Incidence of microbiological contamination of local bone autograft used in posterior lumbar interbody fusion and its association with postoperative spinal infection

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OBJECTIVE The aim of this study was to examine the results of microbiological cultures from local bone autografts used in posterior lumbar interbody fusion (PLIF) and to identify their association with postoperative spinal infection.

METHODS The authors retrospectively evaluated cases involving 328 patients who had no previous spinal surgeries and underwent PLIF for degenerative diseases with a minimum 1-year follow-up. Local bone was obtained during laminectomy, and microbiological culture was performed immediately prior to bone grafting. The associations between culture results from local bone autografts and postoperative spinal infections were evaluated.

RESULTS The contamination rate of local bone was 4.3% (14 of 328 cases). Coagulase-negative Staphylococcus (29%) was the most common contaminant isolated, followed by Streptococcus species and methicillin-sensitive Staphylococcus aureus. Of 14 patients with positive culture results, 5 (35.7%) had postoperative spinal infections and were treated with intravenous antibiotics for a minimum of 4 weeks. One of these 5 patients also underwent reoperation for debridement during this 4-week period. Regardless of the microbiological culture results, the infection rate after PLIF with local bone autograft was 2.4% (8 of 328 cases), with 5 (62.5%) of 8 patients showing positive results on autograft culture.

CONCLUSIONS The incidence of contamination of local bone autograft during PLIF was considerable, and positive culture results were significantly associated with postoperative spinal infection. Special attention focused on the preparation of local bone for autograft and its microbiological culture will be helpful for the control of postoperative spinal infection.

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KEY WORDS contamination; local bone autograft; posterior lumbar interbody fusion; infection
spectively reviewed the records of 512 patients who underwent lumbar fusion surgeries using local bone autografts at Samsung Medical Center. After excluding patients with a history of previous spinal surgery or spinal infection and those with a diagnosis of adolescent idiopathic scoliosis, congenital malformation of the spine, fracture, or rheumatological or other inflammatory joint disease (such as ankylosing spondylitis), we identified 405 patients who underwent PLIF for degenerative diseases. Seventy-seven patients without culture results from local bone autografts and a minimum 1-year follow-up were excluded. The remaining 328 patients were included in this study. We examined microbiological culture results for prepared autogenous local bone graft in intervertebral spaces and associations between positive culture results of prepared local bone and postoperative spinal infection. This study protocol was approved by the Samsung Medical Center institutional review board.

Patients

The 328 patients comprised 101 males and 227 females with a mean age of 60 years (range 21–84 years). All patients underwent PLIF at intervertebral disc levels from L1–2 to L5–S1 with local bone autografts and titanium cages. Local bone autografts included any bone obtained during surgery. Most of the local bone was derived from a lamina, spinous process, or facet joint, and once obtained, it was carefully prepared by a highly trained surgical assistant (with an MD degree). Harvested local bone was prepared by the complete removal of soft tissue or cartilage and morselized, using a bone mill, into 2- to 3-mm fragments. After soft tissue removal, prepared bone was wrapped in saline-soaked gauze during the interval before use in PLIF. Prior to its application to the cage or intervertebral disc space, 2 or 3 fragments of prepared bone were transferred to a culture tube containing saline, which was labeled with the patient’s name and identification number, for microbiological screening (Fig. 1). Routine microbiological culture and screening of prepared local bone were performed for all cases and included gram stain and culture, acid-fast bacilli stain, fungus culture, and polymerase chain reaction analysis for Mycobacterium tuberculosis. Patients underwent 1-level (n = 116), 2-level (n = 91), or ≥ 3-level (n = 121) PLIF surgeries from L1–2 to L5–S1 intervertebral disc levels for lumbar degenerative diseases.

Surgical Technique

All surgeries were performed at the same institution by 2 senior surgeons (C.S.L. and S.S.C.) who had similar experience in this spinal surgery. In all cases, PLIF with prepared local bone autografts and titanium cages was performed using a midline incision and augmented by posterior instrumentation. If local bone was not sufficient for PLIF, irradiated allograft bone (γ irradiation, 25 cGy) or harvested autogenous iliac cancellous bone was applied. When allograft bone was used in PLIF, microbiological culture was performed, but culture screening was not performed for autogenous iliac bone grafts because the preparation procedure of the autogenous iliac bone was simple and clear. No bone morphogenetic protein, demineralized bone matrix, or any type of bone substitute was used in this study.

Based on previous criteria for surgical site infection, postoperative spinal infection was defined by the following criteria: 1) an increase in levels of inflammatory markers such as C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR); 2) an aggravation of clinical symptoms and signs, including back pain or radiating pain in the lower extremities, fever, or redness/tenderness/swelling at the surgical site; and 3) no evidence of inflammation in other parts of body. In this study, superficial wound infection during the early postoperative period, such as stitch-out abscess, was not considered a postoperative spinal infection, and only deep spinal infection was regarded as a postoperative spinal infection. Alternatively, absence of postoperative infection was defined as absence of any infectious signs or symptoms during the 1-year postoperative period. At each outpatient clinic visit (1, 3, 6, and 12 months after surgery), evidence of infection was actively sought. This involved obtaining a history of pain, inspecting the wound, and monitoring for radiographic changes. Radiographic changes, however, were not included in the postoperative infection criteria because those changes could not be definite in the early postoperative stage. However, if definitive signs of infection were observed on simple x-rays, such as a halo around the cages or subsidence of the cage, further workups, including MRI, were evaluated. Routine postoperative antibiotics were applied, with first-generation cephalosporin administered during the first 3 days postoperatively and oral antibiotics used until postoperative Day 7. For those patients diagnosed with postoperative spinal infection, all medical treatments for spinal infection were performed after consultation with a physician from our institution’s infectious disease section. Infection indicators (complete blood count, CRP, and ESR) were checked preoperatively and on postoperative Days 3, 5, and 7 and twice weekly thereafter, if necessary.

The cases of patients who showed positive culture re-
results of prepared local bone autografts were investigated in detail, and subsequent progression of their conditions and all treatment procedures were reviewed. The associations between positive local bone culture and postoperative spinal infection were also evaluated. In addition, regardless of microbiological culture results for prepared bone, the cases of all patients who showed postoperative spinal infection symptoms and signs were analyzed in this study.

Results

There were 328 patients who met the inclusion criteria. The contamination rate of prepared local bone autografts in these cases was 4.3% (14 of 328). *Staphylococcus* species were the most commonly isolated contaminants and were found in 42.9% (6 of 14) of the contaminated local bone. Coagulase-negative *Staphylococcus* was found in 4 of these patients (28.6%), and methicillin-sensitive *Staphylococcus aureus* was isolated in 2 patients. *Pseudomonas* and *Streptococcus* species were the next most common contaminants, identified in 2 cases each. Other local bone contaminants included *Propionibacterium, Enterococcus*, and the fungus *Candida parapsilosis*.

In 5 (35.7%) of the 14 patients with positive culture results, these results were associated with postoperative spinal infections. These 5 (1.5%) of 328 patients were treated with intravenous antibiotics for a minimum of 4 weeks; however, 1 of the 5 patients underwent reoperation for debridement while being treated with antibiotic therapy. In the remaining 9 patients, positive culture results were also obtained for local bone but did not meet the criteria for postoperative spinal infection. These patients were closely observed without the need for additional management and were routinely discharged under the conditions of no specific symptoms or laboratory abnormality associated with postoperative spinal infection. Detailed characteristics of the patients who showed positive culture results are shown in Table 1. The postoperative spinal infections were not associated with specific microorganisms.

Three patients without positive culture results for local bone showed symptoms and signs of postoperative spinal infection, and their details are presented in Table 2. Regardless of the microbiological culture results, the infection rate after PLIF with local bone autograft was 2.4% (8 of 328 patients). In 5 of the 8 infected patients (62.5%), postoperative spinal infection was associated with the contamination of prepared local bone autograft. Meanwhile, irradiated allograft bone was used in 80 patients, but there were no positive culture results for these grafts.

Patients showing symptoms and signs of postoperative spinal infection were treated with intravenous antibiotics until their CRP levels were normalized across 3 consecutive samplings. If the results of laboratory tests and clinical symptoms worsened despite appropriate systemic antibiotic therapy, surgical management was undertaken. Reoperations were performed in 2 patients (1 with and 1 without positive culture for local bone autograft) who displayed signs and symptoms of aggravated infection despite treatment with the appropriate antibiotic agents.

Regarding the relationship between fusion length and infection rate, among the 8 patients who were found to have postoperative infections, 2, 3, and 3 patients underwent fusion of 2, 3, and 3 vertebrae, respectively. The association between fusion length and postoperative infection rate was not significant (P = 0.33).

### Table 1. Characteristics of the patients who had positive results on microbiological culture of local bone autograft and the association with postoperative spinal infection

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Yr of Op</th>
<th>Sex, Age (yrs)</th>
<th>PLIF Level</th>
<th>Cultured Bacteria in Local Bone</th>
<th>Postop Spinal Infection</th>
<th>Reop</th>
<th>IV ABx, Duration</th>
<th>POD of CRP Level</th>
<th>POD of CRP Reincrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2008</td>
<td>F, 58</td>
<td>L2–S1</td>
<td><em>Pseudomonas aeruginosa</em></td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>2008</td>
<td>F, 57</td>
<td>L3–S1</td>
<td><em>P. aeruginosa</em></td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>2008</td>
<td>F, 71</td>
<td>L5–S1</td>
<td><em>Enterococcus faecium</em></td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td>2008</td>
<td>F, 64</td>
<td>L4–5</td>
<td>MSCNS</td>
<td>Y</td>
<td>N</td>
<td>Cefazolin + vancomycin, 4 wks</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>2008</td>
<td>F, 72</td>
<td>L2–S1</td>
<td>MSCNS</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>6</td>
<td>2008</td>
<td>M, 65</td>
<td>L3–5</td>
<td>1) MRSA; 2) <em>Propionibacterium acnes</em></td>
<td>Y</td>
<td>N</td>
<td>Cefazolin + vancomycin, 6 wks</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>7</td>
<td>2008</td>
<td>F, 54</td>
<td>L4–S1</td>
<td>MSCNS</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td>8</td>
<td>2008</td>
<td>F, 63</td>
<td>L3–S1</td>
<td>MSCNS</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td>9</td>
<td>2008</td>
<td>F, 74</td>
<td>L2–5</td>
<td>MSSA</td>
<td>Y</td>
<td>N</td>
<td>Cefazolin, 4 wks</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>2008</td>
<td>M, 63</td>
<td>L3–4</td>
<td><em>Streptococcus parasanguinis</em></td>
<td>N</td>
<td>N</td>
<td>Cefazadone due to dural tear, 9 days</td>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td>11</td>
<td>2009</td>
<td>M, 71</td>
<td>L4–S1</td>
<td>MSSA</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td>12</td>
<td>2009</td>
<td>F, 58</td>
<td>L3–5</td>
<td><em>Candida parapsilosis</em></td>
<td>Y</td>
<td>Y (4 wks postop)</td>
<td>Fluconazole, 4 wks (failed), MRNCNS in reop field 4 wks postop → vancomycin, 6 wks</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>13</td>
<td>2009</td>
<td>F, 57</td>
<td>L3–S1</td>
<td><em>Streptococcus viridans</em></td>
<td>Y</td>
<td>N</td>
<td>Cefazolin, 4 wks</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>14</td>
<td>2009</td>
<td>F, 71</td>
<td>L1–5</td>
<td><em>P. acnes</em></td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>3</td>
<td>—</td>
</tr>
</tbody>
</table>

ABx = antibiotic agent(s); IV = intravenous; MRNCNS = methicillin-resistant coagulase-negative *Staphylococcus*; MRSA = methicillin-resistant *S. aureus*; MSCNS = methicillin-susceptible coagulase-negative *Staphylococcus*; MSSA = methicillin-susceptible *S. aureus*; POD = postoperative day.

* No patient had diabetes mellitus, and only the patient in Case 10 was a smoker.
Contamination rates for local bone autograft used in PLIF

Table 2. Characteristics of patients who had postoperative spinal infections without positive results on microbiological culture of prepared local bone autograft*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Yr of Op</th>
<th>Sex, Age (yrs)</th>
<th>PLIF Level</th>
<th>Cultured Bacteria in Operative Wound</th>
<th>Reop.</th>
<th>IV Abx, Duration</th>
<th>POD of CRP</th>
<th>POD of CRP Reincrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>15†</td>
<td>2008</td>
<td>F, 68</td>
<td>L4–5</td>
<td>None detected</td>
<td>N</td>
<td>Cefazolin, 4 wks</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>16</td>
<td>2008</td>
<td>M, 73</td>
<td>L3–5</td>
<td>MRCNS</td>
<td>Y (POD 19)</td>
<td>Vancomycin + teicoplanin, 10 wks</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>17†</td>
<td>2009</td>
<td>F, 70</td>
<td>L2–S1</td>
<td>MRCNS</td>
<td>N</td>
<td>Vancomycin, 5 wks</td>
<td>3</td>
<td>12</td>
</tr>
</tbody>
</table>

* No patients had diabetes mellitus or were smokers, except as indicated (Case 15).
† Revisited emergency room after discharge. This patient had diabetes mellitus and chronic renal failure.

Discussion

Local bone grafting has become a routine procedure in the field of lumbar fusion surgery. Although enormous efforts are made to minimize the risk of contamination during the preparation of local bone autografts for lumbar spinal fusion, it is difficult to guarantee that local bone grafts are not exposed to contaminated environments. This study was performed to examine microbiological culture results for local bone autografts used in PLIF and to identify the associations with postoperative spinal infection.

In this study, the contamination rate of autogenous local bone was 4.3% (14 of 328 cases). Of 14 patients showing positive microbiological culture results, 5 patients (35.7%) showed an association between culture results and postoperative spinal infection. These 5 patients were treated with intravenous antibiotics for a minimum of 4 weeks, except for 1 patient who additionally underwent reoperation for debridement. Regardless of the microbiological culture results, the infection rate after PLIF with local bone autograft was 2.4% (8 of 328 cases), and in 5 (62.5%) of the 8 cases of infection, postoperative spinal infection was associated with the contamination of the prepared local bone. The results indicated that the contamination rate of local bone was not negligible, and the association of contamination of prepared local bone with postoperative spinal infection was significant.

Although a few studies have shown an association between postoperative infection and different types of bone grafts, there is a lack of evidence regarding the contamination rates of prepared local bone and its association with postoperative spinal infection. Mikhail et al. reported that there was no significant difference in the infection rate following spine fusion using irradiated allograft, nonirradiated allograft, or autograft. However, they did not show the results of direct contamination rates of prepared local bone and did not explain the reason for the nonsignificant increase in infection rates that they found in autogenous bone grafts. James et al. directly examined contamination rates of femoral heads donated at primary hip arthroplasty and reported that a positive culture of the femoral head plays no part in future complications. However, the chances of exposure to contaminated environments are much higher in the preparation of autogenous local bone grafts during spinal surgery than in the preparation of allografts during arthroplasty, and the number of infections was so low in the study by James et al. that these investigators did not examine infection rates. In our results, coagulase-negative Staphylococcus was the most common contaminant isolated and was found in 4 of 14 patients (28.6%) with contaminated local bone, followed by Pseudomonas species in 2 patients, Streptococcus species in 2 patients, and methicillin-sensitive Staphylococcus aureus in 2 patients. This result is consistent with previous results regarding bone graft contamination. However, postoperative spinal infections were not associated with specific microorganisms. The presence of some of the infectious microorganisms, such as Pseudomonas or Propionibacterium species, was attributed to simple contamination during bone preparation. CRP levels were highest at postoperative Days 3–5 and then decreased continuously in patients who did not show postoperative infection signs or symptoms, but all patients with postoperative spinal infection showed another increase in CRP levels within the 2nd postoperative week (Days 8–14). In cases suspicious for postoperative infection, we focused special attention on postoperative changes in laboratory results during this period.

In spite of the enormous effort made to maintain aseptic conditions, contamination of local bone grafts occurred (4.3%). We considered the following as the most probable causes of local bone contamination: surgical assistants who were inexperienced or unfamiliar with aseptic procedures, even though they were well educated, and long-term exposure to atmosphere and dryness. Therefore, to decrease the contamination rates of local bone autografts and prevent postoperative spinal infections, we recommend the following: 1) local bone preparation should be consistently carried out by experienced surgical assistants, such as senior residents or specialized medical assistants, who are familiar with aseptic procedures; 2) microbiological culture of local bone is necessary and should be performed carefully and systematically; 3) prepared bone should be kept in aseptic, humidified conditions; 4) postoperative laboratory results should be closely observed for changes, particularly during the postoperative 2-week period in questionable cases; and 5) local bone should be soaked in antibiotic or disinfectant solution prior to use for PLIF. In addition, a special test such as the STAT gram stain may be helpful to control infection rates associated with the prepared local bone grafts.

The surgeon should remain cautious when interpreting autograft culture results. In Case 12, the result of lo-
cal bone culture showed growth of *Candida parapsilosis*. Because the patient showed signs and symptoms of postoperative spinal infection, administration of an antifungal agent as well as an antibacterial agent was started. However, the postoperative infection was not controlled, and the patient underwent reoperation. The culture results of the wound during reoperation showed growth of methicillin-susceptible coagulase-negative *Staphylococcus*. With 6-week vancomycin administration after the reoperation, the patient’s infection was controlled. The case illustrates that although a surgeon must consider the possibility of contamination of prepared local bone, he or she should not completely depend on the culture results.

In the general consideration of risk factors for postoperative spinal infection, patient factors should also be included. In this study, we included diabetes, fusion length, and smoking. In future studies, the inclusion of more factors, such as transfusion, obesity, and other patient characteristics, would be helpful to gain a better understanding of the influencing factors associated with postoperative infection. Operation time and the time that the autograft remained out of the wound were not evaluated in detail in this study, but approximate operation times were as follows: 3, 4, and 4.5 hours for 1-level, 2-level, and ≥ 3-level PLIF, respectively. Therefore, local bone was out of the wound between the start of laminectomy and cage insertion, and the expected times were 2 (1 level), 3 (2 levels), and more than 3.5 hours (≥ 3 levels), respectively.

There were some limitations in this study. First, we could not confirm a direct correlation between positive culture results and postoperative spinal infection, because identification of the source of postoperative infection was very difficult, particularly in patients who were treated with medical therapy without reexploration for presumed infection. Thus, instead, we introduced postoperative infection criteria based on previous studies and strictly applied them. Second, it is the convention in Korea for a surgical assistant to prepare local bone, and this individual is generally a low-level resident or medical assistant with limited experience. Such inconsistent surgical assistance may be a limiting factor in this study. In future studies, it will be necessary to examine the positive culture rates of local bone prepared by an experienced surgical assistant using a consistent and reliable protocol. Finally, factors that could have affected the postoperative infection rates, such as long operative time and large amounts of blood loss, were not evaluated in detail. These factors are important, but we focused only on the contamination rate of prepared bone and its association with postoperative infection, regardless of other factors.

Conclusions

In this study of 328 patients who underwent PLIF, the contamination rate of local bone autograft was not negligible, and positive culture results were significantly associated with postoperative spinal infection. Special attention should be paid to the preparation of local bone autografts to avoid contamination, and systematic use of microbiological cultures will be helpful for the control of postoperative spinal infection.

References


Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: all authors. Acquisition of data: Lee, Chung, Kim, Shin. Analysis and interpretation of data: Kang, Lee, Chung, Kim. Drafting the article: Lee, Chung, Kim. Critically revising the article: Kang, Shin. Reviewed submitted version of manuscript: Kang.

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