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Calcium Phosphate Treatment for Acute Pubic Rami Fractures of the Pelvis: A new approach to Surgical Internal Fixation

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Abstract

Pubic rami fractures of the pelvis warrant more consideration in their management, as their incidence increases with our aging population. These fractures usually result from a low energy trauma such as a fall. These fractures result in a significant loss of autonomy in a previously active patient. Current treatment includes a non-surgical approach including bedrest, pain management, and mobility to comfort. This treatment plan can lead to potential co-morbidities that include cardiac, pulmonary, skin, and mobility issues. The indication for surgical intervention is narrow in scope and limited to observation, or in some cases, screw fixation.

A method of internal fixation, using Calcium Phosphate, has led to improved outcomes in their management. This method of internal fixation provides an immediate improvement of post injury pain, an increase in immediate post treatment mobility and a decrease in the acute hospital length of stay. This minimally invasive surgical treatment is safe, affords minimal risk, and offers a high patient benefit in the care and management of patients with this pelvic fracture.

Our study, from January 1, 2018 to December 31, 2019, identified 233 patients who sustained pubic rami fractures. Ninety (38% of total patients) patients, who sustained pubic rami fractures, were treated with Calcium Phosphate. There were 10 males and 80 females, average ages were 78 and 86 respectively. On hospital admission, work-up included pelvic x-rays as well as a CT scan.

All received Calcium Phosphate for fracture fixation after admission. All patients presented on admission with a 10/10 on the pain scale. After treatment, the patients' noted a significant decrease in fracture pain, (average pain of 0- 3). All were encouraged to weight bear with physical therapy. Average Hospital length of stay was 11 days with discharge at an average of 3.7 days for females and 3 days for males post treatment.

There were nine patients less than 3 months at the time of follow-up, 16 at 4-6 months, 25 at 7-12 months, and 30 at +1 year. Clinic follow-up included pain assessment, function and radiographs. There were no infections with this technique and fracture healing noted, with incorporation of the calcium phosphate at 12 weeks. Complete healing and calcium phosphate incorporation was documented at 1 year. There was no restriction of motion or function by any patient.

Not all patients were available for return for a clinic visit at follow-up. A phone survey was conducted to inquire about patient's satisfaction with treatment. Out of the 90 patients, nine were deceased, leaving 81 available for the survey. Sixty-one responded (76%). The results showed 100% improved from the surgery, 100% achieved the goal of improved function by the technique, 85% were extremely satisfied with the surgery (17% satisfied) and 100% stated they would have the procedure again if needed.

This Calcium Phosphate bone scaffold technique for treatment of pubic rami fractures is a minimally invasive procedure. The treatment addresses the problem of pubic rami fracture pain and allows early mobilization. Calcium phosphate is delivered into pubic rami fractures percutaneously. The findings of this study indicate the technique is safe, easily reproducible, with immediate pain relief. Our findings allow early mobilization of these patients with weight bearing. The length of stay after treatment is shortened. The calcium phosphate scaffold stabilizes the fracture and incorporates into the fracture healing callous long term.

Keywords: Surgery • Calcium phosphate • Fracture

Introduction

The concept of pubic rami fracture stabilization for pain control, hemostasis, minimization of fracture deformity and early mobilization, improves the potential for favorable patient outcomes. One way to assist in pain management and fracture stabilization is through filling these fractures with a biologic, bone scaffold material, calcium phosphate. The principle behind this technique is the targeted filling of the pubic rami fractures with a flow-able calcium phosphate (CaP, Accufill) bone scaffold substitute material [1,2]. This produces a synthetic callous scaffold providing (structural support) fracture defect filling and osteoconduction to aid in fracture healing [3,4].

Surgical fixation of unstable pelvic ring fractures allows mobilization of patients and provides improved clinical outcomes. This approach can be applied to stable anterior pubic rami fractures [5] . Pubic rami fractures are minimally displaced in stable anterior pubic rami fractures. The patients with stable anterior pelvic fractures are difficult to mobilize within the first few days after admission. These patients experience significant pain from the injury [6]. Pain relief is difficult to realize for several days with conservative treatment. The use of narcotic pain medication may not offer up enough relief, making mobilization difficult.

The goal of this report is to describe a technique of internal fixation, which improves clinical results. Fracture stability and pain relief is achieved through calcium phosphate fixation, which mimics human bone mineral. This technique provides an alternative to the conservative, non-operative approach currently recommended for these fractures as well as surgical screw fixation.

Epidemiology

Pelvic fractures alone represent 7% of all osteoporosis related fractures in people greater than 50 years of age in the United States. These fractures account for 5% of the total cost burden [7]. Pubic rami fractures occur in patients greater than 65 years of age after a low-energy fall. Pubic rami fractures are common in elderly females. One study by Kannus, found the majority of pelvic fractures have an osteoporotic origin and their study noted that 64% of all pelvic fractures are osteoporotic. Their study found that in patients over the age of 60 the percentage of osteoporosis as a cause of these fractures increased to 94% [8].

A study, by the Mayo Clinic, by Melton reported on the incidence of pelvic fractures over a 10-year period (1968-1977) [9]. Their study found that for men aged 55-74, the incidence of low energy pelvic fractures was 7/100,000 person years. The rate increased to 63.9/100,000 in men of 75 years and older. The rate increased to 220.3/100,000 person years when older than 85. The same study found the rate for

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women in the age group of 55-74 as being 56.9/100,000 person years. This rate increased to 249.5/100,000 person years in those women of age 75 and older. This rate further increased to 446.3/100,000 person years for women over the age of 85.

The Mayo Clinic study pointed out that the incidence of osteoporotic pelvic fractures increased an average of 23 %/year over the past 3 decades in women and men over the age of 65. The study also noted that in patients greater than 80 years old the incidence increased an average of 54%. They concluded that based on this data over the last 30 years that the current increase in osteoporotic pelvic fractures would triple by the year 2030.

Risk Factors

A history of osteoporosis is one of the risk factors associated with pelvic rami fractures after an insignificant fall [10]. Other risk factors include prior internal fixation of a proximal femoral neck fracture as well as a total hip arthroplasty. A fall on a previously stabilized hip fracture or total hip may result in a force transmission to the pubic rami as well as the sacrum. This results in a lateral compression fracture. Lower lumbar arthritis as well as lumbar scoliosis may also contribute to a lateral compression fracture of the pelvis after a fall [11]. Lateral compression fracture of the pubic rami can be associated with acute intertrochanteric fracture or intra-capsular fracture of the hip.

Pubic Rami Fracture Classification

Pubic rami fractures are categorized as lateral compression injuries according to Young and Burgess's classification [12,13]. The lateral compression fracture is the most common fracture seen involving the pubic rami. The mechanism of injury is the patient falling from the standing position onto the affected side. The resulting force, being a laterally directed force causing the fractures to the superior and inferior pubic rami. The diagnosis of the pubic rami fracture confirmed on routine radiographs. The low energy fall is the mechanism most responsible for the majority of the pubic rami fractures; however, there has been a reported incidence of fractures in the absence of any trauma [14].

Mechanism of Injury

Hill reported in a large series of consecutive elderly patients with osteoporotic pubic rami fractures that 87.4% of the cases were a result of a simple fall mainly occurring at home. A study by Morris found, 83% of the pelvic fractures in their series where the result of falls from standing, walking or transferring. Studies by Taillandier and Breuil, found simple low energy falls accounted for 86.6% and 89% of the pelvic fracture in their study [15,16].

Diagnostic Imaging

All patients who present with pelvic trauma should undergo a series of radiographs at the time of injury. AP of the pelvis is performed. Further studies including inlet outlet and Judet views of the pelvis should be done when appropriate [17]. A CT scan of the pelvis locates the pubic rami fractures, and any sacral ala fractures associated with these injuries. The CT scan also aids in surgical preparation for management of the pubic rami fractures.

Current Non-Operative Treatment

Current non-operative management has included bedrest, pain management, and physical therapy according to comfort. This conservative approach has been associated with other comorbidities, including cardiac, pulmonary, DVT complications, urinary retention, constipation, pressure ulcers, pneumonia, and significant muscle atrophy, limiting return to active function. All of these potential problems from non-operative management contribute to the extension of the patient's length of stay in the hospital. These potential problems also contribute to the patient's inability to return to the preinjury state of function [18].

Current Proposed Operative Treatment

A treatment of pubic rami fractures by calcium phosphate internal fixation technique is described [19]. The basis of patient evaluation and work up for calcium phosphate intervention has been reported for use in other applications of bone and joint pathology. [20-22]. The goal of this report is to describe a technique for minimally treatable pelvic fractures. This bone scaffolding procedure has been shown to improve pain and decrease time to mobilization.

Calcium phosphate scaffolding involves preparation of the injectable calcium phosphate for placement into the fracture site through provided cannulated trocars. These 11 gauge trocars have two tip configurations in the larger size (end delivery and side-port delivery). The trocars are inserted by hand control. The trocars are placed under fluoroscopy control.

flow across the fracture site was evaluated in the cadaver lab. Dissection of the anterior pelvis was carried down to the pubic body and a trocar with side-port delivery was inserted under direct vision and checked with fluoroscopy. An osteotomy mimicking a fracture pattern was made through the pubic rami. The calcium phosphate was inserted using the established technique. The pubic rami fracture filled with calcium phosphate and the rami removed to show the flow across the osteotomy [Figures 1,2,3].

Surgical Technique for Subchondroplasty in pubic rami fractures

Various levels of anesthesia can be used. This may be dependent upon several factors including the comfort of the patient. These include general endotracheal, LMA, and IV sedation with local anesthesia at the injection site on the pubic body. The patient is positioned supine on the operating table. The symphysis area prepped and sterile drapes used to isolate the area. Intra-operative fluoroscopy is essential. The AP view and the inlet view (40-degree cephalo-caudal view and the outlet view 10 – 20 degrees caudo-cephalad) are the most important for trocar placement.

The surgeon should palpate the thickness of the pubic bone. The area of trocar insertion is infiltrated with 1% lidocaine. Bleeding in this area is minimal. The trocar is inserted through puncturing the skin, rarely is an incision necessary. Trocar placement is medial to the obturator foramen. Appropriate angle and direction established using fluoroscopy, and then hand insertion of the trocars is performed. The trocar is inserted close to the symphysis, 0.5 – 1 cm laterally and posterior from the anterior edge. The widest bone area is in this location. The depth of the trocar and direction is checked on the AP pelvis view. (Figure 4,5 trocar placement with C-arm in inlet view; 5 , trocar placement on AP view; 6, trocar placement on inlet view.)

Once satisfactory placement is realized, the mixing and injecting of the calcium phosphate can start. 3-5 cc are standard amounts used, up to a total of 10 ml, depending upon the fracture pattern. (Figures 6, 7, show trocars in place). The flow of the calcium phosphate is followed after each syringe is emptied. Extravasation of the calcium phosphate at the fracture site is to be expected and is indicative of the flow of the calcium phosphate to the fracture site. No sequelae has been encountered by the calcium phosphate extravasation.

Methods

From January 1, 2018 to December 31, 2019, our study identified 233 patients who sustained pubic rami fractures. Ninety (38% of total patients) patients, who sustained pubic rami fractures, treated with calcium phosphate fixation. There were 10 males and 80 females, average ages were 78 and 86 respectively. On hospital admission, work-up included pelvic x-rays as well as a CT scan. All received Calcium Phosphate for fracture fixation after admission. All patients presented on admission with a 10/10 on the pain scale. The mechanism of Injury was low energy falls in 78 females, with one MVA, and one thrown from a horse. Eight males had low energy falls, with one fell from a roof, and one bicycle accident. The male who fell from the roof also had posterior pelvic injuries. One female patient had acute

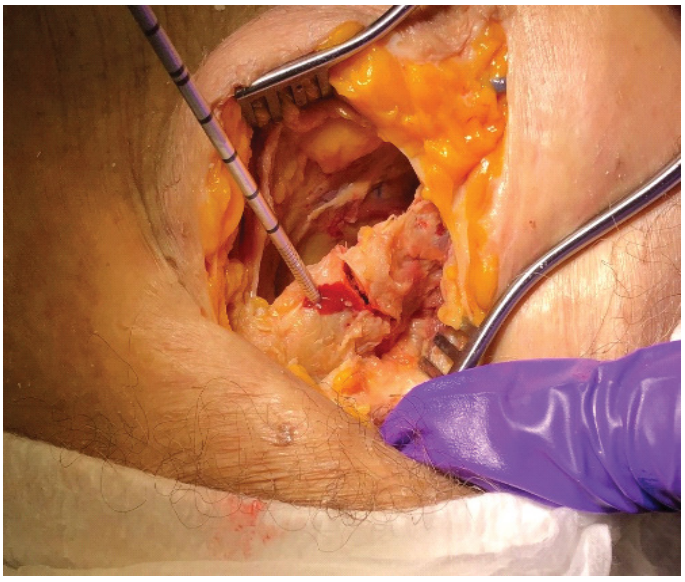

Figure 1. Trocar placement in pubic symphysis. Osteotomy representing fracture.

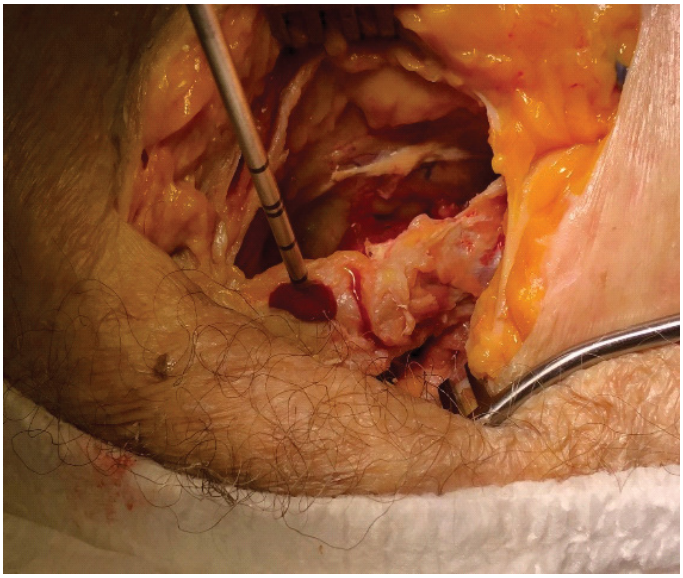

Figure 2. Trocar in position and calcium phosphate being delivered. Note fluid extravasation from osteotomy site.

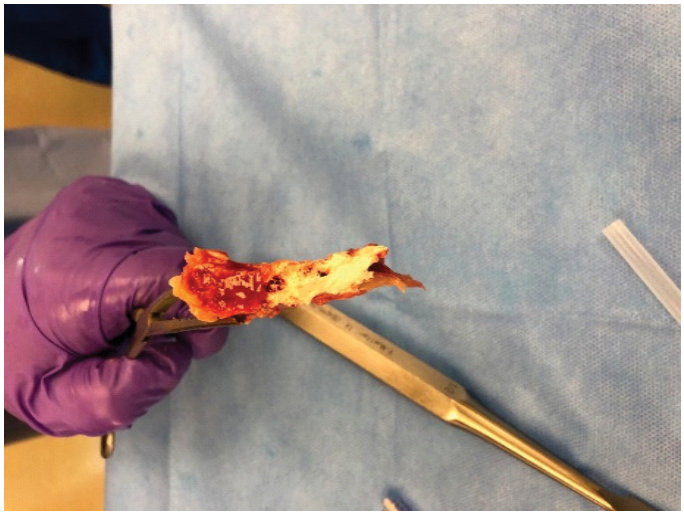

Figure 3. Pubic bone specimen showing calcium phosphate flow.

Figure 4. Trocar placement using C-arm. Note C-arm angle and trocar direction.

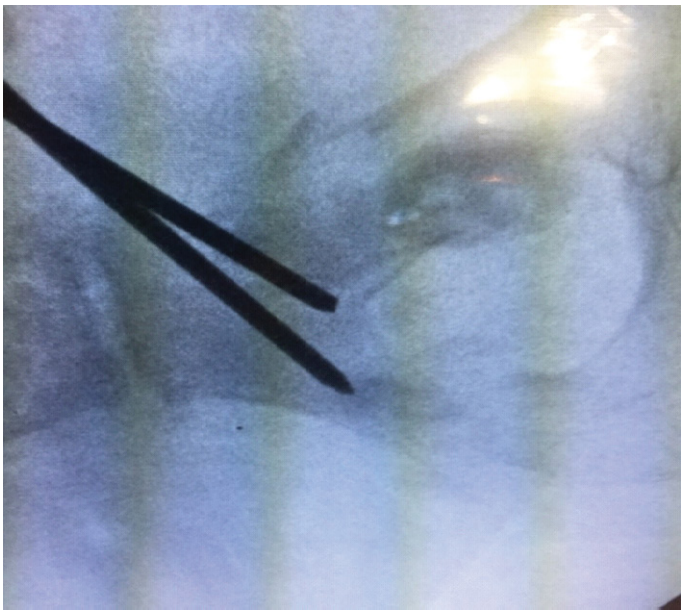

Figure 5. C-arm AP view of pelvis with trocar placement for superior and inferior fractures. Delivery of calcium phosphate.

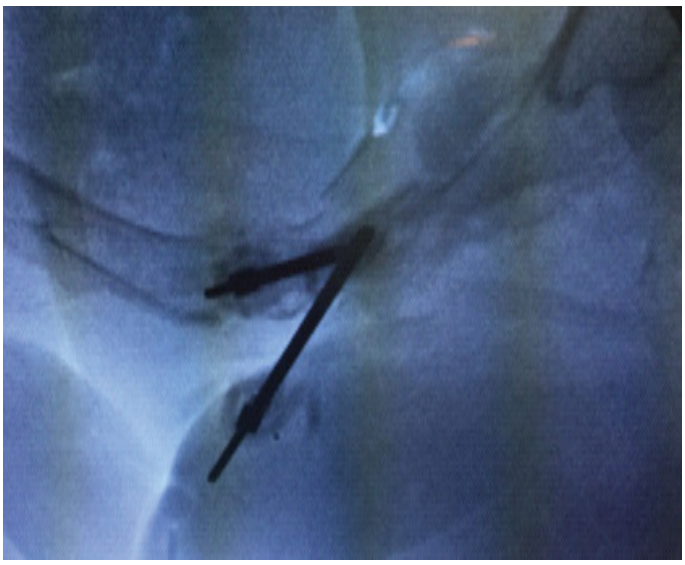

Figure 6. Inlet pelvic view showing trocar placement with calcium phosphate delivery.

bilateral pubic rami fractures after thrown from a horse. Two female patients had acute femoral fractures, which needed fixation or hemi-arthroplasty replacement. The one male, who fell from the roof, was a multiple trauma patient, and needed acute S-I joint screw fixation, with ipsilateral anterior pubic rami fixation with calcium phosphate. The youngest patient was a male thrown over the handlebars on his bicycle during a race. He sustained closed superior and inferior pubic rami fractures. Four patients had previous fractured hip fixation prior to fall and resultant ipsilateral pubic rami fractures.

Post procedure treatment medications included, Ibuprofen 800 mg 1 po TID, Medrol dose pack and cyclobenzaprine 10 mg 1 po TID, in addition to opioid pain medication as needed. The combination of medications helped with inflammation and muscle soreness from the injury as well as the procedure. The injection sites were covered with durabond skin glue and an optifoam bandage. No sutures were used. There was no bleeding encountered.

Results

After treatment, in the PACU, the patients' noted a significant decrease in fracture

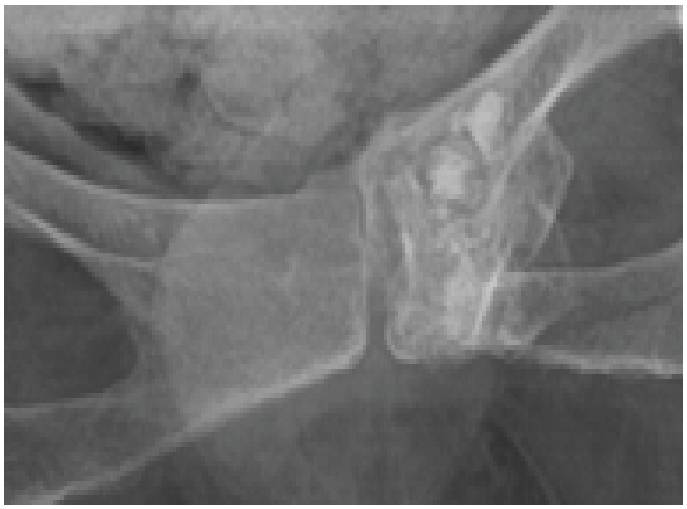

Figure 7. Anterior pelvic view at one year follow-up demonstrating healing of fracture and incorporation of calcium phosphate. Minimal extravasation noted.

pain, (average pain of 0- 3). After return to the orthopedic floor, the patients were encouraged to be out of bed to a chair and weight bearing with physical therapy. Average Hospital length of stay was 11 days with discharge at an average of 3.7 days for females and 3 days for males post treatment.

There were nine patients less than 3 months at the time of follow-up, 16 at 4-6 months, 26 at 7-12 months, and 30 at +1 year. Clinic follow-up included pain assessment, function and radiographs. There were no infections with this technique. Fracture healing noted, with incorporation of the calcium phosphate at 12 weeks. Complete healing and calcium phosphate incorporation documented at 1 year. (Fig. 7, 1-year follow-up post treatment). There was no restriction of motion or function by any patient.

Not all patients were available for return for a clinic visit at follow-up. A phone survey conducted. The survey was to inquire about patient's satisfaction with treatment. Out of the 90 patients, nine were deceased, leaving 81 available for the survey. Sixty-one responded (76%). The results showed 100% improved from the surgery, 100% improved function achieved by the technique, 85% were extremely satisfied with the surgery (17% satisfied) and 100% stated they would have the procedure again if needed.

Discussion

Pennal and Sutherland [23] reported relevant classification systems initially based on the mechanism of injury. Three categories of pelvic ring injuries included: (1) avulsion fractures, (2) 'stable' fractures, and (3) 'unstable' fractures.

Dunn and Morris reexamined the non-operative concept for the management of pelvic ring injuries and dislocations, based on the Pennal/Sutherland classification system [24]. Pennal and Tile introduced the aspect of fracture stability to the Pennal/ Sutherland classification and incorporated mechanisms and vectors of injury [25]. The Pennal/Tile classification helped as the basis for decision-making, operative, or non-operative management of anterior pelvic ring injuries [26]. Classification systems are based on the publications by Tile. The classification used in our study was by Young and Burgess.

Depending on the fracture type, different treatment strategies have been preferred. Initial treatment of A2 fractures/lateral compression has been conservative and non-operative. All patients have need of bed rest and opioid pain medication. Patients are difficult to mobilize upon admission because of intense pain. Pain relief if not immediate, usually means mobilization will remain close to impossible. After a few days, or possibly a week of bed rest, with significant pain relief, only then is careful mobilization started. Full-weight bearing by the patient is allowed. However, forced mobilization maybe difficult until radiographic evidence of fracture healing is present. The idea of anterior pubic rami fracture stabilization with calcium phosphate for pain control and early mobilization is new. The need for pain relief and early mobilization has led to the use of calcium phosphate as an early synthetic bone scaffold useful in the treatment of lateral compression pubic rami fractures. Filling these fractures with calcium phosphate for bone stabilization does not inhibit bone healing. This form of treatment, particularly in elderly females has helped with preventing an acute medical condition from becoming a significant health care problem.

There is no consensus about the optimal treatment strategy for these fractures. Calcium phosphate acts as a point of internal fixation, and early scaffold formation, providing bone support for early mobilization and pain relief. The goal of this study was to describe a technique that increases patient satisfaction and decreases medical co-morbidities associated with prolonged non-surgical management.

Conclusion

A bone scaffolding technique using calcium phosphate was presented as a minimally invasive procedure for treating acute pubic rami fractures. This procedure solves the problems of fracture pain and early mobilization. Calcium phosphate stabilizes and augments natural cancellous bone fractures. Calcium phosphate is a flow-able material injected into pubic rami fractures percutaneously. The findings from this study demonstrate the technique to be safe, reproducible, affording immediate pain relief and allowing early mobilization. The benefits from this treatment is, the length of stay from hospitalization is shortened, opioid medication decreased and comorbidities associated with prolonged bed rest and limited mobility lessened.

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