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Medical Rehabilitation in Patient with Post ORIF et causa Neglected Epiphyseal Fracture Distal Radius-Ulna Sinistra: A Case Report

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Abstract: Distal radius-ulna fracture is one of the most common human osseous injuries, with incidence rate increasing worldwide. There are two peaks of prevalence: the first around the 10th and the second around the 60th year of life. During childhood, they are among the most common pediatric fractures accounting for 19.9 to 35.8% of all pediatric fractures. We reported a case of a boy 13 years old diagnosed as post open reduction internal fixation distal radius ulna et causa epiphyseal fracture. He came to rehabilitation outpatient clinic with chief complaint pain on his left forearm. He underwent a surgery two weeks ago at the distal radius ulna. The surgeon did osteotomy on ulna and then fixated with plate and screw. On physical examination, there were pain and range of motion limitation mainly on the forearm and wrist joint. The patient was treated with low level laser therapy at the surgical wound to promote healing and decrease edema, initial digital motion exercise along with active range of motion of the uninvolved joints. He was also educated about icing and medicamentation if pain still persisted. Once adequate bony healing had occurred, active, active-assisted, progressive passive wrist motion, and strengthening exercise using resistance were performed to maximize the result. At the end of rehabilitation program, there was great improvement on pain and also range of motion improvement. Albeit, there was still a slight range of motion limitation on ulnar deviation and wrist extension by 5 degrees. In conclusion, rehabilitation program is very beneficial in treating post-surgery patient using modalities and exercises to improve functional function.
Keywords: epiphyseal fracture; radius-ulna; medical rehabilitation

INTRODUCTION

Wrist is one of the most complicated joints in the human body, comprising more than 20 articular interactions and complex intercalated motion segments. The topographic shape of the distal radius articular surface functions as a specialized support base for the carpus. To perform this function, the articular surface must be smooth and positioned correctly in space relative to the three-dimensional regional anatomy of the wrist. However, these surface relationships are highly unstable and would be destined for carpal collapse without their associated ligamentous support.[1]

Stable anatomic restoration of the articular surface of the distal radius at the time of surgery is critical for a successful outcome. The goals of surgical treatment include restoring radial length, volar tilt, radial inclination, and articular reduction at both the radiocarpal and distal radial–ulnar joints. The optimal method of treatment would accomplish restoration of the distal radius anatomy with minimal disturbance of the surrounding soft tissues.[1-4]

To achieve stable anatomic after fracture, the tissue involved must be fixated in order to heal. If the fracture were complete, comminuted, involve joint then internal or external fixation is needed. The most common was internal fixation using plate and screw at dorsal region or commonly called dorsal plating. A dorsal approach to the distal radius for comminuted intra-articular fractures affords excellent exposure of the joint surface. Dorsal plating can reliably buttress the joint, leading to low rates of arthrosis, but at the expense of wrist stiffness and high rates of extensor tendon problems. New, smaller implants may prove capable of supporting the joint with lower rates of extensor irritation. Initial therapy after dorsal plating is directed at edema control, protective static splinting, digital motion exercises, and active motion of the uninvolved joints. Increasing activities of daily living are permitted while using a protective static splint during this phase. Because the distal complex of the fracture slopes volarly and the fixation enters from the dorsum, it is theoretically possible for the distal bone complex and carpus to slip volarly off of the distal fixation screws during the early postoperative period. Until skeletal healing has occurred, early active wrist motion must proceed with caution. Because of screws, extensor tendon irritation, dorsal swelling, the dorsal location of the plate and pain during digital extension exercises are common problems. Extensor tendon rupture has been reported in the early postoperative phase. Unfortunately, once the unique dorsal extensor mechanism and its associated fibroseptae are disrupted from dorsal plate fixation, scarring is inevitable. Once adequate bony healing has occurred, active, active-assisted, and progressive passive wrist motion strengthening is not usually initiated until both complete skeletal healing and at least a plateau in motion have been achieved. [4-9]

CASE REPORT

A case of a 13 years old boy came to rehabilitation outpatient clinic with chief complaint of pain in the left lower arm. Patient felt pain on the left lower arm (post surgery area) and sharp pain, intermittently, especially during activity or moving his arm. There was no referred pain, the pain aggravated when he tried to move his wrist especially when he tried to bend to the fifth finger side, he rested his arm to relieve the pain. Basic daily activities were limited and partial assisted by his parents, especially toileting and dressing.

Patient got an accident in December 2018 (three years ago). He fell while playing hide and seek with his friend and used his left arm as support for his body and injured his left arm. It got swollen and pain at first, however, he did not go to the doctor, and just get pain medications and gentle massage by his parents. After a few days the pain and swell was gone, so he went back to his daily activity gradually. Three years later he noticed that his left wirst was bended to the thumb side when he got marching practice at school. Then he went to orthopedic ward at Siloam Hospital, had a CT-scan and found that one of his bone is longer than the other one on his left lower arm. Patient was admitted to Prof. Dr. R. D. Kandou hospital for surgery. He had surgery at 20th December 2022 (11 days before admission) and referred to rehabilitation outpatient clinic afterwards.

On admission, he was alert, vital sign within normal limit and BMI was 20.62 kg/m^2 (normal), posture examination was within normal limit. On local status on the left lower hand

(Figure 1), we found, as follows: Look: on partial fixation using gypsum, surgical wound ± 15cm, slight erythema at wound site at left lower arm (post surgery area) suture (+), pus (-), blood (-), wound looked well dressed and dry, hematoma (-), edema (-), arm length discrepancy (+1,5cm), normal on right side, and Anthropometry was shown on Table 1; Feel: tenderness around wound site, numeric pain rating scale (NPRS) 5-6, crepitation (-), mass (-), warmth (-); Move: full range of motion (ROM) on shoulder and elbow, limited on wrist joint due to pain (Table 1); normal ROM on right upper extremity, full range of motion (Table 2).

Figure 1. A, Left forearm using fixation; B, Range of motion testing; C, Left forearm in backslab without elastic bandage; D, Local status at left forearm without backslab

Table 1. Anthropometry upper extremity, there were length discrepancies of 1,5 cm on left side forearm

Anthropometry (cm)		
(Arm length) Acromion - Elbow	21	21
Arm Circumference	24	23
(Forearm length) Elbow - Wrist	20	**18,5**
Forearm Circumference	22	21
(Hand length) Manus	14	14
Total upper extremity length	**55**	**53,5**
Anthropometry (cm)		
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Total upper extremity length	**55**	**53,5**

Table 2. Range of motion of left upper extremity; there was range of motion limitation on left upper extremity especially on forearm while normal on finger

ROM			**MMT (Manual muscle test)**		
Lower Arm					
Supination	0-90	**0-45**	Supination	5	Pain
Wrist					
Flexion	0-80	**0-45**	Flexion	5	Pain

ROM			**MMT (Manual muscle test)**		
Extension	0-70	**0-60**	Extension	5	Pain
Ulnar Deviation	0-30	**0-10**	Ulnar Deviation	5	Pain
Radial Deviation	0-20	**0-5**	Radial Deviation	5	Pain
Thumb					
Abduction	0-70	0-70	Abduction	5	Pain
Adduction	70-0	70-0	Adduction	5	Pain
MCP Flexion	0-50	0-50	MCP Flexion	5	Pain
IP Flexion	0-90	0-90	IP Flexion	5	Pain
MCP Extension	0-20	0-20	MCP Extension	5	Pain
IP Extension	0-20	0-20	IP Extension	5	Pain
Other Fingers					Pain
Abduction	0-20	0-20	Abduction	5	Pain
Adduction	20-0	20-0	Adduction	5	Pain
MCP Flexion	0-90	0-90	MCP Flexion	5	Pain
PIP Flexion	0-100	0-100	PIP Flexion	5	Pain
DIP Flexion	0-90	0-90	DIP Flexion	5	Pain
MCP Extension	0-30	0-30	MCP Extension	5	Pain
IP Extension	0-10	0-10	IP Extension	5	Pain

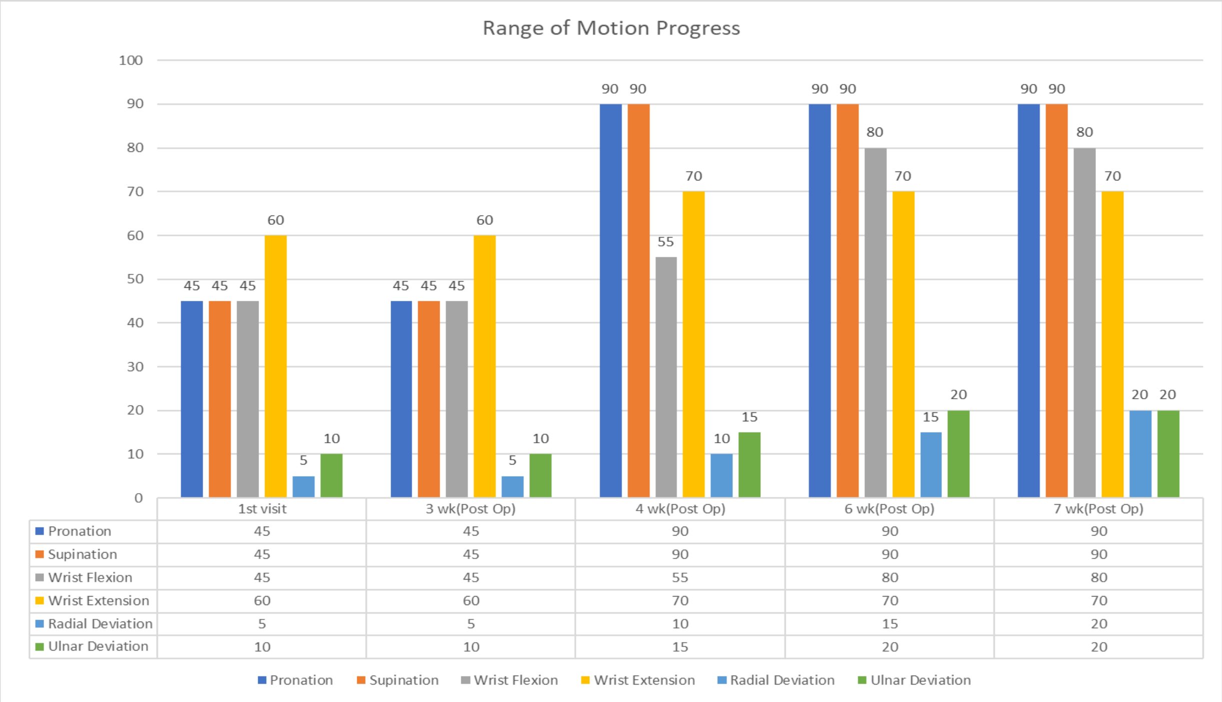
In evaluation of funtional status, the Barthel index was 15 which was moderate dependent in toiletting and dressing. Supportive examination was CT-scan before surgery and x-ray on left lower arm after surgery using dorsal plating (Figure 2).

Figure 2. Above, CT scan upper extremity before surgery; Below, X-Ray after internal fixation on forearm

REHABILITATION PROGRAM

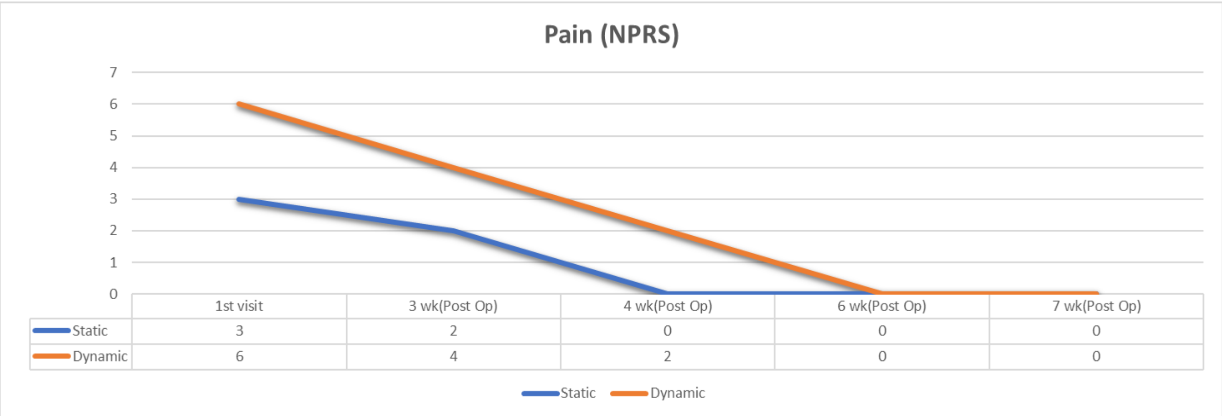
This patient had some rehabilitation problems, including: pain on left forearm (post operation area), ROM limitation on left wrist (some muscle could not be evaluated due to pain), difficulty in simple task using left hand (carrying, lifting, and grasping object), limitation of basic ADL, upper extremity length discrepancy (left side shorter 1,5 cm), and limitation activity in school.

Comprehensive rehabilitation management given for this patient, included: paracetamol 500mg tab 3x/day PO prn, low level laser therapy 830 nm, 50 mW, 1 cm2, 4 J/cm2, 1 min 20 sec on post operation area, ice pack around surgical wound 3-5x/day, 5-15min/times prn, ROM exercise and stretching (three times a week, when patient gets used to it, increased daily, stretch to the point of feeling tightness or slight discomfort, holding static stretch for 10 seconds, 4 repetitions), plan strengthening upper left extremity after pain subside - basic hand task specific training for ADL as tolerated, observation until patient start to full functional without symtomps, plan consult to orthopaedic surgeon if needed, education and mental support, as well as psychological and social medic teams. Figure 3, 4, and 5 showed the progression of ROM, pain (using NPRS), and hand function until seven weeks post operation.



	1st visit	3 wk(Post Op)	4 wk(Post Op)	6 wk(Post Op)	7 wk(Post Op)
Pronation	45	45	90	90	90
Supination	45	45	90	90	90
Wrist Flexion	45	45	55	80	80
Wrist Extension	60	60	70	70	70
Radial Deviation	5	5	10	15	20
Ulnar Deviation	10	10	15	20	20

Figure 3. Range of motion progression



	1st visit	3 wk(Post Op)	4 wk(Post Op)	6 wk(Post Op)	7 wk(Post Op)
Static	3	2	0	0	0
Dynamic	6	4	2	0	0

Figure 4. Pain progression using NPRS scale

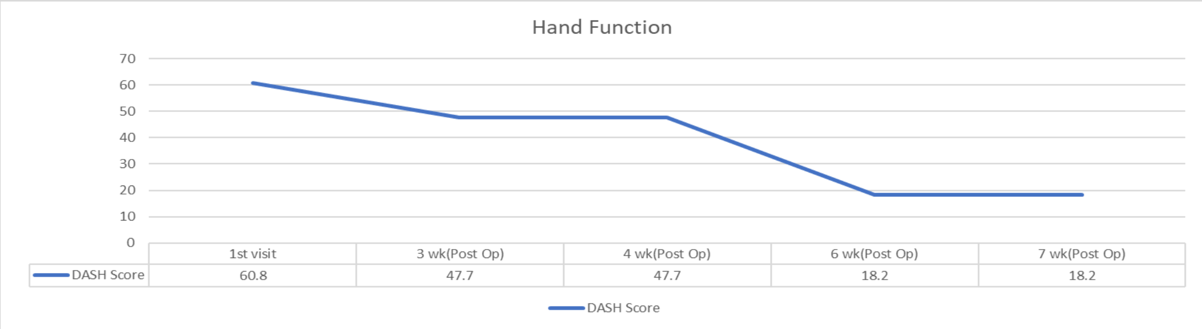


Figure 5. Hand function progression

DISCUSSION

Distal radius fractures are one of the most common human osseous injuries, with incidence rates increasing worldwide. There are two peaks of prevalence: the first around the 10th and the second around the 60th year of life. During childhood, they are among the most common pediatric fractures accounting for 19.9 to 35.8% of all pediatric fractures. Transitional fractures are defined as epiphyseal injuries in which partial closure of the epiphyseal growth plate has already occurred and must be clearly differentiated from pediatric fractures as an independent fracture entity. Despite the frequency of distal radius fractures, especially during childhood, transitional fractures of the distal radius are rare.[4,10,11]

Transitional fractures are a special type of fracture in adolescents with partial closure of the epiphyseal growth plate, that show different specific fracture patterns compared to fractures in children with wide open physis. Transitional fractures are most commonly reported in the distal tibia. Depending on the number of fragments, the transitional fractures of the distal tibia are divided in two-plane, three plane I or three plane II fractures.[11-13]

Theoretically, these fractures could occur in any other physeal growth plate of the body. The physiology of the closure of the epiphyseal growth plate in general, and closure of the distal radius in particular, as well as the forces acting at the distal radius need to be reviewed to discuss the different treatment options of this rare injury.[11-13]

The distal part of the radius has a quadrilateral crosssection including the metaphysis and the epiphysis. According to the biomechanical model of Rikli and Regazzoni, the distal forearm is divided into three columns: the radial, the intermediate and the ulnar column. A biomechanical study evaluating the distribution of forces transmitted across the human radioulno carpal joint under physiologic conditions and was able to confirm the existence of two main force transmission centers: one at the intermediate column opposite the proximal pole of the scaphoid, and the second at the ulnar column opposite the lunate. Furthermore, it was demonstrated that the majority of the load (up to three-fourths) was transmitted through the ulnar column.[13,14]

The wrist is one of the most complicated joints in the human body, comprising more than 20 articular interactions and complex intercalated motion segments. The topographic shape of the distal radius articular surface functions as a specialized support base for the carpus. To perform this function, the articular surface must be smooth, level, and positioned correctly in space relative to the three-dimensional regional anatomy of the wrist. There are seven true carpal bones that consist of two rows: scaphoid, lunate, and triquetrum in the proximal row; and trapezium, trapezoid, capitate, and hamate in the distal row. Each of these bones has a complex surface geometry that matches the surfaces of its neighbors. However, these surface relationships are highly unstable and would be destined for carpal collapse without their associated ligamentous support. The only restraint to such a derangement of the normal anatomy is the powerful system of multiple intrinsic and extrinsic ligaments interconnecting the carpal bones and joining the carpus as a unit to the radius proximally and the hand distally. Transgressing the wrist are multiple extrinsic flexor and extensor tendons that create normal force vectors through the wrist with active motion or grip. In an in vitro cadaveric study, resultant forces five times that of measured grip strength were found to transmit across the distal radius during a simulated gripping action These normal-moment arms and resultant force vectors are capable of producing displacement in the setting of a fracture or ligament injury.[1,4,13,14]

The goals of surgical treatment include restoring radial length, volar tilt, radial inclination, and articular reduction at both the radiocarpal and distal radial–ulnar joints. The optimal method of treatment would accomplish restoration of the distal radius anatomy with minimal disturbance of the surrounding soft tissues. The true incidence of related soft tissue injuries is becoming more apparent with further research and more detailed evaluations of distal radius injuries. No longer is the fracture considered alone, but rather in the context of associated fracture and soft tissue injury patterns: median nerve compression, carpal/ ulnar fractures, disruption of the extrinsic, intrinsic, or distal radioulnar ligaments, and tearing of the fibrocartilage disc. Each of these injuries affects the surgical strategy used, the methods of therapy planned, and the final functional outcome. The details of therapy for such major additional injury patterns are beyond the scope of this article but are mentioned to stimulate awareness of the presence of such injuries. Initial therapy after dorsal plating is directed at edema control, protective static splinting, digital motion exercises, and active motion of the uninvolved joints. Increasing activities of daily living are permitted while using a protective static splint during this phase. Because the distal complex of the fracture slopes volarly and the fixation enters from the dorsum, it is theoretically possible for the distal bone complex and carpus to slip volarly off of the distal fixation screws during the early postoperative period. Until skeletal healing has occurred, early active wrist motion must proceed with caution. Because of the dorsal location of the plate and screws, extensor tendon irritation, dorsal swelling, and pain during digital extension exercises are common problems. Extensor tendon rupture has been reported in the early postoperative phase. Unfortunately, once the unique dorsal extensor mechanism and its associated fibroseptae are disrupted from dorsal plate fixation, scarring is inevitable. As a result, dorsal extrinsic capsular stiffness is common and further potential loss of wrist motion can occur. Scar management techniques and skin mobilization with deep massage after surgical wound healing is helpful in decreasing tendon adherence at the skin level. To maximize the excursion of normal tendons relative to surrounding postsurgical adhesions, a new technique has been described. Rapid tendon acceleration through preload (potential energy loading) and rapid release (acceleration) of normal tendons through a damaged zone of tissue improved final total active tendon motion, decreased final active/passive discrepancy, and minimized the formation of tendon adhesions after tenolysis procedures and crush injuries. This technique can be applied to isolated extensor tendons after dorsal plating. Acceleration of normal tendons through a zone of scarred tendon sheath during tissue repair and remodeling may prevent adhesion formation. The basis of this technique was derived from orthopedic research, which has shown that bone, muscle, and collagenous tissues respond to specific patterns of loading by remodeling the composition, organization, and mechanical properties of their matrices.[11-14]

Once adequate bony healing has occurred, active, active-assisted, and progressive passive wrist motion exercises are initiated. A broader spectrum of daily activities and light work is appropriate at this phase. Special emphasis is on active wrist flexion to counteract the scarring of the dorsal wrist capsule. If digital and/or wrist contractures develop, static progressive splinting is helpful and can be started eight weeks after surgery. Strengthening is not usually initiated until both complete skeletal healing and at least a plateau in motion have been achieved. Between four and six months is when the majority of strength improvement is expected. Contact sports and heavy labor are not usually permitted until after six months.

In this patient we give low laser therapy with settings of 830 nm, 50 mW, 1 cm2, 4 J/cm2, on post surgical area to enhance the healing process of the surgical wound healing and also reduce the pain symtomps as soon as possible. Icing is also given to this patient to help reduce pain and edema. After 2 weeks of therapy, the pain reduced significantly and the pain completely gone after 4 weeks of therapy (five weeks post surgical).

The LLLT, currently called photobiomodulation therapy (PBMT) due to its photochemical effect, in which light is absorbed, promotes a chemical change known as photobiostimulation, which influences the release of several growth factors involved in the for mation of epithelial cells, fibroblasts, collagen and vascular proliferation, making it a therapy that promotes wound healing and pain reduction, besides stimulating the synthesis of enzymes that act on lysosomes and mitochondria.[1,9,10,15]

Four weeks postoperatively, the advancement of active motion to more progressive passive stretching is appropriate, whereas the use of static protective wrist splints is gradually discontinued. An expanded set of activities with limited resistance is allowed. By six to eight weeks, patients should already have gained the majority of their wrist motion, as opposed to those treated with external fixation, which are just beginning wrist motion exercises. In our experience, static progressive splints are rarely required with this method, which is in contrast to external fixation. Strengthening is initiated around eight weeks after surgery. By three months, patients can return to all activities with the exception of contact sports and heavy labor (this is allowed after six months).

In this patient, we measured the grip strength in both hands after the gips was removed with result 19 kg on right side and 12 kg one left side, and increased to 20 kg and 14 kg after 7 weeks after surgical. In the 6-week post operation using distal plating, after the pain is completely gone, we give strengthening exercise using dumbells using 40% of his RM 3x/weeks, 3 sets, 8-12 repetitions per sets. ROM stretching and exercise still given to this patient to maximize the functional outcome, even though after eight weeks post operation, there is still slight ROM limitation (ulnar deviation) by 10 degrees (Figure 6, 7).

Figure 6. A, Grip strength measurement on right hand; B, Grip strength measurement on left hand; C, Strengthening of upper extremities using dumbells as home program

Figure 7. Both upper extremites after eight weeks of rehabilitation program

The outcome in distal radius fracture management is dependent on numerous factors such as the fracture pattern, associated injuries, patient characteristics, and treatment rendered by the surgeon. Therapists cannot influence any of these factors but are expected to shepherd the patient through swelling, stiffness, pain, weakness, and the difficulty of returning to functional activities. This can prove a daunting task indeed. Early active rehabilitation protocols are appropriate with specific surgical methods of distal radius fixation.[6,7,12]

The various problems in rehabilitation for distal radius fractures into three basic categories derived from the method of surgical treatment. The specific challenges faced are unique for each strategy and dictate where the therapist should focus his or her energy. External fixation is often characterized by extrinsic digital tightness, capsular stiffness, dysfunctional posture, and radial neuralgia. Dorsal plating is often characterized by extensor tendon gliding dysfunction and incomplete load-bearing capability of the implant. Volar fixed-angle plating features an early active motion program and emphasis on achieving early wrist extension. Naturally, those injuries involving higher energy mechanisms and poor bone stock will be overall more difficult to treat throughout the rehabilitation process.[13,14]

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Conflict of Interest

The authors affirm no conflict of interest in this study.

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