

Posterior fixation without debridement for pyogenic spondylitis can promote infection control: Initial evaluation of a “pyogenic spondylitis posterior fixation rat model”

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INTRODUCTION: Pyogenic spondylitis is one of the most common infectious diseases, and its prevalence is increasing annually with societal aging. Recently, minimally invasive posterior fixation has been reported to mechanically stabilize the infected site and control infection. However, the molecular basis for posterior fixation alone to promote infection control remains unknown. This study aimed to elucidate the basic mechanism of the infection control process of posterior fixation in pyogenic spondylitis using a new animal model, the pyogenic spondylitis–posterior fixation rat model.

METHODS: This study was designed and conducted with the approval of the Institutional Animal Care and Use Committee. Eight-week-old female Wistar rats were used (N = 30). Under general anesthesia, 0.1 mL of 10⁶ CFU/1 mL methicillin-susceptible *Staphylococcus aureus* (MSSA: ATCC6548) solution was injected between the 6th/7th caudal vertebrae of the rats to develop pyogenic spondylitis rats. Three days after solution injection, surgery was performed in the fixation and control groups. Four 1.2-mm diameter stainless steel screws, two each for the 6th and 7th caudal vertebrae, were inserted under general anesthesia. To fix the infected lesion in the fixation group (N = 15), a resin external fixator was used between the four screws. In the control group (N = 15), only screw insertion was performed (Figure 1). At 7, 14, and 21 days postoperatively, five animals in each group were euthanized and fixed in formalin. The degree of bone destruction caused by infection was compared by micro-computed tomography (CT) between the 6th and 7th caudal vertebrae: the bone destruction rate of the epiphysis (area ratio of bone destruction area/epiphysis) and tissue samples from the same area. The “reactive bone formation” around the infected area was used to determine the presence of infection in the model. Standard statistical analysis was performed, and data were compared using Welch’s t-test.

RESULTS SECTION: Micro CT: Reactive bone formation was observed around the cortical bone of the 6th and 7th caudal vertebrae in all 30 models, indicating the presence of infection. The bone destruction rates of the fixation and control groups were 20% and 33% (p = 0.23) on postoperative day 7, 35% and 56% (p = 0.0007) on day 14, and 30% and 52% (p < 0.0001) on day 21. On postoperative days 14 and 21, the bone destruction rates were lower in the fixation group than in the control group. On postoperative day 21, osteosclerosis had started in the infected area (Figure 2).

Histologic findings: On hematoxylin and eosin staining, the intervertebral discs in both groups were degenerated by infection. In the fixation group, the bone destruction was localized, and the structure of the growth plate cartilage was preserved, whereas in the control group, the bone destruction was extensive and extended to the metaphysis. In cathepsin K staining, the fixation group tended to have fewer osteoclasts at the infection site than the control group (Figure 3).

DISCUSSION: In this study, we created a new animal model, i.e., the “pyogenic spondylitis posterior fixation rat model,” by combining the conventional pyogenic spondylitis model with a posterior fixation model. Infection was detected in all cases, and bone destruction was attenuated, and the normal structure was preserved in the fixation group. Cathepsin K staining results suggest that fixation suppresses osteoclast expression, leading to infection control.

SIGNIFICANCE/CLINICAL RELEVANCE: This study was an initial evaluation of the pyogenic spondylitis–posterior fixation rat model to elucidate the mechanism by, which posterior fixation in pyogenic spondylitis controls infection. The mechanism of infection control is that fixation suppresses osteoclast expression and reduces infection-induced bone destruction.

IMAGES AND TABLES:

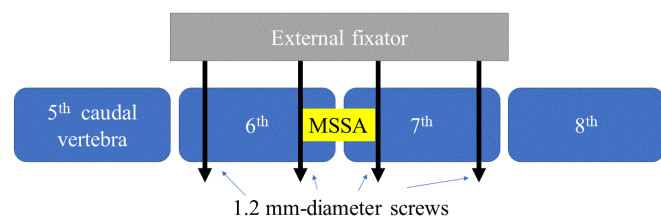


Figure 1. Experimental procedures: The MSSA solution was injected between the 6th and 7th caudal vertebrae, four 1.2-mm screws were inserted into the 6th and 7th caudal vertebrae, and the fixation group was fixed by external fixation.

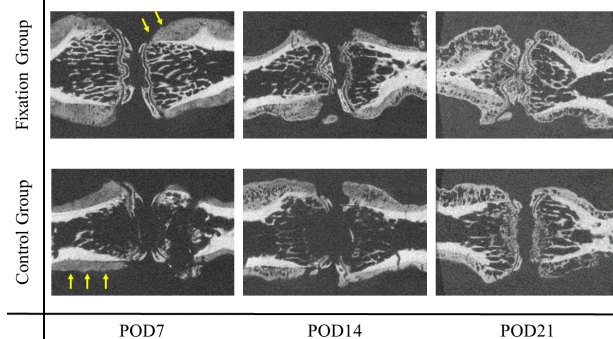


Figure 2. Micro CT: Reactive bone formation was observed around the cortical bone in all cases (yellow arrows). On postoperative day (POD) 7 and 14, the destruction of the epiphysis is localized in the fixation group, whereas in the control group, it extends beyond the epiphysis. On POD 21, osteosclerosis had begun in the infected area.

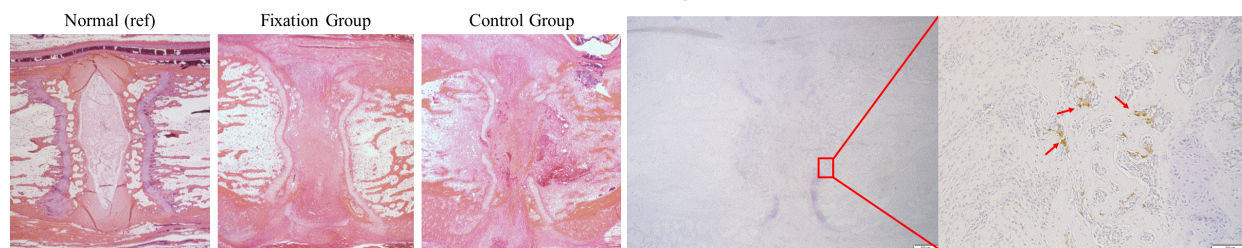


Figure 3 Histological findings: Hematoxylin and eosin staining (left) in the low-power field. The control group showed extensive bone destruction beyond the growth plate cartilage. Cathepsin K staining (right) in the low- and high-power fields of the control group. Osteoclasts (red arrows) are highly expressed in the bone destruction areas.