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CASE REPORT

Use of Carbon Fiber–Reinforced PEEK in the Treatment of Proximal Humerus Fractures: Same Steps but More Advanced Implant

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Summary: Carbon fiber–reinforced PEEK composite materials have recently begun to be used more widely in orthopaedic trauma surgery. Metallic implants for fracture fixation have been the most common method of fracture fixation, but not necessarily the best implant choice. In the current case series, the author demonstrates the utilization of carbon fiber–reinforced PEEK implants and its many benefits over metallic implants.

Key Words: carbon fiber, composite, PEEK, trauma, fracture, proximal humerus, metal sensitivity, metal allergy, modulus of elasticity

INTRODUCTION

Proximal humeral fractures have been an increasingly common injury in communities and present significant complications in their management.[1] Fracture patterns can range from nondisplaced to severely comminuted with intra-articular extension.[2] Multiple treatment options exist for the wide variety of fractures, including nonsurgical management, locking plate fixation, intramedullary nailing, and arthroplasty.[3,4] Locking plate fixation has evolved as the most common humeral head preserving procedure for treating proximal humeral fractures.[5] Locking plates have been responsible for decreasing the rate of surgical complications and increasing patient function after open reduction and internal fixation of displaced 2-, 3-, and 4-part proximal humerus fractures.[6]

Implant material has undergone little change from the creation of stainless steel and titanium constructs. There exist significant concerns regarding the use of metal implants ranging from metal sensitivity[7] to postfixation imaging to mechanical factors.[8] Carbon fiber–reinforced PEEK (CFR-PEEK) implants are being developed in orthopaedic trauma for treatment of long bone fractures and periarticular fractures as an alternative to metal implants because of these concerns. Although CFR-PEEK implants have been used in orthopaedic care for many years, only recently has the production of this material been cost effective for use in routine orthopaedic trauma. In

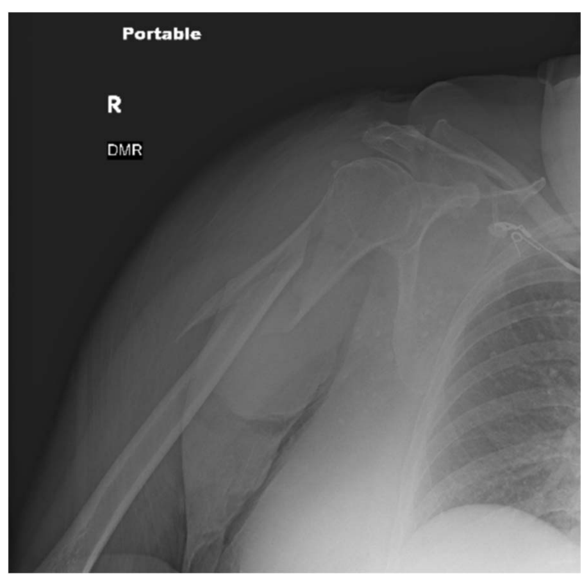

FIGURE 1. Radiograph from the emergency department that demonstrate a spiral proximal humerus and shaft fracture with significant displacement in a morbidly obese patient.

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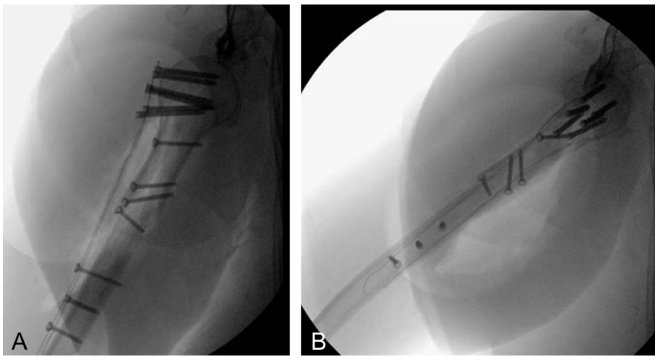

FIGURE 2. A and B, Intraoperative fluoroscopic AP and lateral views demonstrating fixation with multiple lag screws and carbon fiber PEEK composite plate and screws.

this report, a CFR-PEEK locking plate is used for the treatment of 2 proximal humeral fractures. Both patients are 68-year-old women with simple falls that present with different fracture patterns. Both patients also stated extreme metal sensitivity reactions in the past.

PATIENT #1

This 68-year-old obese woman fell on an outstretched right hand from standing height. She sustained a severely displaced humeral fracture extending from the proximal humerus to the shaft of the humerus. She was discharged home from the emergency department and followed up 1 day after the injury (Fig. 1). Surgery was performed 5 days after the injury.

Surgical Technique

This patient was placed in the beach chair positioner, and an extended deltopectoral approach to the shoulder was performed. Because of the extensive length of the fracture, part of the deltoid insertion was elevated off the humerus and multiple lag screws were used to reduce the fracture. Once appropriately reduced, the proper plate was chosen. The CFR-PEEK plate is radiolucent; so, a tantalum marker is placed circumferentially at the border of the plate to be able to visualize on radiographs. Once appropriate positioning of the plate was confirmed, screws were placed in the shaft and the head in a locking variable angle fashion. #2 high strength braided suture is passed through the rotator cuff tissue and then through the plate and is used to reinforce proximal fixation in the head (Figs. 2A, B and 3A).

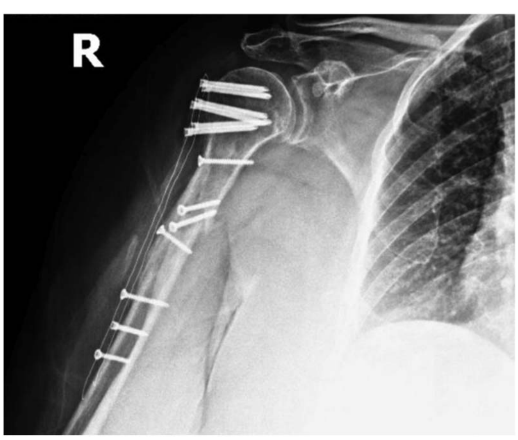

FIGURE 3. Radiograph at 4 months demonstrating fracture healing and fixation.

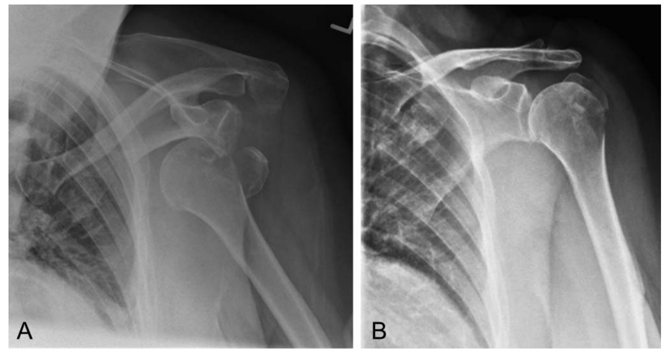

FIGURE 4. A and B, Prereduction and postreduction radiographs demonstrating a displaced greater tuberosity fracture.

PATIENT #2

This 68-year-old obese woman fell on an outstretched left hand from standing height. She sustained a fracture and dislocation of the proximal humerus with a significantly displaced greater tuberosity fragment. The glenohumeral joint was reduced, but the greater tuberosity fragment remained significantly displaced (Figs. 4A, B). The decision was made to perform an open reduction and internal fixation to properly reduce the fracture and stabilize it.

Surgical Technique

This patient was placed in the beach chair position, and a deltoid splitting approach was performed. After splitting the deltoid between the anterior and middle third, along the avascular raphe, the bursal tissue was excised. The axillary nerve was visualized and protected throughout the procedure. #2 high strength braided suture was passed through the musculotendinous junction of the rotator cuff tissue and attached to the displaced greater tuberosity fracture and to the subscapularis tendon insertion on the lesser tuberosity. The bed of the fracture on the humerus was debrided, and reduction and provisional fixation were performed by tying rotator cuff sutures together. The appropriate plate was chosen, and more suture was passed through the rotator cuff tissue and then passed through suture holes in the

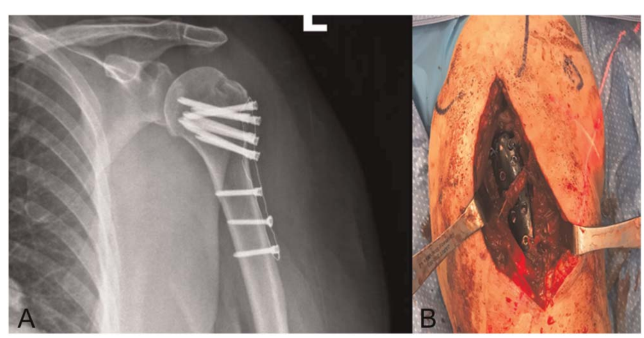

FIGURE 5. A, Immediate postoperative radiographs demonstrating fracture fixation using a CFR-PEEK composite plate and screws; (B) intraoperative photograph demonstrating the axillary nerve lying over the plate.

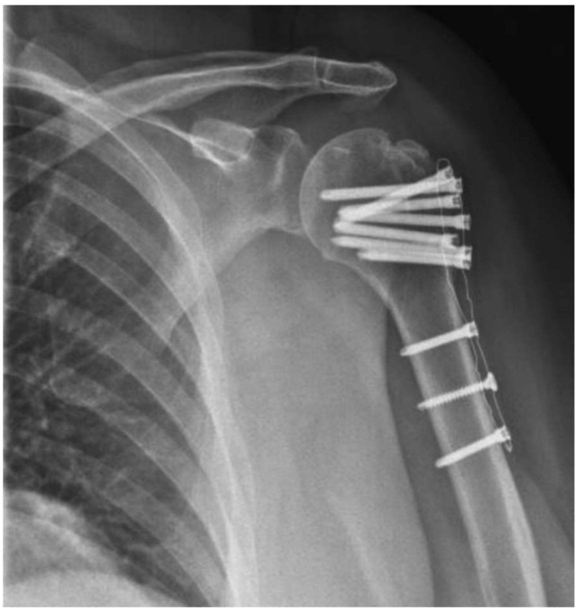

FIGURE 6. Four-month postoperative radiograph demonstrating union of the greater tuberosity with stable fixation and plate placement.

FIGURE 7. Postoperative photograph of patient #1 ROM following 2.5 months after right proximal humerus ORIF showing patient lacking 10° of forward elevation.

FIGURE 8. Postoperative photograph of patient #2 ROM following 3 months after left proximal humerus ORIF showing patient lacking 15° of forward elevation.

plate. The plate was placed at the appropriate height and position; multiple locking and nonlocking screws were placed in the head and shaft, and the sutures were tied in place (Figs. 5A, B and 6).

Postoperative Course

Both patients were placed in slings immediately after surgical intervention and started on pendulum exercises. Both patients were started with physical therapy with passive range of motion transitioning to active range of motion at 6 weeks postoperatively. Strengthening exercises were initiated after full range of motion was achieved, at 2.5 months postoperatively in both cases (Figs. 7, 8).

DISCUSSION

These 2 cases demonstrate several benefits to using CFR-PEEK composite implants in fracture care. The use of a nonmetallic plate for these patients was ideal for implant choice because of the known metal sensitivity in both patient's history. The strength of the implant is a second factor with far superior loads to failure then stainless steel or titanium implants. Metallic implants fail at under 100,000 cycles, but after 1,000,000 cycles without failure, testing on CFR-PEEK

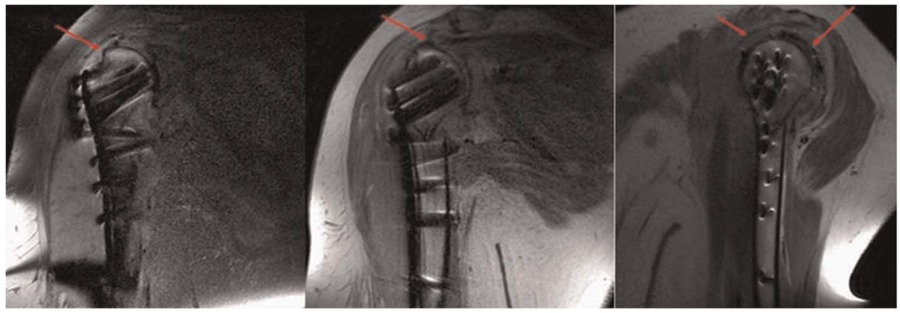

FIGURE 9. Example of MRI after surgical fixation of proximal humerus fracture using CFR-PEEK proximal humerus plate and screw. Arrows demonstrate a complete rotator cuff tear with retraction (figures courtesy of Bruce Ziran, MD).

composite plates was terminated. In addition to improved fatigue strength of implants, the locking screw to plate interface of CFR-PEEK composite plates has been shown to have increased mechanical stability in comparison with stainless steel plates.[9]

Another advantage to using CFR-PEEK composite material in fracture care is the benefit of using a material with the closest modulus of elasticity to bone compared with metallic implants. This allows for less rigidity of the implant with increased strength that has the potential for increasing callus formation and fracture healing. Also, the ability to visualize healing of the fracture on plain radiographs is enhanced due to the lack of metal, radio-opaque, implants overlying the fracture site.

The ability to perform advanced imaging techniques on tissues surrounding these composite implants is another significant benefit to this technology. Magnetic resonance imaging (MRI) is a common technique to visualize structure around the shoulder and is not likely to be of clinical benefit with metallic implants in place. With the use of CFR-PEEK composite implants, standard MRI techniques can assist in the diagnosis of rotator cuff pathology from tendinitis to tears (Figs. 9A–C).

The use of CFR-PEEK composite implants has a large advantage over metallic implants in the setting of oncology, where radiation may be required. Metallic implants may scatter radiation and injure tissue that was meant to remain untreated, but the use of composite implants around possible tumor sites limits the amount of radiation scatter decreasing the morbidity of the procedure.

The nature of the CFR-PEEK composite material, while most similar to bone, does not allow for the surgeon to bend the plate longitudinally when fixating various fractures. In some circumstances, this can leave the implant raised off the bone in more comminuted or deformed fractures. The author has noted this scenario, but has not had negative effects due to this concern.

CONCLUSION

Although the material may be different than the standard implants surgeons are accustomed to, the benefits of using CFR-PEEK composite implants are numerous. With no changes to the procedures involved in surgical fixation and repair of fractures, surgeons can get the benefits of advanced composite material without the need to alter long-standing techniques.

ACKNOWLEDGMENTS

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