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CR-PEEK VARIABLE ANGLE LOCKING PLATE SYSTEM IN THE TREATMENT OF DISPLACED PROXIMAL HUMERAL FRACTURES – IS IT RELIABLE

Orthopaedics

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ABSTRACT

Background : Treatment options for displaced proximal humeral fractures are continuously evolving. CR-PEEK plate, a new addition to plethora of fixation systems already available for fixation of displaced proximal humeral fractures. To evaluate the results of internal fixation of displaced proximal humeral fractures with CR-PEEK variable angle locking plate system. **Material and Method:** 30 healthy active patients(average age was fifty-three years) with displaced two to four-part fractures underwent open reduction and internal fixation with a CR-PEEK locking plate system (Arthrex, USA). All cases were operated by a single surgeon at a tertiary referral centre. They were evaluated clinically and radiologically at 2, 6, 12, 24,52 weeks or until union. Objective assessment was measured by the Constant scoring system and Subjective assessment by the Oxford shoulder questionnaire. Through an anterior deltopectoral approach, the fracture was reduced. A pre-contoured CR-PEEK plate was applied with minimum of five titanium variable angle locking screws in head fragment. **Results:** There were 20 males and 10 female patients. There were 4 two-part neck fractures, 10 displaced two-part greater tuberosity fractures, 8 three-part fractures and 8 four- part fractures. All fractures united with a mean healing time of 15 weeks. There were no mal-union, non-union or failure of fixation. There were no implant related problems like plate breakage or screw penetration. The mean constant score at final follow up was 84. The average range of flexion was 160 , abduction of 154 and external rotation of 30. Functionally, we achieved good or excellent results in 27 patients and fair results in 3 patients. Two patients requested for plate removal , thus were removed easily. **Conclusions:** Thus from our study it can be concluded that internal fixation with CR-PEEK locking plate system is a reliable and safe method of treating displaced proximal humerus fractures. The advantages include ability to monitor reduction during surgery and check healing of bone during follow up visits and easy removal of plate when required.

KEYWORDS

INTRODUCTION

The proximal humeral fractures constitute 4-5% of all fractures and 45% of humeral fractures. Most of these fractures occur in woman over the age of 50 with the exception of isolated greater tuberosity fractures which occur with increased frequency in young individuals. More than 85% of these fractures are minimally displaced or undisplaced and are effectively treated symptomatically with immobilization followed by early motion[1,2].

Displaced proximal humeral fractures need fixation for optimal results. For fixation of displaced proximal humeral fractures, many choices are available to operating surgeon. Commonly used techniques are open reduction internal fixation using various plate and screw systems most notable being PHILOS Plate, Suture plate ,T Plate, Hemiarthroplasty or total shoulder arthroplasty and some times K-wires and Screws only, in a minimally invasive fashion[3,4,5,6,7,8].

CR-PEEK Plate is relatively new addition to plethora of armamentarium of fixation devices available for proximal humeral fixation. Its advantages are its modulus of elasticity closer to bone, high tensile strength, absence of cold welding between plate and screw, its radio-lucency helps in better intra-operative reduction .It is MRI compatible. In addition it is a locking and variable angle plate.The aim of this study to evaluate results of internal fixation of displaced proximal humeral fractures with CR PEEK Locking plate system.

MATERIAL AND METHOD

This prospective study in a series of 30 patients who were operated between November 2016 and 2017, was conducted at MIOT International Hospital,Chennai,India. 30 healthy active patients with displaced two to four-part fractures underwent open reduction and internal fixation with a CR-PEEK locking plate system (Arthrex, USA). All cases were operated by a single surgeon at a tertiary referral centre. Their average age was fifty-three years. They were evaluated clinically and radiologically at 2, 6, 12, 24, 52 weeks or until union. Objective assessment was measured by the Constant scoring system and Subjectiveassessment by the Oxford shoulder questionnaire.

Surgical Technique

Through an anterior delto-pectoral approach,the fracture was reduced. A pre-contoured CR-PEEK plate was applied with minimum of five titanium variable angle locking screws in head fragment. Tuberosities approximation was reinforced with fiber-wire sutures through the rotator cuff and the holes in the plate. Rotator cuff was repaired at time of surgery in all patients having tear associated with fracture. Intra-operative fluoroscopy was used to assess reduction. Wound was closed over suction drain. The shoulder was immobilised in a arm pouch for one month .Hand grip, Elbow flexion, Shoulder shrugs, forward and backward shoulder rolls, Gravity assisted Pendulum movements, Assisted arm elevation up to 90 degree or as pain permits, was started from first post operative day in all patients strictly. Patients were adviced exercises every two hour session. Each exercise adviced for 50 times. Patients were adviced sling for one month to be taken out only during bathing and exercises. Sling was discarded after one month and Phase 2 exercise adviced .During third month muscle strengthening exercises were added.

Intraoperative Pictures Showing Use Of Fiber Wire For Reduction And Radiolucency Of Plate

RESULTS

There were 20 males and 10 female patients. There were 4 two-part neck fractures, 10 displaced two-part greater tuberosity fractures, 8 three-part fractures and 8 four- part fractures. All fractures united with a mean healing time of fifteen weeks. There were no mal-union, non-union or failure of fixation. There were no implant related problems like plate breakage or screw penetration. The mean constant score at final follow up was 84. The average range of flexion was 160, abduction of 154 and external rotation of 30. Functionally, we achieved good or excellent results in 27 patients and fair results in 3 patients. All patients were satisfied with the outcome. Two patients have requested plate removal. Plates were removed easily.

Number of patients	Male	Female
30	20	10

Side of injury	Dominant Hand	Non Dominant Hand
30	17	13

Distribution of patients according to Neers's classification			
2-part neck fracture	Displaced greater tuberosity fracture	3-part fracture	4-part fracture
4	10	8	8

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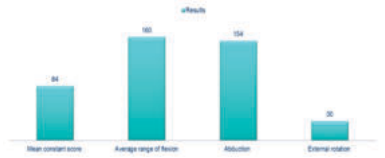
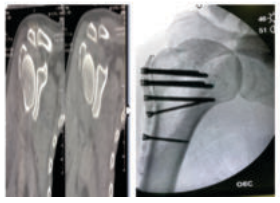
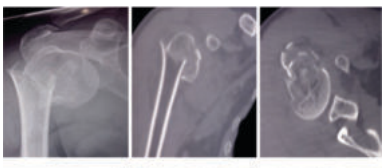
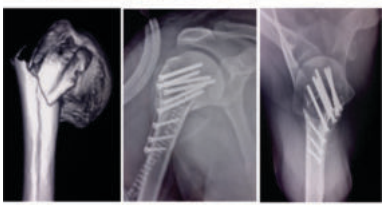




DISCUSSION

The proximal humeral fractures continue to pose difficult challenge to operating surgeon especially 3 or 4 part fractures in osteoporotic bone of elderly patients. Loss of reduction, Screw backout, Screw penetration in joint and ultimate failure of fixation are some of complications associated with their operative management. These complications were a common occurrence with conventional plates .

To obviate these complications locking plate system made of stainless steel and titanium were introduced. They revolutionized the treatment of osteoporotic fractures of proximal humerus. Over period of time they became implants of first choice for management of proximal humeral fractures and continued to be used world wide. There are less incidence of screw back out, secondary joint penetration of screws, loss of reduction and good to excellent results reported by many authors. Addition of variable angle facility made locking plate more versatile giving surgeon a 10 to 15 degree freedom to manipulate the screw in desired direction. But locking plates made of stainless steel and titanium do have some undesirable properties .

1. Mismatched Modulus Of Elasticity Between Bone, Stainless Steel And Titanium

The modulus of elasticity of stainless steel is 230 Gigapascals, Titanium 106-155 Gigapascals, Cortical bone 12- 20 Giga pascals, Cancellous bone is 1 Gigapascal. This mismatch between modulus of elasticity results in theoretical stress shielding of bone.These plates sort of overprotect the bone resulting in stress shielding with its undesirable side effects.

2. Problem Of Cold Welding

Cold welding is a solid state welding process in which joining takes place with out fusion/heating at the interface of two parts to be welded. The reason for this unexpected behavior is when atoms in contact are all of same kind, there is no way for atoms to know that they are in different parts like plate and screw. Cold welding makes removal of hardware difficult or sometimes impossible. It is encountered in both titanium and stainless steel locking plate systems.

3. Radiopacity of stainless steel and titanium plate are advantageous in assessing union ,infection ,tumour progression .More radiographic exposures are required to look for intra-operative reduction of fracture fragments.

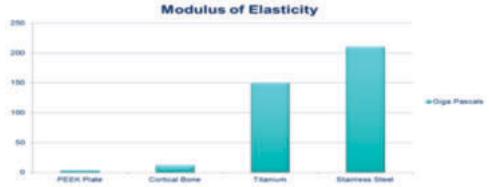
4. MRI and CT artifacts acting as a barrier to assess union, infection or tumour progression.

5. Stainless steel and titanium plate elicit more intense tissue inflammatory reaction and generate significant wear particles.

To overcome these problems CRP PEEK plates were introduced for fixation of proximal humeral fractures .They are variable angle locking plates with comparable or better results than stainless steel and titanium plates.

Carbon reinforced polyetheretherketone is a composite material composed of layers of carbon fiber sheets, with fibers oriented in varying directions, embedded within a polymer matrix of PEEK. The manufacturing of CR PEEK plate devices is such that altering the carbon fiber orientations, plates of different modulus of elasticity can be synthesized to suit to a particular bone[12,13].It has excellent biocompatibility when studied in vivo and in vitro[14,15,16,17].

1. The CR-PEEK has modulus of elasticity close to bone. Its modulus of elasticity is 3.5 gigapascals compared to 230 giga pascals of stainless steel,106 to 155 for titanium alloy,12 to 20 for cortical bone and 1 gigapascal for cancellous bone[18]. Comparable modulus of elasticity holds a promise for less stress shielding[19].

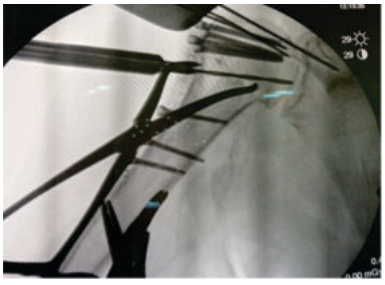


2. Cold welding.The problem of cold welding becomes relevant at time of removal of hardware after failed fixation, improper fixation, infection or patient request for removal of implant.Since all theatres are not equipped with metal cutting machines retention of screws in Medullary canal of bone may preclude future replacement procedure .Cold welding is not a problem with PEEK Plate as screws in PEEK Plate system are made of titanium and plate made of PEEK.

It is a radiolucent plate allowing superior intraoperative fluoroscopic visualization of fracture fragments and hence better fracture reduction. PEEK is MRI compatible and absence of artifacts on CT and MRI

postoperative can be useful to assess fracture reduction, Union, Infection, tumor progression[20].Radio-opaque bits are added to plate to make it visible for proper positioning.

At our center we compared 10 cases of proximal humeral fractures fixed with titanium plate and 10 cases fixed with CFR-PEEK Plate. Five cases in each group were 2 part and 4 cases were 3 part fractures and one case was 4 part fracture. On an average we had 6 less fluoroscopic exposures in PEEK Group compared to titanium group .



Radiolucency Allows Better Visualuation Of Fracture Fragments

CR PEEK is a variable angle plate offering advantages of variable angle plate.

It has excellent bending strength. Commercially available plates and nails have been tested to 1 million fatigue cycles without failure. The average bending strength for a 4.5-mm CFR-PEEK plate is 19.1 Nm (Newton meters), while the bending strength for a similar 4.5-mm stainless steel locking compression plate is 16.7 Nm. The average bending strength of a commercially available 10-mm CFR-PEEK intramedullary tibial nail is 80.3 Nm, while the bending strength of an 11-mm titanium tibial nail is 43 Nm[22}

CR-PEEK Plate has Less incidence of varus collapse.In a Level 2 study Evaluating (CFR-PEEK) locking plate, Schliemann et al. showed a lower rate of varus deformity in comparison to the control titanium locking plate. They believed that this was due to CFR-PEEK being less rigid and having a similar elastic modulus to bone[23].

The PEEK Plate has comparable results to other plate systems in fixation of proximal humeral fractures

The major disadvantage of PEEK Plate is that it comes as pre-contured plate and there is limited possibility to model it to fit bony contours.

CONCLUSIONS

Our results suggest, internal fixation with CR-PEEK locking plate system is a reliable and safe method of treating displaced proximal humerus fractures. The advantages include ability to monitor reduction during surgery and check healing of bone during follow up visits and easy removal of plate when required

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