

Nonunion After Clavicle Osteosynthesis: High Incidence of Infection

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Purpose: There is scant literature regarding nonunions in clavicle fractures (OTA 15) following osteosynthesis. As the incidence of operative treatment of clavicle fractures is increasing, it is important to elucidate the etiologies of major complications. We investigated a series of nonunions following primary osteosynthesis of clavicle fractures in order to identify potential causes of failure. We hypothesized that a large portion of clavicle nonunions following surgical intervention would be infected.

Methods: We performed a retrospective review of nonunion cases following clavicle osteosynthesis that were referred to the orthopaedic trauma service at our institution. The cases were identified using our institutional orthopaedic trauma surgery database. Data were collected to define patient characteristics, comorbidities, and concomitant injuries. Radiographs were reviewed for original method of fixation and evidence of implant failure. In addition, microbiologic data from cultures obtained during the revision surgery were analyzed. We performed revision osteosynthesis in a single stage using a double plate technique. A 2.7-mm reconstruction locking plate is applied superiorly and a 2.4-mm LCP (locking compression plate) is applied anteroinferiorly. When possible, interfragmentary fixation was applied. Iliac crest bone graft was used when a cortical defect or shortening was present. Antibiotics were added to the postoperative regimen if cultures were positive. Postoperative radiographs were reviewed and assessed for union.

Results: Clinical and radiographic follow-up was available for 20 cases. The average age was 44 years (± 13 years). There was an average 14.6 months (range, 4-30 months) between the index procedure and the revision surgery for nonunion. In four cases (20%) the nonunions were diagnosed radiographically after the hardware was removed from the primary osteosynthesis (Fig. 1). In 9 cases (45%) there was catastrophic hardware failure that prompted the revision surgery. In the 18 cases in which cultures were taken, 16 of the 18 (89%) had positive cultures that were treated as infections with a prolonged course of antibiotics. 14 of these patients' cultures grew *Propionibacterium acnes*, one grew *Enterococcus faecalis* in addition to *P. acnes*, one grew *Staphylococcus auricularis* in addition to *P. acnes*, and two grew *Streptococcus epidermidis*. Average clinical follow-up was 30 months and the average radiographic follow-up was 26 months. No patients required revision following the nonunion surgery. All infections were treated with a single-stage revision and a course of intravenous or oral antibiotics. All cases with radiographic follow-up achieved union.

Conclusion: There is a high rate of positive cultures in cases of nonunion following osteosynthesis of the clavicle. Data from our cohort of patients suggest the etiology of midshaft clavicle nonunions often results from a combination of suboptimal mechanical fixation and latent infection. Our treatment protocol of superior and anterior plating, interfragmentary

fixation, bone grafting, and appropriate antimicrobial treatment for latent infections has resulted in 100% union rate in the revision setting.

