP view (**C**). The pin is clearly shown to be within the confinement of the pedicle. **Fig. A** reproduced with permission from the Society of Cardiovascular and Interventional Radiology (SCVIR)

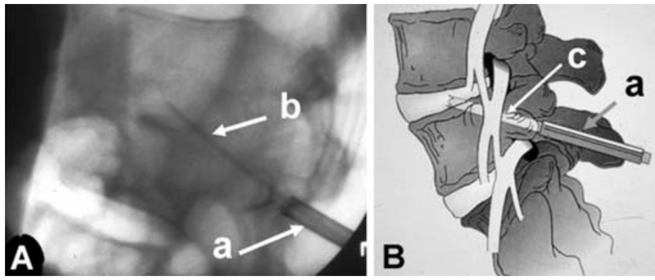

Fig. 3A–C Hard-copy reproduction from image intensifier (**A**) that shows the working sleeve (**a**) abutting against the entrance to the pedicle and the guide pin (**b**). Diagrammatic illustration (**B**) showing the toothed end bone cutting tool (**C**) is inserted over the guide pin through the working sleeve (**a**) and the pedicle into the disc space

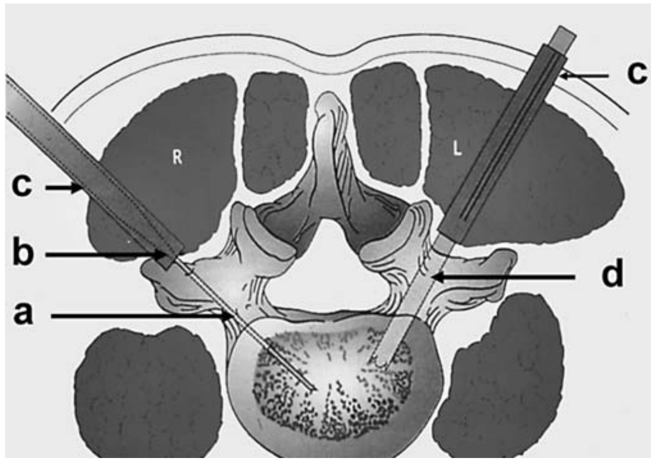

Fig. 4a–d Axial diagram illustrating the instrumentation for creating transpedicular channel for the insertion of discectomy instrumentation. A guide pin is first inserted percutaneously through the pedicle and subchondral bone into the disc space (**a**). Subsequently, a tissue dilator (**b**) is introduced over the guide pin, and over the tissue dilator, a sleeve (**c**) is placed to be used as a working channel. Then the dilator is removed and a toothed cutting bone tool (**d**) is inserted over the guide pin into the intended target. (Modified with permission from Quadrant Healthcom, Inc.)

scopic view (Fig. 2). The C arm of the image intensifier is then rotated 90° to obtain a lateral view of the guide pin. Cephalad angulation in the sagittal plane allows the center of the disc to be reached without violating the confinements of the pedicle to the disc. We strongly urge the access of the intended discectomy level be from the more caudally placed, adjacent pedicle. Access through a more cephalad pedicle has the potential of penetrating into the inferior borders of the pedicle and compromising the exiting nerve root.

The physician holds the guide pin steady with one hand, and with the other hand, taps the pin gently with a mallet until the tip of the pin reaches the inner annulus of the posterolateral portion of the disc. Image-intensifier views in the posteroanterior and lateral planes can assess the accurate positioning and progression of the guide pin within the pedicle (Fig. 3). After the guide-pin insertion, a small stab-wound incision (about 1 cm) is made to allow the passage of a modified Kambin tissue dilator (5.35 mm diameter; Smith and Nephew) over the guide pin until it reaches unyielding structure (bone, entrance to the pedicle) (Fig. 4). A cannulated modified Kambin sleeve (6.4 mm diameter; Smith and Nephew) is passed over the tissue dilator and guide pin until it abuts with the cortical margins of the pedicle (Figs. 3 and 4). Use of a cannulated sleeve prevents inadvertent clogging of the bone biopsy instrument with subcutaneous tissue or muscle fibers and facilitates insertion of the discectomy instrument. The tissue dilator is then removed and the cutting bone tool (5.15 mm diameter; Smith and Nephew) is inserted (Figs. 3 and 4). The cutting bone tool is a cylindrical sleeve (15 and 18 cm long) with the distal end fashioned in a cutting toothed edge and the proximal end in a knob-shaped configuration for the attachment of a T-handle, low-torque device. The cutting bone tool is advanced to the intended target by means of the torque device. Simultaneous removal of the Steinmann pin and the biopsy tool successfully withdraws a core of bone impacted between the guide pin and the biopsy instrument [11, 13, 23]. A modified Kambin discectomy forceps (Smith and Nephew) is then inserted through the cannulated sleeve (Fig. 5) to allow extraction of additional tissue from the disc. Bone, disc, and tissue samples are sent for pathohistologic and bacteriologic studies. Repositioning the guide pin through the pedicular tract allows insertion of the biopsy instrument into a different part of the disc. Discectomy is performed in a piecemeal fashion by positioning the biopsy forceps into different positions to withdraw more tissue.

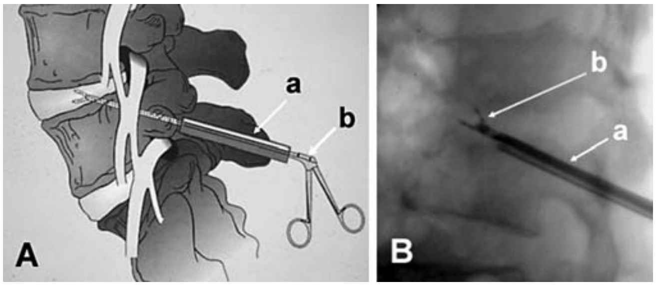

Fig. 5A–B Diagrammatic illustration (**A**) and hard-copy reproduction from image intensifier (**B**) during percutaneous transpedicular discectomy demonstrating the working sleeve (**a**) and the discectomy forceps (**b**)

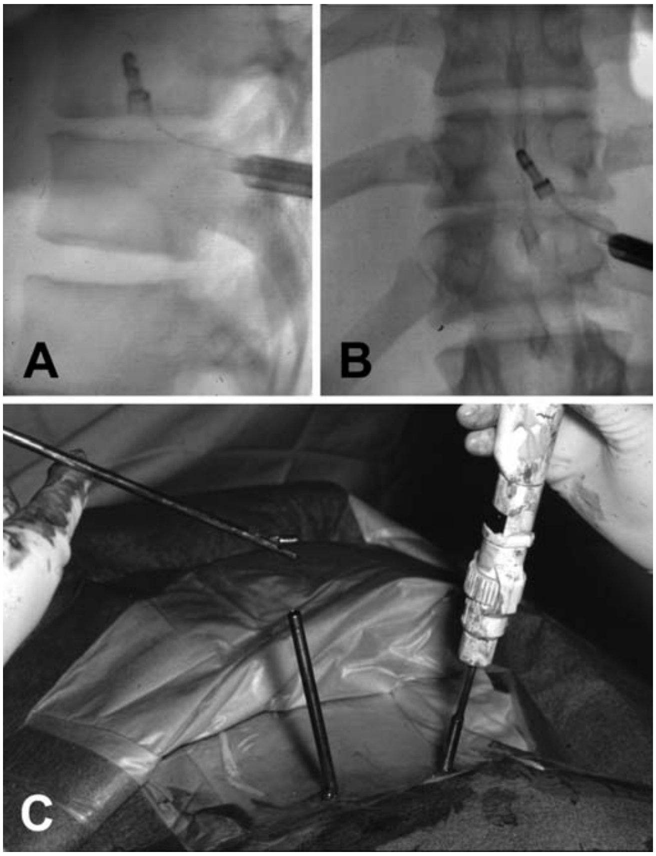

Fig. 6A–C Hard-copy reproduction from image intensifier during percutaneous transpedicular discectomy using the flexible automated nucleotome (Surgical Dynamics, Atlanta, CA, USA) as seen on lateral view (**A**) and posteroanterior view (**B**). Picture (**C**) shows the position of bilateral transpedicular working sleeves, the flexible nucleotome is introduced through one sleeve (*right*) and discectomy forceps are just about to be inserted in the other sleeve (*left*). (**Fig. A** reproduced with permission from Harcourt Brace and Co. Ltd.)

The second phase of the procedure requires the use of a flexible automated nucleotome (Surgical Dynamics, Alameda, CA, USA). The tip of the nucleotome is passed through the skin sleeve and the created pedicular channel. Excision of the disc is achieved

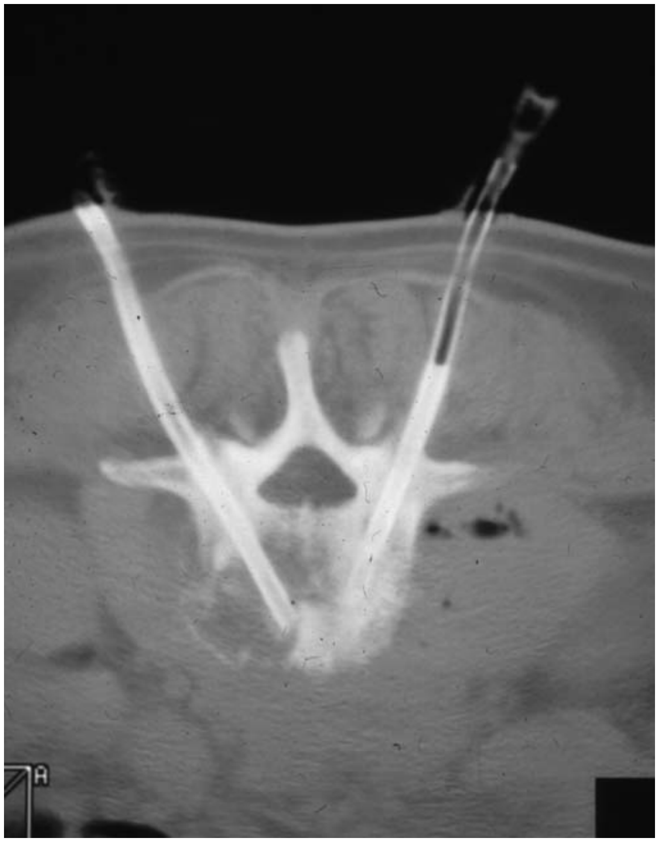

Fig. 7 Bilateral percutaneous transpedicular intervertebral disc drainage tubes for suction of pus and irrigation with appropriate antibiotics

by angulating the flexible tip of the nucleotome within the vertebral body and disc space under fluoroscopic guidance (Fig. 6). After completion of the discectomy, the disc is irrigated and drained by passing 10Fr metal-braided sheaths (Arrow International, Reading PA, USA) through the pedicular channels (Fig. 7). The sheaths receive suction from a vacuum draining bag (Snyder Hemovac, Zimmer Patient Care Division, Dover, OH, USA). A solution of 10 ml saline and 2 g of cefazolin (Ancef, Smith-Kline Beecham, Philadelphia, PA, USA) irrigates the disc space. The choice of antibiotics is determined by Gram's stain or culture results.

Results

The scintigraphic investigation (Tc^{99} and Ga^{67} scan) was positive in all 27 tested patients. In all 34 patients, the MRI T1, T2, and T1 with gadolinium signals were pathological. Twenty-five of 34 (73.5%) cultures were positive with the following bacterial growth: *Staphylococcus aureus* 13 cases (52%), *Staphylococcus coagulase negative sp* 4 (16%), *Streptococcus viridans* 2, *Enterococcus sp.* 1, *Pseudomonas aeruginoasa* 1, *Candida sp.* 1, *Serratia marcescens* 1, and *Brucella* 2. Both cases affected by *Brucella* drained purulent material. No neurological complications were encountered from this procedure. There was only one minor technical mishap of a retained drain tube that was retrieved quite easily and uneventfully by means of a biopsy forceps through the pedicular channel under fluoroscopic control.

Twenty-one out of 28 patients (75%) in the first series [12] showed immediate improvement in pain response noticeable within 24 h. Residual resolving pain was managed with decreasing doses of oral narcotics, and the patients were discharged on the second or third postoperative day. The following reasons were apparent in the seven patients that failed to respond to surgery:

– Three patients were paraparetic from severe neurocompression; in two of these patients, the culprit was infected disc herniation (L1-L2 and T7-T8) and in one epidural abscess (T8-T9). Three patients remained with severe back pain and radiculopathy manifested with severe sciatica and drop foot. In these patients, there was excessive osteolytic bone destruction that led to foraminal stenosis (L4-L5) in one patient and compressive radiculopathy from associated epidural inflammatory granulation tissue (L4-L5) in the other two patients. Although the infection was brought under control in one patient, he remained with excruciating back pain that failed to respond on account of kyphotic deformity from severe osteolytic bone destruction. Subsequently, six of these patients underwent reconstructive surgery (anterior decompression, bone graft and posterior instrumentation) with restoration of complete function in five patients. One patient was considered a poor risk, was not operated on, and remained paraparetic. In the long-term, the success rate dropped to 68% because, although the infection responded in two patients, they subsequently underwent surgery for painful pseudarthrosis (L4-L5) and persistent foraminal stenosis (L5-S1) respectively.
– One patient with paraparesis from epidural abscess after percutaneous transpedicular discectomy and drainage of the purulent material had an immediate improvement of pain and neurologic deficit. This patient eventually became ambulatory.

In the second group of six patients, there was one nonrespondent (success rate 83%). All patients suffered from excruciating low back pain, and in addition, two patients exhibited sciatica with drop foot caused by L4-L5 pyogenic epidural abscess. There was no evidence of severe osteolytic destruction on CT scan. All five patients with primary hematogenous pyogenic infection had an immediate relief of back pain and sciatica, with restoration of the neurological deficit. The results were sustained at 18 months follow-up. The nonrespondent patient was suffering from secondary spondylodiscitis after L4-L5 laminectomy-discectomy and remained with disabling back pain.

The overall success rate of unselected patients, when combining both groups, was 76% (26/34 patients) in early results and 71% (24/34 patients) in the long-term follow-up. This could reach 83% with stricter selection criteria.

Discussion

In the first group of patients (all suffered from primary hematogenous spondylodiscitis), treatment failures for unrelenting back pain were attributed to pseudarthrosis with instability or severe kyphotic deformity caused by extensive osteolytic destruction of the vertebral body (Fig. 8). In the second group, there was one case of postlaminectomy-discectomy discitis in which the implementation of the procedure was delayed for 2 months after the onset of symptoms and the resultant back pain was attributed to L4-L5 instability caused either by bone infection or laminectomy. The other five cases of primary hematogenous pyogenic infection (including the *Brucella* cases) responded successfully to percutaneous transpedicular discectomy and drainage.

Patients with neurological deficit did not fare well with percutaneous transpedicular discectomy encountered in the first series. Pathological entities contributing to neurological deficit were foraminal stenosis caused by collapsed infected disc destruction and infected granulation tissue, severe neurocompression of the thecal sac and its contents by large epidural abscess, or infected herniated nucleus pulposus. Therefore, these factors should be con-

Fig. 8 Extensive bone destruction caused by severe infectious osteolysis resulting in kyphotic deformity. This type of lesion is contraindicated for percutaneous transpedicular discectomy (PTD)

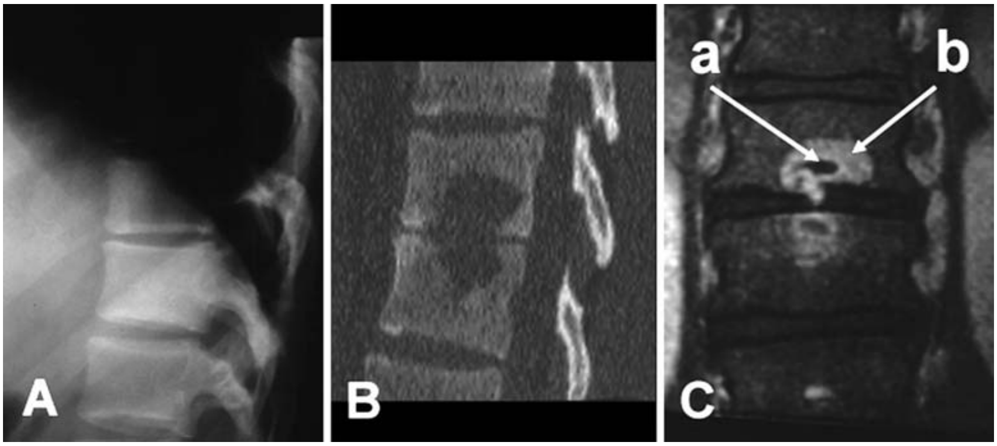

Fig. 9A–C Shows a spondylodiscitis on a lateral plain radiograph that fails to demonstrate any bone destructive process (**A**). The osteolytic lesion is beautifully depicted on lateral reformats CT scan (**B**). Frontal MRI gadolinium enhanced T1 weighted image demonstrates the typical hallow of infection (**C**). Decreased signal intensity (*see arrow a*) indicates pus, whereas increased signal intensity (*arrow b*) is suggestive of vascular inflammatory tissue. (**Fig. B** reproduced with permission from Harcourt Brace and Co. Ltd.)

sidered as exclusion criteria for this procedure. Although the overall success rate of this series was 76%, with stricter clinical selection this can reach a better response.

In this context, one can extrapolate that percutaneous discectomy most likely should yield a similar response. In a series of 16 patients with spondylodiscitis [10] (without neurological complications from epidural abscess) treated with PLD, 19% of the patients required traditional surgical intervention with interbody fusion.

Nagata et al [20] reported that in 23 cases of early spondylodiscitis, the success rate of percutaneous suction aspiration and drainage was 87%. It is conceivable to attribute this high success rate to the implementation of the minimally invasive surgery in the early stages of spondylodiscitis before the onset of complications such as cord compression by epidural abscess or extensive bone destruction.

By allowing better targeting of the lesion with the instrumentation (Fig. 9), automated nucleotome (Surgical Dynamics, Alameda, CA, USA) can shorten surgical time of the procedure as opposed to the more tedious and piecemeal excision of the infected material by the Kambin or Yang discectomy forceps alone.

The indication of the choice of anesthesia is determined by the cooperation of the patient and the severity of pain. The best diagnostic test for spondylodiscitis is tissue diagnosis with bacteriologic studies [1, 19]. Tissue cultures yielded the offending microbes in 73.5% of cases corresponding to the literature reports of 42–91% [1, 5, 20, 21, 24, 25, 31]. A positive culture is not required for diagnosis but is extremely important for optimal antibiotic therapy [3]. Transpedicular biopsy has been shown to be highly effective and safe [11, 18, 19, 23, 26]. If the tissue samples are indicative of infection, we recommend the use of this relatively simple procedure that allows maximum evacuation of the infected tissue and therefore promotes rapid healing.

PTD is designed for the management of early spondylodiscitis. It is reasonable to advocate that debulking and draining the infected tissues early, an effective control of the infection process, can prevent catastrophic formation of epidural abscesses [15] and destructive osteolytic vertebral collapse with kyphotic deformities, which are not uncommon and occur most frequently when surgical treatment is delayed [4]. Also, by expediting the healing process, the spine may remain in good alignment thus preventing pain from kyphotic deformities.

According to published reports, mechanical back pain is not uncommonly associated with conservative treatment of vertebral osteomyelitis [7, 14, 15]. PTD, by approaching the infected disc space through the vertebral end plates, may promote invasion and absorption of the infection process by vascular granulation tissue from the vertebral body through the subchondral bone [6]. This concept is also echoed in Nagata's approach in which the end plate of the vertebral body is removed using a motor-driven shaver [20]. Traditional surgical treatment for spondylodiskitis, or its established complications, is associated with prolonged hospital stay, high socioeconomic cost [14], and increased morbidity from extensive surgical procedure. We agree with reports indicating that massive bone destruction, large epidural abscess, and major or progressive neurologic deficit remain indications for major open surgical intervention [5, 14]. Although this was not a prospective randomized study, there is some evidence to support this conclusion. The conclusions from our study would be best corroborated by a prospective randomized study.

In conclusion, this procedure is very effective in the early stages of spondylodiscitis before the onset of extensive bone destruction or the formation of large epidural abscess or infected disc herniation. The advantage of this procedure is its minimal invasiveness that allows bacteriological and histological testing, drainage of infected material, prompt relief of pain and suffering, and early patient mobilization. PTD should also be considered as a cost-effective procedure because most patients can be discharged on the second or third postoperative day, thus decreasing prolonged hospital stay necessary for bed rest and analgesia control.

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