Propionibacterium acnes: an under-appreciated cause of post-neurosurgical infection

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Background: Propionibacterium acnes is increasingly recognized as a cause of post-neurosurgical infection. This review of patients with P. acnes neurosurgical infection was carried out in order to determine clinical characteristics and outcomes in relation to duration of antimicrobial treatment.

Methods: We retrospectively reviewed the charts of consecutive patients with P. acnes isolated from neurosurgical specimens from 1 January 1999 to 30 June 2005. We defined P. acnes neurosurgical infection as isolation of P. acnes alone from a sterile neurosurgical site in a patient who clinically improved following treatment with an appropriate antibiotic.

Results: We identified 28 patients with definite P. acnes neurosurgical infection; median age 49 years (range 23–77); 15 (54%) male. All patients had prior neurosurgical procedures: 27 (96%) post-craniotomy. The median time from surgery to presentation was 54 days (range 12–1578). Eighteen out of 28 (64%) patients who met the definition of neurosurgical infection had Gram-positive bacilli seen in at least one surgical specimen compared with only 2/56 (4%) patients who did not meet the definition (P < 0.0001). Intravenous benzyl penicillin + oral penicillin VK was the most common treatment. The median duration of antibiotic treatment for intracranial infection was 29 days. Five of nine patients who had extracranial bone-flap-associated infection had ≤7 days of intravenous treatment and were cured. Two patients had relapse or reinfection.

Conclusions: P. acnes neurosurgical infection often presents in an indolent fashion. Gram-positive bacilli on Gram stain should not be discounted as a contaminant in neurosurgical specimens. Associated bone flaps should be removed. Intravenous benzyl penicillin + oral penicillin VK remains effective treatment.

Keywords: central nervous system, Gram-positive, antibiotic therapy

Introduction

Propionibacterium acnes is increasingly recognized as a cause of post-neurosurgical infection.1–4 While it has most frequently been isolated from infected neurosurgical shunts, it has also been described as a pathogen in a wide range of neurosurgical post-operative infections.1,2,4–6 Optimal treatment is uncertain.

P. acnes is a Gram-positive pleomorphic diphtheroid-like anaerobic bacillus.2 Some strains are aerotolerant. It is part of the normal skin flora, especially of the scalp, and is therefore a common contaminant of scalp wound swabs. P. acnes can be difficult to isolate because of its slow growth and anaerobic requirements.

We reviewed patients with neurosurgical P. acnes infection to determine the clinical characteristics, site of infection, antibiotic treatment and clinical outcome.

Methods

Study population

The neurosurgical service at Auckland City Hospital is the tertiary referral centre for an adult population of 1.7 million and performs ~1200 neurosurgical operations each year. We retrospectively reviewed the charts of consecutive adult patients (age ≥15 years) who had P. acnes isolated from wound swabs, tissue specimens, aspirates and other sterile site specimens collected during...
neurosurgical operations at Auckland City Hospital over the 6.5 years from 1 January 1999 to 30 June 2005.

Data collection
We reviewed the clinical charts of all patients from whom P. acnes was isolated from a neurosurgical specimen to collect information on patient demographics, presentation characteristics, surgical interventions, antibiotic treatment and clinical outcome. We considered patients who had P. acnes isolated alone from a normally sterile neurological site and who clinically improved following treatment with an appropriate antibiotic to have definite P. acnes neurosurgical infection.

Patients with surgical findings of osteomyelitis of the bone flap and/or osteomyelitis of surrounding bone, regardless of whether or not the bone flap had been replaced with a prosthetic plate, were considered to have bone-flap-associated infection. We diagnosed complicating extracranial subgaleal abscess, and/or intracranial infection including extradural and subdural abscesses, brain abscess, or meningitis, by conventional clinical, radiological and/or surgical findings. P. acnes was considered a contaminant when isolated alone from a normally sterile neurosurgical site in a patient whose condition did not worsen when either not treated or treated for ≤3 days with appropriate antibiotics. We considered the antibiotic regimen in use on the seventh day after the neurosurgical procedure, when all microbiological data were expected to be available, to be the definitive antimicrobial regimen. Routine neurosurgical antibiotic prophylaxis given to the majority of patients was cefazolin 1.0 g as either a stat dose or 8 hourly for four doses.

Microbiology
P. acnes was identified routinely in the microbiology laboratory as an anaerobic Gram-positive bacillus with pleomorphic diptheroid morphology that tested indole-positive and catalase-positive, with enhanced growth when grown anaerobically. Anaerobic cultures were checked three times each week. Routine susceptibility testing was not done, but antimicrobial treatment was informed by the results of susceptibility testing of previous isolates.

Statistical methods
Results are presented as medians (range). P values (two-tailed) were calculated using Fisher’s exact test.

Ethics
The study was considered by the Auckland Ethics Committee, which deemed that it was an audit and therefore did not require Ethics Committee approval.

Results
Between 1 January 1999 and 30 June 2005, P. acnes was isolated from neurosurgical specimens from 84 patients. Twenty-eight (33%) patients met our definition of definite P. acnes neurosurgical infection. We excluded 24 patients who had P. acnes plus other organisms isolated from the neurosurgical specimen(s) and 32 patients whose P. acnes isolates were considered contaminants.

Initial assessment
Of the 28 patients with definite P. acnes neurosurgical infections, 15 (54%) were male and the median age was 49 (range 23–77) years. Thirteen (46%) were European, six (21%) Maori, five (18%) Asian and four (14%) Pacific Islanders. All patients had prior neurosurgical procedures. The preceding surgery was a craniotomy in all patients except one who had a burr hole to drain a subdural haemorrhage. The underlying diagnoses were tumour in 21 patients (75%) (17 meningioma, 2 glioblastoma, 1 oligodendroglioma and 1 adenocarcinoma), a cerebral aneurysm that required clipping in 3 patients (11%), seizure disorders requiring surgery in 2 patients (7%) (temporal lobectomy and hemispherectomy), revision of a ventriculoperitoneal shunt in 1 patient (4%) and subdural haemorrhage (4%) in the patient requiring a burr hole. The median time from surgery to presentation was 54 days (range 12 to 1578) except for one ‘outlier’ who had resection of a meningioma 38 years earlier and presented with a multi-focal left frontal lobe cerebral abscess at the site of the previous surgery.

Eight (29%) patients had started antibiotics before admission and in five (18%), the antibiotic had activity against P. acnes (four amoxicillin/clavulanate and one clindamycin). Four (14%) patients had diabetes mellitus and five (18%) patients were being treated with dexamethasone (between 2 and 8 mg per day) at the time of diagnosis of definite P. acnes neurosurgical infection.

The presenting signs and symptoms are shown in Table 1. The median duration of symptoms prior to presentation was 10 days (range 2–120). Eleven (39%) patients presented with neurological deficits. Only seven (25%) patients were febrile (temperature >37.5°C) on admission with a median temperature in the group that was febrile of 38.4°C (range 37.9–38.6). All patients presented with local signs of inflammation at the neurosurgical site (including persistent swelling, peri-craniotomy bone margin tenderness, neurological signs or a combination of these symptoms. The median white blood count was 8.3 × 10^9 cells/L (range 5.2–22.8); 23 (82%) patients had a normal total white blood count (4.0–11.0 × 10^9 cells/L). The median erythrocyte sedimentation rate (ESR) was 31 mm/h (range 1–116) and C-reactive protein (CRP) was 9 mg/L (range 1–117). Fifteen of 23 (65%) patients had an elevated ESR (based on standard age-related reference ranges) or CRP (>5 mg/L).

The sites of infection were bone-flap- or prosthesis-associated infection, subdural abscess, extradural abscess, cerebral abscess,

<table>
<thead>
<tr>
<th>Table 1. Presenting features of patients with P. acnes neurosurgical infection</th>
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<tbody>
<tr>
<td>Characteristics</td>
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<tr>
<td>History of fever</td>
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<tr>
<td>Febrile on admission</td>
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<tr>
<td>Headache</td>
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<tr>
<td>At site of bone flap swelling</td>
</tr>
<tr>
<td>pain</td>
</tr>
<tr>
<td>wound discharge</td>
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<tr>
<td>Neurological abnormality</td>
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</table>
meningitis and subgaleal abscess, as shown in Table 2. Twenty-two patients (patients 1–22) (79%) had *P. acnes* bone-flap-associated infection. In three of these patients, the bone infection was not associated with infection of adjacent tissues. However, 6 patients had bone infection complicated by an adjacent subgaleal abscess and 13 had infection of various intracranial tissues.

**Microbiology**

Eighteen (64%) patients had Gram-positive bacilli seen on Gram stain of at least one surgical specimen. Only 2 of the 56 (4%) patients who had *P. acnes* isolated from neurosurgical specimens but who did not meet the definition for definite *P. acnes* neurosurgical infection had Gram-positive bacilli seen in neurosurgical specimens (*P* < 0.0001). Both of these patients had brain abscesses from which several other anaerobic organisms were isolated. In the 28 patients with definite infection, *P. acnes* grew a median of 4 days (range 2–9) after specimens were taken.

**Treatment and outcome**

All patients had at least one surgical procedure performed to drain pus and/or to remove the infected bone flap or prosthesis (Table 2). All but one patient with bone-flap-associated infection eventually had the bone flap removed. Eight (29%) patients required a further surgical procedure; removal of an infected bone flap in three and further debridement in five patients.

Nearly all isolates of *P. acnes* are susceptible to benzylpenicillin and clindamycin. Our general intention was to treat definitively with intravenous (iv) benzyl penicillin followed by oral penicillin VK (extracranial infection only) with the duration and route dependent on the sites of infection. Patients with a history of penicillin allergy were initially treated intravenously with a cephalosporin (cefazolin, ceftriaxone or cefoxitin) or clindamycin followed by oral clindamycin. In the event, 26/30 (87%) episodes were managed definitively with these agents. Overall, 18/30 (60%) episodes were managed definitively with iv benzyl penicillin and/or oral penicillin VK and a further 3 with iv and/or oral amoxicillin. The initial empirical treatment in 10 patients was with agents not active against *P. acnes*. It took a median of 4 days (range 1–8) until effective antibiotic treatment began in these 10 patients.

The nine patients (patients 1–9) with extracranial infection only (with/without subgaleal infection) tended to be managed more conservatively than those with intracranial infection. While the median duration of all antibiotic treatment in this group was 29 days (range 7–56), the median duration of iv treatment was only 6 days (range 0–28) and of oral treatment was 14 days (range 3–42). In 6 of 10 (60%) episodes, iv treatment was for ≤7 days and in 6 of 10 (60%) episodes, subsequent oral treatment was ≤14 days. Two patients did not have bone flaps removed (patients 5 and 9); both received only 7 days of antibiotic and one failed. No patient with bone flap removal relapsed.

Our intention was to treat all those with focal intracranial infection with or without associated bone flap infection (i.e. those with subdural, extradural or cerebral abscess) with iv antibiotic for 4–6 weeks. In the event, the 19 patients (20 episodes) with intracranial infection received a median of 29 days (range 11–142) of total antibiotic treatment. Fourteen episodes were managed with iv antibiotics alone, four with subsequent oral antibiotic and two, successfully (patients 13 and 26), with oral antibiotics alone.

**Follow-up**

The median length of follow-up was 326 days (range 54–1324). Three patients died 5, 6 and 11 months after initial admission with definite *P. acnes* neurosurgical infection, but all these deaths were unrelated to this infection.

There was one definite and one possible relapse. One patient (patient 5) initially diagnosed with a subgaleal abscess 206 days after meningioma resection did not have bone flap removal and was treated with only 7 days of iv/oral amoxicillin/clavulananate. She re-presented 40 days later with bone-flap-associated infection. Surgical specimens grew *P. acnes* again. She was cured after removal of the bone flap and 42 days of iv benzyl penicillin. The other patient (patient 22) presented with bone-flap-associated infection, a subdural abscess and meningitis following a left hemispherectomy. Following debridement and removal of the infected bone flap, he had 11 days of iv benzyl penicillin followed by 14 days of oral penicillin VK. Twelve months later, there was no evidence of persisting infection and a Rickham reservoir was inserted. The patient presented 10 weeks after that with *P. acnes* meningitis and was treated successfully with iv benzyl penicillin and oral rifampicin.

**Discussion**

This review of 28 patients is the largest reported case series of *P. acnes* neurosurgical infection. The indolent nature of infection with this pathogen is illustrated by the prolonged duration of symptoms prior to presentation, rarity of fever, usually normal white blood count, no attributable mortality and the significant time lapse from previous neurosurgery to presentation. These findings are similar to previous reports.

In this review, we rejected a small majority of the *P. acnes* isolates as contaminants, reflecting their frequency as commensal scalp flora. Nevertheless, we considered one-third of all patients from whom *P. acnes* was isolated from a neurosurgical specimen to have definite *P. acnes* neurosurgical infection. We used strict criteria to identify a group of patients for whom there could be no doubt of the pathogenic role of *P. acnes*. We excluded those patients who had a polymicrobial flora including *P. acnes* (isolated most commonly from brain abscesses), but acknowledge the potential role of *P. acnes* in those clinical situations. This decision results in an underestimate of the true frequency of *P. acnes* as a contributor to post-neurosurgical infection. Eighteen of 28 (64%) patients with definite *P. acnes* neurosurgical infection had Gram-positive bacilli seen in at least one neurosurgical specimen compared with 2 of 56 (4%) patients who did not meet this definition. Although we acknowledge the confounding effects of our retrospective evaluation on this sort of judgment, the finding nevertheless supports the relevance of Gram-positive bacilli alone on Gram stain when only *P. acnes* is subsequently cultured.

The results of our study contrast in two important respects with the findings of Barazi et al. who reviewed 18 case reports of post-operative intracranial infection due to *P. acnes*. They found a propensity for *P. acnes* neurosurgical infection to occur
Table 2. Details of patients with *P. acnes* neurosurgical infection

<table>
<thead>
<tr>
<th>Patient number</th>
<th>Age/gender</th>
<th>Time from neurosurgery to presentation (days)</th>
<th>Infection site(s)</th>
<th>Surgery&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Antibiotic treatment&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Outcome</th>
<th>Follow-up (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>57/M</td>
<td>34</td>
<td>B</td>
<td>d0 removal of BF</td>
<td>PEN d6 to 7, PVK d7 to 21</td>
<td>Cure</td>
<td>326</td>
</tr>
<tr>
<td>2</td>
<td>38/F</td>
<td>100</td>
<td>B, P</td>
<td>d0 removal of P, d14 removal of BF</td>
<td>AMC d0 to 1, FOX d1 to 15, PVK d15 to 29</td>
<td>Cure</td>
<td>678</td>
</tr>
<tr>
<td>3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>75/F</td>
<td>1578</td>
<td>B, P</td>
<td>d0 removal of P</td>
<td>CFZ d0 to 28, CLI d28 to 56</td>
<td>Cure</td>
<td>326, died</td>
</tr>
<tr>
<td>4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>69/M</td>
<td>70</td>
<td>B, P, SG</td>
<td>d0 removal of P</td>
<td>AMC d0 to 1, AMC d1 to 15</td>
<td>Cure</td>
<td>721</td>
</tr>
<tr>
<td>5&lt;sup&gt;d&lt;/sup&gt;</td>
<td>69/F</td>
<td>206</td>
<td>B, P, SG</td>
<td>d0 removal of BF</td>
<td>AMC d0 to 4, AMC d4 to 7</td>
<td>Relapse</td>
<td>622</td>
</tr>
<tr>
<td>6&lt;sup&gt;e&lt;/sup&gt;</td>
<td>66/F</td>
<td>25</td>
<td>B, SG</td>
<td>d0 removal of BF</td>
<td>nil</td>
<td>Cure</td>
<td>1007</td>
</tr>
<tr>
<td>7&lt;sup&gt;e&lt;/sup&gt;</td>
<td>55/M</td>
<td>47</td>
<td>B, SG</td>
<td>d0 removal of BF</td>
<td>CLI d1 to 8, CLI d8 to 29</td>
<td>Cure</td>
<td>128, died</td>
</tr>
<tr>
<td>8</td>
<td>33/M</td>
<td>12</td>
<td>B, SG</td>
<td>d0 removal of BF</td>
<td>PEN d3 to 25, PVK d25 to 37, PRB d25 to 37</td>
<td>Cure</td>
<td>393</td>
</tr>
<tr>
<td>9&lt;sup&gt;e&lt;/sup&gt;</td>
<td>75/F</td>
<td>178</td>
<td>B, SG</td>
<td>d0 drainage SG</td>
<td>nil</td>
<td>Cure</td>
<td>802</td>
</tr>
<tr>
<td>10</td>
<td>49/F</td>
<td>146</td>
<td>B, ED, SG</td>
<td>d0 removal of BF</td>
<td>PEN d1 to 14, PVK d14 to 28</td>
<td>Cure</td>
<td>858</td>
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<tr>
<td>11</td>
<td>63/F</td>
<td>64</td>
<td>B, ED</td>
<td>d0 drainage ED + removal of BF, d2 drainage ED</td>
<td>CRO d0 to 6, PEN d6 to 28</td>
<td>Cure</td>
<td>1324</td>
</tr>
<tr>
<td>12</td>
<td>43/F</td>
<td>54</td>
<td>B, ED</td>
<td>d0 removal of BF</td>
<td>CRO d1 to 4, PEN d4 to 32</td>
<td>Cure</td>
<td>230</td>
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<tr>
<td>13</td>
<td>24/M</td>
<td>162</td>
<td>B, ED</td>
<td>d0 removal of BF</td>
<td>nil</td>
<td>Cure</td>
<td>110</td>
</tr>
<tr>
<td>14</td>
<td>59/M</td>
<td>57</td>
<td>B, ED</td>
<td>d0 removal of BF, d5 drainage of ED</td>
<td>CRO d0 to 7, VAN d0 to 7, PEN d7 to 11</td>
<td>Cure</td>
<td>173</td>
</tr>
<tr>
<td>15</td>
<td>52/M</td>
<td>33</td>
<td>B, ED</td>
<td>d0 removal BF + drainage ED</td>
<td>PEN d0 to 3, PEN d2 to 30</td>
<td>Cure</td>
<td>280</td>
</tr>
<tr>
<td>16</td>
<td>40/F</td>
<td>85</td>
<td>B, ED</td>
<td>d0 removal of BF</td>
<td>PEN d4 to 7, PVK d7 to 21</td>
<td>Cure</td>
<td>245</td>
</tr>
<tr>
<td>17&lt;sup&gt;e&lt;/sup&gt;</td>
<td>65/M</td>
<td>63</td>
<td>B, CA</td>
<td>d0 removal of BF</td>
<td>PEN d5 to 33, nil</td>
<td>Cure</td>
<td>204</td>
</tr>
<tr>
<td>18&lt;sup&gt;e&lt;/sup&gt;</td>
<td>47/M</td>
<td>21</td>
<td>B, CA, SG</td>
<td>d0 removal of BF + drainage of CA</td>
<td>CRO d8 to 50</td>
<td>nil</td>
<td>Cure</td>
</tr>
<tr>
<td>19&lt;sup&gt;e&lt;/sup&gt;</td>
<td>65/F</td>
<td>53</td>
<td>B, P, CA, SG</td>
<td>d0 drainage of CA, d2 removal + replaced P</td>
<td>AMC d0 to 2, PEN d4 to 46</td>
<td>Cure</td>
<td>54</td>
</tr>
<tr>
<td>20</td>
<td>34/M</td>
<td>364</td>
<td>B, P, ED, CA</td>
<td>d0 removal of BF/P + drainage ED/CA</td>
<td>PEN d1 to 43</td>
<td>nil</td>
<td>Cure</td>
</tr>
<tr>
<td>No.</td>
<td>Age</td>
<td>Sex</td>
<td>Admission Code</td>
<td>Initial Diagnosis</td>
<td>Initial Management</td>
<td>Duration</td>
<td>Outcome</td>
</tr>
<tr>
<td>-----</td>
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</tr>
<tr>
<td>21</td>
<td>73</td>
<td>M</td>
<td>14 005</td>
<td>B, ED, CA, SG</td>
<td>d0 drainage of CA, d7 drainage of CA + removal of BF</td>
<td>58</td>
<td>Cure</td>
</tr>
<tr>
<td>22</td>
<td>22</td>
<td>M</td>
<td>21</td>
<td>B, ED, SG, M, SD</td>
<td>d0 removal of BF</td>
<td>16</td>
<td>Possible relapse</td>
</tr>
<tr>
<td>23</td>
<td>435</td>
<td>M</td>
<td>435</td>
<td>Removal of Rickham reservoir</td>
<td>d435 removal of Rickham reservoir</td>
<td>17</td>
<td>Cure</td>
</tr>
</tbody>
</table>

Intracranial infection: without bone flap infection

<table>
<thead>
<tr>
<th>No.</th>
<th>Age</th>
<th>Sex</th>
<th>Admission Code</th>
<th>Initial Diagnosis</th>
<th>Initial Management</th>
<th>Duration</th>
<th>Outcome</th>
</tr>
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<tbody>
<tr>
<td>23</td>
<td>72</td>
<td>F</td>
<td>32</td>
<td>CA</td>
<td>d0 drainage of CA</td>
<td>32</td>
<td>Cure 195, died</td>
</tr>
<tr>
<td>24</td>
<td>67</td>
<td>F</td>
<td>37</td>
<td>CA</td>
<td>d0 drainage of CA</td>
<td>36</td>
<td>Cure</td>
</tr>
<tr>
<td>25</td>
<td>70</td>
<td>F</td>
<td>37</td>
<td>CA</td>
<td>d0 drainage of CA, d14 removal of BF</td>
<td>24</td>
<td>Cure</td>
</tr>
<tr>
<td>26</td>
<td>78</td>
<td>M</td>
<td>43</td>
<td>SD</td>
<td>d0 burr hole</td>
<td>24</td>
<td>Cure</td>
</tr>
<tr>
<td>27</td>
<td>69</td>
<td>M</td>
<td>49</td>
<td>SD</td>
<td>d0 drainage of SD</td>
<td>29</td>
<td>Cure</td>
</tr>
<tr>
<td>28</td>
<td>58</td>
<td>M</td>
<td>71</td>
<td>M</td>
<td>d0 removal EVD</td>
<td>21</td>
<td>Cure</td>
</tr>
</tbody>
</table>

B, bone-flap-associated infection; SD, subdural abscess; ED, extradural abscess; CA, cerebral abscess; M, meningitis; SG, subgaleal abscess; P, prosthesis; BF, bone flap; d, day; AMC, amoxicillin/clavulanic acid; PEN, benzylpenicillin; PVK, penicillin VK; RIF, rifampicin; CLI, clindamycin; CFZ, cefazolin; CRO, ceftriaxone; FOX, cefoxitin; VAN, vancomycin; PRB, probenecid.

a d0 (day 0) is the date of surgery when the initial positive specimen was collected.
b Inappropriate antibiotic treatment was excluded from this table.
c Transferred to another institution on CFZ prior to P. acnes being cultured.
d Not seen by an infectious diseases physician.
e Allergic to penicillin.
in immunocompromised patients while we found most infections were in non-immunocompromised patients. Only half of the cases reported by Barazi had \textit{P. acnes} infection following prior craniotomy with the remainder occurring after wound debridement, burrhole surgery, biopsy and ventriculoperitoneal shunt insertion. In contrast, all but one of our patients had \textit{P. acnes} infection following a craniotomy.

\textit{P. acnes} is slow to grow in the laboratory. This often results in a delay in diagnosis and treatment or even a missed diagnosis if specimens are not cultured for an extended period, although the strong correlation between Gram stain positivity and subsequent culture should alert laboratory microbiologists and clinicians to this organism in these clinical situations. In our study, all \textit{P. acnes} had grown by 9 days. These data argue that neurosurgical specimens should be cultured anaerobically for 10 days.

Because of its rarity, the optimal agent, duration and route of antimicrobial treatment for \textit{P. acnes} neurosurgical infection has not been and is unlikely ever to be critically determined. In general, we treated patients with intracranial complications of bone flap infection including subdural, external and cerebral abscess with penicillin given intravenously for 4 weeks, in line with standard recommendations. The two patients with \textit{P. acnes} meningitis not associated with bone flap infection received a shorter duration of treatment, again broadly in line with recommendations for the management of meningitis.

It seems intuitively unlikely that bone-flap-associated infection without intracranial complications and where the bone flap has been removed needs prolonged iv treatment. Cranial bone has an excellent blood supply as have the local soft tissues. One study refers to two patients with bone flap infection treated successfully with only 10 days of iv benzyl penicillin, although both did have intracranial complicating factors and both had surgical treatment. Although the median duration of antibiotic treatment in our patients with bone flap infection without intracranial complications was 29 days (range 7–56), the median duration of iv treatment was 6 days (range 0–28) and of oral treatment 14 days (range 3–42). Although our data are uncontrolled, they do suggest that shorter courses, perhaps 14 days or even less, might be adequate where there is confidence that there is no intracranial infection complicating the bone flap infection and the flap has been removed. The only definite failure was in a patient with a retained bone flap. Although two patients had a follow-up period of $<$4 months, the median time of follow-up of 326 days was well beyond the median time to initial presentation of 54 days.

\textit{P. acnes} is susceptible in vitro to many antibiotics including the majority of \(eta\)-lactams, clindamycin, vancomycin and fluoroquinolones. While variations of these agents might be used in some neurological units before microbiological data are available, our data support the definitive use of iv benzyl penicillin and oral penicillin VK or amoxicillin, and clindamycin (in cases without meningitis) or a cephalosporin where patients are allergic to penicillin in patients infected with \textit{P. acnes} after neurosurgery. There is need for broader spectrum or newer agents.

Our data highlight the clinical importance of \textit{P. acnes} when it is isolated from neurosurgical specimens and supports the need for routine anaerobic culture for 10 days for all neurosurgical specimens. Empirical treatment that has activity against \textit{P. acnes} should be used when Gram-positive bacilli are seen on Gram stain, but there were no adverse outcomes when appropriate treatment was delayed, reflecting the low virulence of this organism. While treatment duration was not prospectively studied, our experience suggests that short treatment courses of perhaps 14 days of a narrow-spectrum antibiotic (e.g. benzyl penicillin and penicillin VK) are sufficient for bone-flap-associated infection where there is no intracranial infection and the bone flap is removed. These same old agents clearly remain appropriate in general for \textit{P. acnes} infection occurring after neurosurgical operations.

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**References**


_P. acnes_ post-neurosurgical infection