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ORIGINAL ARTICLE

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# Late implant infections caused by *Propionibacterium acnes* in scoliosis surgery

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**Abstract** One hundred and one consecutive adolescent scoliosis patients instrumented from the posterior between 1995 and 2002, with a minimum follow-up of 24 months (maximum 106 months), were reviewed for incidence of infection. Stainless steel implants with pedicle screws were used in the thoracic and lumbar spine of all patients. All were operated on by a single surgeon. There were no early infections. Incidence of late infection was 6.9% (seven patients). Clinical indicators for infection were the sudden onset of local pain and swelling without fever after an initial pain-free interval. There were no reliable laboratory parameters. Normal CRP and ESR did not rule out a late infection. Extended cultures were done from intraoperative swabs. *Propionibacterium acnes* was found in six patients. There were no other organisms identified. No causative organism could be identified in one patient, despite extended cultures. All patients were successfully treated with implant removal and antibiotic therapy for 4–9 weeks. No pseudarthrosis was seen on implant removal. Despite bony fusion, loss of correction between 10° and 26° was observed in three patients after implant removal.

**Keywords** Late implant infection · Scoliosis · *Propionibacterium acnes*

## Introduction

Acute infection after instrumented spinal surgery is a readily detectable complication. In late operative site problems, there is controversy as to whether these symptoms are caused by soft tissue reaction to the implant material, by pseudarthrosis or by bacterial infection [5]. Chronic bacterial infection has been widely made responsible for late operative site problems in recent years [4, 10, 13, 18, 23, 26]. Specific investigations and adequate laboratory methods can isolate bacterial species, mainly *Staphylococcus epidermidis* and *Propionibacterium acnes*, in most of the cases undergoing revision surgery [3, 17, 26]. Very few reports exist up to now for the incidence and pathology of late infections in adolescent scoliosis patients. This study is a retrospective analysis of late infections in a homogenous group of adolescent scoliosis patients instrumented with segmental pedicular screws. The aims of this study are to evaluate the incidence of late infections, to identify the causative bacteria in our series compared with other studies [3, 13, 17, 23, 26], to analyse the success of management with implant removal and systemic antibiotic therapy, and to evaluate the loss of scoliosis correction after implant removal.

## Materials and methods

Scoliosis patients instrumented from the posterior consecutively since 1995, with a minimum follow-up of 24 months (maximum 106, mean 57) are included in this study. Patients older than 20 years at the time of operation and patients with revision operations were excluded from this study. The group consisted of 67

idiopathic, 32 neuromuscular (18 muscular dystrophy, nine cerebral paresis, two poliomyelitis, two tumours, one syringomyelia) and two patients with neurofibromatosis scoliosis, making a total of 101 (33 male, 69 female) patients, with median age 13.6 (6–19.5) years at operation. All were operated on by the senior author (K.M.). Strict aseptic rules were observed. Perioperative infection prophylaxis with Cefuroximum i.v. was given routinely for 24 h, beginning 30 min before skin incision. The knife for skin incision was discarded after cutting the skin. Double layers of gloves were worn and were changed during the course of the operation. The spine was instrumented in the thoracic as well as the lumbar region with pedicle screw-only constructs using stainless steel implants (USS, Stratec Medical, Switzerland). The average of 11 (8–17) pedicle screws were implanted per patient. Crosslinks were regularly used. The average number of segments fused was nine (5–14) in idiopathic patients and 14 (6–16) in neuromuscular patients. Autologous bone graft was used in all patients. Additional allograft was used in neuromuscular patients. The operation wound was thoroughly irrigated repeatedly during the operation. Stepwise wound closure with braided absorbable suture material and intracutaneous skin closure was done with two subfascial suction drains. In 30 of 101 patients, a same-day ventral release during the same anaesthesia was performed before the posterior procedure. In these patients antibiotic prophylaxis was extended to 48 h. The average operation time was 266 min (SD 70). In all cases a cellsaver was used during the operation. Cellsavers were not used for wound drains after the operation. Wound drains were removed after 24–48 h. Average duration of stay in the hospital was 11 days (SD 3). All wounds were primarily healed on discharge. Diagnosis of late operative site infection was made by increasing pain and swelling at the operation site after a pain-free interval. Routine blood tests and radiographs were taken. No MRI or bone scans were taken additionally. The swabs taken in revision surgery were incubated up to 14 days with a special protocol, as described by Jakab et al. [15], which is the standard procedure in our institution to detect low virulent organisms. The following factors were analysed and grouped according to the method proposed by Viola et al. [26]: (1) parameters prior to index surgery, (2) perioperative parameters at index surgery, (3) clinical presentation at revision surgery, (4) parameters at revision surgery and (5) parameters at last follow-up.

## Results

Seven patients of 101 were clinically diagnosed for late infection and underwent revision surgery. They include five patients with idiopathic scoliosis and two patients with muscular dystrophy. This constitutes a late infection rate of 7.45% for the idiopathic patients, 6.25% for the neuromuscular patients and 6.9% for the whole group. Their characteristics are listed in Table 1.

Perioperative parameters at the index surgery are listed in Table 2. None of the patients had increased risks for infection at index surgery, like previous spinal operations, urinary tract infections, trauma or infections of the respiratory system. All had normal laboratory blood parameters. The two patients with muscular dystrophy had longer operation time. All of the seven patients had an uncomplicated hospitalisation, with good wound healing on discharge. There was no difference in patients' characteristics and perioperative parameters compared with the rest of the group.

Table 3 demonstrates parameters at the time of presentation with late infection. All patients had 2–8 weeks of pain before presenting to our hospital. No patient was febrile. All patients underwent revision surgery within 2 weeks after presentation. At the time of hospitalisation all patients had local swelling at the operation site and two patients had a sinus drainage. All patients had an average symptom-free interval of 127 weeks (minimum 57, maximum 215). In all patients, the spine was radiologically considered fused without loss of correction and without signs of implant loosening on standard X-rays. The erythrocyte sedimentation rate (ESR) was elevated in all except one patient. C-reactive protein (CRP) was highly elevated in two patients, moderately elevated in three patients and normal ($< 5$ mg/l) in two patients.

**Table 1** Patient characteristics

| | Patient 1 | Patient 2 | Patient 3 | Patient 4 | Patient 5 | Patient 6 | Patient 7 |
|---|---|---|---|---|---|---|---|
| Age at index surgery | 16 | 14 | 16 | 15 | 15 | 17 | 17 |
| Sex | F | F | F | M | M | F | F |
| Diagnosis | Idiopathic | Idiopathic | Sarco-glycanopathy | Idiopathic | Duchenne | Idiopathic | Idiopathic |
| Level of fusion | T4–L2 | T3–T11 | T4–Ileum | T4–L1 | T4–Ileum | T5–T11 | T5–T12 |
| Number of vertebrae fused | 11 | 9 | 15 | 9 | 15 | 7 | 8 |
| Anterior release | No | No | No | No | No | No | No |
| Number of pedicle screws | 11 | 10 | 13 | 11 | 14 | 9 | 9 |
| Number of interlinks | 2 | 2 | 2 | 2 | 1 | 2 | 1 |

**Table 2** Perioperative parameters at index surgery

| | Patient 1 | Patient 2 | Patient 3 | Patient 4 | Patient 5 | Patient 6 | Patient 7 |
|---|---|---|---|---|---|---|---|
| Preoperative risks for infection | No | No | No | No | No | No | No |
| Duration of operation (min) | 260 | 300 | 320 | 270 | 305 | 310 | 250 |
| Type of bone graft used | Auto | Auto | Auto/allo | Auto | Auto/allo | Auto | Auto |
| Intensive care unit (days) | 3 | 3 | 3 | 4 | 2 | 1 | 3 |
| Duration of wound drains (h) | 48 | 48 | 48 | 24 | 48 | 48 | 24 |
| Hospital stay (days) | 11 | 12 | 22 | 16 | 24 | 11 | 13 |

**Table 3** Clinical and laboratory parameters before revision surgery

| | Patient 1 | Patient 2 | Patient 3 | Patient 4 | Patient 5 | Patient 6 | Patient 7 |
|---|---|---|---|---|---|---|---|
| Duraftion of pain (weeks) | 6 | 4 | 6 | 8 | 2 | 8 | 4 |
| Local findings | Sinus drainage | Swelling | Swelling | Swelling | Swelling | Swelling | Sinus drainage |
| Time from index to revision surgery (months) | 34 | 14 | 54 | 26 | 18 | 30 | 50 |
| Loss of scoliosis correction | No | No | No | No | No | No | No |
| C-reactive protein (mg/l) | < 5.0 | 14.1 | 31.7 | 143.7 | 212.0 | < 5.0 | 33 |
| Leukocytes (G/l) | 7.18 | 12.65 | 11.17 | 9.50 | 26.34 | 7.40 | 8.67 |
| Erythrocyte sedimentation rate (mm/h) | 17 | Missing | 34 | 92 | 60 | 8 | 54 |
| Fever (> 37.6°C) | No | No | No | No | No | No | No |

The leukocytes count (Lc) was normal in three patients, highly raised in one patient, and moderately raised in the others. No incidences potentially suspicious for promoting infection could be found in all these patients.

Table 4 shows the parameters at revision surgery and hospitalisation. No patient received antibiotics prior to revision surgery. In all patients except one there was macroscopic purulence at the implant site. The patient without purulence had necrotic tissue around the implant material. In one patient the microbiological culture results were negative, in all others *P. acnes* could be isolated. One patient had a single broken screw and one had partial screw loosening distally. No pseudarthrosis but rather good bony fusion mass was observed in all cases. After complete implant removal and thorough soft tissue debridement the wound was closed over suction drains. Non-specific parenteral antibiotics were started immediately after the operation, which were then changed after a few days to culture-directed oral antibiotics for an average of 6.4 weeks (minimum 4, maximum 9). All wounds healed without problems. No second look or further revision operations were necessary. One patient with Duchenne muscular dystrophy was kept at hospital for an extended period for physical rehabilitation. All others were discharged when wound healing was complete after removal of skin sutures.

At the last follow-up (Table 5), all patients remained pain free. Despite intraoperative finding of good bony fusion, some loss of correction was found in three patients after implant removal. The patient with the shortest period between index surgery and implant removal (14 months) had 26° loss of correction. The other two patients had a 10° loss of correction.

## Discussion

The cause of late implant infection is still controversial. Some authors propose mechanical and metal irritation at the implantation site as cause for pain and soft tissue reactions [7, 12, 25, 28]. However, the greater part of the contributors meanwhile make delayed infection responsible for the clinical symptoms of these patients. The reason for the late onset of the clinical symptoms is seen either in a haematogenous seeding of bacteria [3, 13] or in the late exacerbation of bacterial contamination at initial surgery [4, 17–19, 23, 26]. Recent studies tend to support the latter hypothesis by detecting the normal low-virulent skin flora as the main causing organisms of delayed infections. Within this specific spectrum *S. epidermidis*, *S. aureus* and *P. acnes* are the most cited species [3, 4, 7, 13, 17, 18, 26]. Very little literature exists about late infections after elective surgery in adolescent patients with scoliosis. Meta-analysis studies dealing with delayed infection after spine fusion in general are difficult because in most studies multiple pathologies of the spine are included, as well as patients showing confounding characteristics like urinary tract infections, trauma or drug abuse [13]. Adolescent patients with scoliosis as in our study are a homogeneous population

undergoing elective operation without specific risk factors for postoperative acute or late infection. Heggeness et al. and others described a number of factors possibly explaining the haematogenous pathway of a delayed infection [9, 11, 13, 27]. They hypothesised intermittent bacteremia with a possible origin from genitourinary tract, dental caries or gastrointestinal tract. It is, however, questionable whether such mechanisms apply for late infections with *P. acnes*, which is a member of normal skin flora of humans. A study by Jakab et al. [15] clearly documented the pathogenic potential and role of *P acnes* in late postoperative infections. *P. acnes* has a high affinity for deep skin structures, making it difficult to eradicate with commonly used disinfectants. Low inocula during surgery may enable *P. acnes* to reside intracellularly and remain in a dormant state [8, 15]. Due to unknown factors the inoculation changes into a clinical infection after a period of time, even after a number of years [3, 4, 17, 18, 26]. Mechanical irritation and metal fretting might be co-factors in this process. There are reports about favourable behaviour of titanium versus steel biomaterials in respect to bacterial adhesion [2, 21, 22] and about differences in acute infection rates between stainless steel and titanium implants [1, 16]. Titanium implants might, therefore, be of advantage in this respect of reducing the risk for early as well as late infections. Reported incidence rates of delayed infections after instrumented spine surgery are 0.3–8.3%. All authors reported successful treatment through implant removal and primary wound closure, followed by culture-directed antibiotics. The duration of antibiotics varied among different authors, apparently depending on clinical signs of improvement [3, 4, 10, 13, 17, 18, 23, 26]. We report a rate of 6.9% late infections. The known incidence becomes obviously higher with improved cultural techniques. Reoperation frequency for late operative site pain was reported up to 19% and unrecognised infection was suggested as one possible reason for it [5]. The identification of *P. acnes* is difficult and requires specific microbiological diagnosis [15]. We have been routinely using these specific techniques for some years, which led us to identify *P. acnes* in six patients. There were no other causative organism identified in these cases. Adolescents have a higher prevalence of skin acne than the normal population [20] and it is therefore possible that this age group is more susceptible to late infection with *P. acnes*. Even with very strict aseptic techniques and antibiotic prophylaxis local intraoperative bacterial contamination is possible [6]. Clark and Shufflebarger [4] in one of the more recent studies found only 1.7% delayed infections, which is very low compared with the other available literature.

**Table 4** Parameters of revision surgery

| | Patient 1 | Patient 2 | Patient 3 | Patient 4 | Patient 5 | Patient 6 | Patient 7 |
|---|---|---|---|---|---|---|---|
| Implant failure | No | No | No | One broken screw | No | No | Distal screw loosening |
| Intraoperative findings | Sinus drainage to implant | Purulence | Purulence | Purulence | Purulence | Necrosis, no purulence | Purulence |
| Pseudarthrosis | No | No | No | No | No | No | No |
| Microbiology | *P. acnes* | Negative cultures | *P. acnes* | *P. acnes* | *P. acnes* | *P. acnes* | *P. acnes* |
| Hospital stay (days) | 9 | 12 | 16 | 11 | 32 | 9 | 6 |
| Parenteral antibiotics | Ciprofloxacin | Ciprofloxacin, rifampicin | Amoxicillin | Ciprofloxacin, rifampicin | Ciprofloxacin, teicoplanin, netilmicin | Amoxicillin | Flucloxacillin |
| Oral antibiotics | Ciprofloxacin | Ciprofloxacin, rifampicin | Amoxicillin | Ciprofloxacin, rifampicin | Clindamycin | Amoxicilllin | Amoxicillin |
| Duration of antibiotics (weeks) | 8 | 4 | 8 | 9 | 8 | 4 | 6 |
| Complications in wound healing | No | No | No | No | No | No | No |

**Table 5** Parameters at last follow-up

| | Patient 1 | Patient 2 | Patient 3 | Patient 4 | Patient 5 | Patient 6 | Patient 7 |
|---|---|---|---|---|---|---|---|
| Pain | No | No | No | No | No | No | No |
| Follow-up after index surgery (months) | 62 | 60 | 62 | 48 | 62 | 94 | 71 |
| Follow-up after revision (months) | 23 | 47 | 15 | 23 | 46 | 66 | 11 |
| Loss of scoliosis correction (°) | 10 | 26 | 0 | 10 | 0 | 5 | 0 |

Unfortunately the published results do not mention enough biometric data to allow further comparative interpretation. Most of the studies do not mention early infections. In our series of 101 patients, there were no early infections. This demonstrates the effectiveness of present aseptic techniques and antibiotic prophylaxis against early postoperative infections. Even though neuromuscular patients are reported to be more prone to early postoperative infections compared with idiopathic patients [24], we did not find any difference in prevalence of late implant infection between neuromuscular and idiopathic patients in our present series, despite the use of allograft in all neuromuscular patients and autograft in idiopathic patients. Late infections after scoliosis surgery remain mainly a clinical diagnosis. The usual presenting symptoms of late implant infections are moderate local pain and swelling with inconsistent laboratory findings. In our series, fever was not a useful indicator for delayed infection, as it was not in others [26]. The location of the infection was mainly seen at the pedicle screws and at the crosslinks. Other authors described similar locations of purulence, especially at interlinks and hooks [3–5, 17, 26]. We believe that implant removal is the key element in treatment of late implant infections. Only with extended cultural techniques could *P. acnes* be found as the causative organism. Non-specific wide-range parenteral antibiotic therapy for a few days, followed by culture-directed oral therapy up to 4–9 weeks was an adequate treatment. We agree with Richards and Emara [17] that delayed infection is mainly a problem of the soft tissue and not of the bone. In our own results, patients with shorter antibiotic therapy (4 weeks) had the same good final outcome as those with longer (8–9 weeks) therapy, an observation also made by other authors [4, 17]. Early infections after corrective operation can compromise the result of the operation if the implants have to be removed [14]. In the case of late infections, we found in the present series significant loss of correction despite bony fusion only in one case, where implant removal was done 14 months after the correction procedure. A loss of correction can occur when the fusion mass is still immature. For all other patients with at least 18 months between primary and revision surgery, we found no significant loss of correction (0°–10°).

## Conclusions

Late infections after elective scoliosis surgery is a problem with a prevalence between 0.3% and 8.3% [3, 4, 17, 23, 26]. Diagnosis is mainly clinical, blood parameters being not reliable. High level of suspicion is necessary when the patient presents with pain at the operation site after a pain-free interval. Specific laboratory methods are needed to prove the bacteriological cause of infection. *P. acnes* is the common causative organism. The current management strategy with implant removal, debridement and antibiotic therapy is adequate and results in good clinical outcome. Despite obvious fusion mass, a certain loss of correction can occur, especially if implants are removed earlier than 18 months after surgery.

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