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Therapeutic Implications of the Radiographic "Drop Sign" Following Elbow Dislocation

A radiographic drop sign following elbow trauma is an abnormality that is controversial with limited information describing optimal management. The consequences of this complex clinical situation includes limited motion, pain, and joint impingement, which may lead to joint stiffness and contracture formation. These authors describe the therapeutic implications of this radiographic finding and present a treatment approach in order to enhance patient outcomes.—VICTORIA PRIGANC, PhD, OTR, CHT, CLT, Practice Forum Editor

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REVIEW OF ELBOW DISLOCATIONS

Elbow dislocation is a common injury treated by physicians and therapists.[1,2] These injuries are classified as simple or complex. A simple elbow dislocation is a capsuloligamentous injury with no associated fractures, whereas a complex dislocation has associated bony injuries. It has been documented that the lateral collateral ligament, medial collateral ligament, and anterior capsule are usually disrupted in all simple dislocations. The extent of injury to the common flexor and extensor origins likely has an important influence on post-dislocation stability. Associated fractures of the radial head and coronoid are most commonly seen, however, avulsions of the epicondyles and shearing fractures of the capitellum and trochlea can also occur.

The initial treatment goal is to obtain a congruent reduction of the articulation, treat any associated injuries as required, and ensure that a stable congruent joint can be maintained, allowing for early range of motion (ROM). Ideally, the physician performing the closed reduction completes an examination under anesthesia to document the stable arc of motion. To do so, the elbow is gradually extended from the stable flexed position (with the forearm in supination, neutral, and pronation), and the angle at which the joint starts to subluxate is recorded. This information is critical for the therapist to be made aware of to implement a safe arc of early ROM. If this information is not available then elbow extension should be limited to 60°, progressively increasing extension by 10° per week.

The optimal time to implement ROM after elbow dislocations is unknown; the period of initial immobilization depends on the injury pattern, associated fractures and soft-tissue injuries, and surgeon preference. Successful rehabilitation relies on close communication between the surgeon and therapist. Before initiating rehabilitation,

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the treating therapist should be informed of the stable arc of motion and the influence of forearm rotation on this arc if this has been determined with an examination under anesthesia. Commonly this information is unavailable as the closed reduction of most elbow dislocations are typically performed in an emergency department. Although the status of the collateral ligament and capsular tissues can be predicted, the physician should advise the therapist of the presence of associated fractures or nerve injuries. If surgery has been performed and some of the structures have been repaired, the surgeon should communicate the details of the surgery and the stability evaluation after repair so that the therapist can create a customized rehabilitation program. This includes isometric contractions, active ROM within a safe arc, and ligament protective orthotic (splint) positioning.[3–6] However, in addition to the above details, the therapist must also be aware of any radiographic abnormalities such a drop sign,[7] as this will directly influence the design of the rehabilitation program.

RADIOGRAPHIC DROP SIGN

A radiographic drop sign is an objective, measurable increase in ulnohumeral distance, which is evident on static lateral radiograph (see Figure 1).[7] An ulnohumeral distance of greater than 4 mm would be considered a positive drop sign as described by Coonrad et al.[7] These authors found that the typical ulnohumeral distance on lateral radiograph in an uninjured elbow is 2–3 mm. A drop sign can be present after simple or complex dislocations treated with or without surgery and indicates that there is persistent instability of the elbow joint.[7,8]

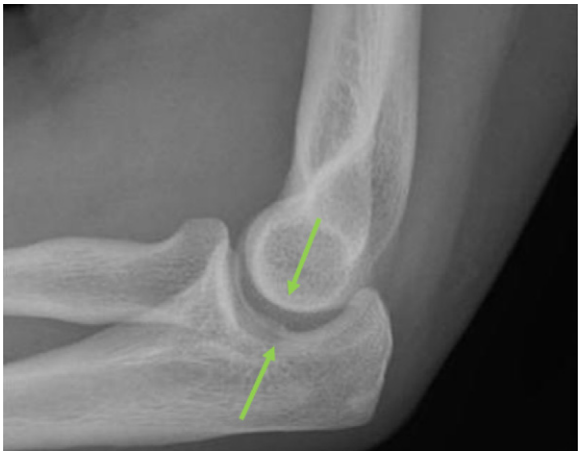

FIGURE 1. *A drop sign is a radiographically measurable increase in ulnohumeral joint distance evident on lateral radiograph.*

The radiographic drop sign is of concern given the known difficulty of restoring stability to the elbow. This slight sagging of the ulnohumeral joint indicates that the articular contact between the ulna and the humerus is suboptimal. If severe, it may warrant operative treatment.[8] If the ulnohumeral joint continues to "sag" and is not addressed, it will likely lead to ulnohumeral impingement, early joint wear, pain, inflammation, recurrent instability, and contribute to elbow stiffness and contracture formation. Thus, a positive drop sign can be detrimental to regaining elbow motion and function.

Soft-tissue Stabilizers of the Elbow and their Contribution to the Radiographic Drop Sign

The highly congruous joint surfaces of the ulnohumeral joint, along with its ligaments and joint capsule, provide the elbow with static stability. The muscles crossing the elbow contribute to joint stability by providing secondary constraints to varus and valgus forces.[9] These muscles create a compressive force, which also enhances stability of the elbow joint.[10] For example, when the biceps, brachialis, anconeus, or triceps muscles contract, joint compressive forces are produced that helps to stabilize and align the ulnohumeral joint preventing dislocation[10,11] (Figure 2).

After elbow dislocation (simple or complex), the dynamic stabilizers of the elbow undergo significant trauma. This trauma produces swelling and

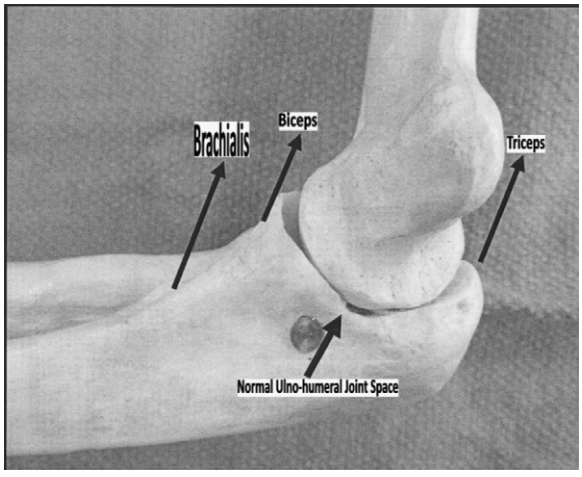

FIGURE 2. *The muscles crossing the elbow joint provide a compressive force, which maintains normal ulnohumeral joint space. When the biceps, brachialis, or triceps contract, the compressive force produced helps stabilize and align the ulnohumeral joint preventing dislocation.*

pain within these structures resulting in an inhibition to produce muscle contraction.[8] Thus, the compressive forces normally produced by the dynamic stabilizers of the elbow are reduced. This decreased amount of ulnohumeral joint compression along with the ligamentous disruption, which occurs after dislocation contributes to the ulnohumeral joint sagging.

Clinical Management of the Radiographic Drop Sign: Implications to Specialized Therapy

We advocate that all patients whom have sustained a simple or complex elbow dislocation be referred to therapy within three to five days post-reduction to initiate controlled active mobilization. Several studies have identified the negative effects of prolonged immobilization after both simple and complex elbow dislocations.[12–16] The manner in which early mobilization is performed is dependent on numerous factors including joint stability after reduction, established safe arc of motion, physician preference, and associated bony and soft-tissue injuries. Listed below is a treatment regime we use to incorporate early mobilization in the presence of a radiographic drop sign.

ORTHOTIC APPLICATION

All patients should be placed in a posterior elbow resting orthosis positioning the elbow in approximately 80–90° of elbow flexion and forearm rotation *specific to the injury pattern to provide optimal ligament protection*.

- *After lateral collateral ligament injuries*, the elbow should be rehabilitated with the forearm positioned in pronation.[12–15] This will pivot the forearm around the medial structures and tension the extensor/supinator group of muscles, which contributes to lateral-sided stability.
- *After medial collateral ligament injuries*, the elbow should be rehabilitated in supination as this will pivot the forearm around the lateral structures and tension the flexor/pronator group of muscles, which contributes to medial-sided stability.[9,10,15]
- *If both the medial and lateral collateral ligaments are disrupted*, the elbow should be positioned in an orthosis and rehabilitated in neutral rotation. In the setting of a simple elbow dislocation, the ligament injuries on the lateral side of the elbow are typically more severe than medially, so it is most common that forearm pronation is the preferred position of splinting and rehabilitation.

INITIAL EXERCISE REGIME

To reduce the gravitational forces distracting the ulnohumeral joint and contributing to "sagging" of the joint, the patient is instructed in a specific exercise regime. In the presence of a radiographic drop sign, patients are instructed to perform the following.

- *Isometric exercise of the triceps, biceps, and brachialis while in the resting orthosis*. Isometric exercise should be performed at regular intervals throughout the day. Isometric exercise enhances compressive joint forces across the ulnohumeral joint producing superior translation of the ulna reducing ulnohumeral sagging[17] (Figure 3).
- *Elbow and forearm active ROM exercises in an overhead manner*. Overhead ROM is performed while supine with the shoulder flexed to 90°. Overhead exercise reduces the gravitational forces distracting the ulnohumeral joint and enhances ulnohumeral joint tracking during

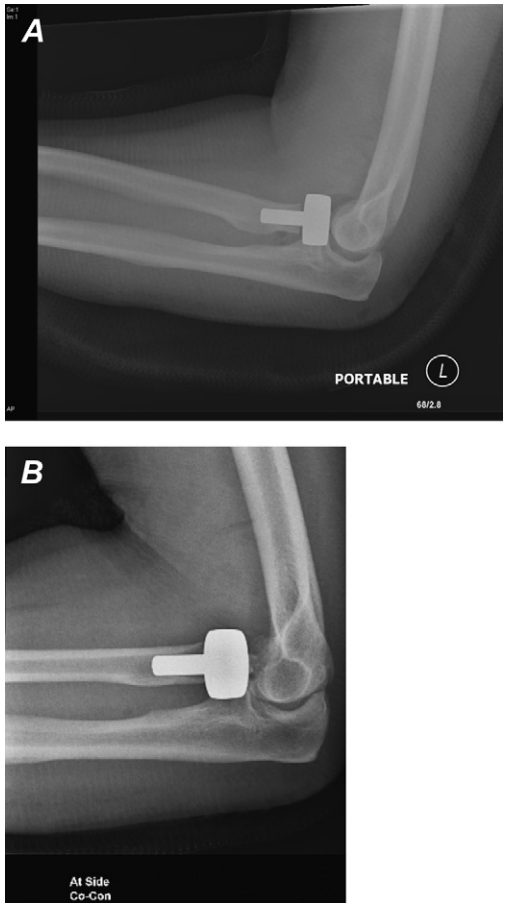

FIGURE 3. A. *Radiographs demonstrating drop sign after terrible triad injury.* ***B.*** *Radiograph taken while patient is performing isometric contraction. Note the decreased gapping of the ulnohumeral joint space.*

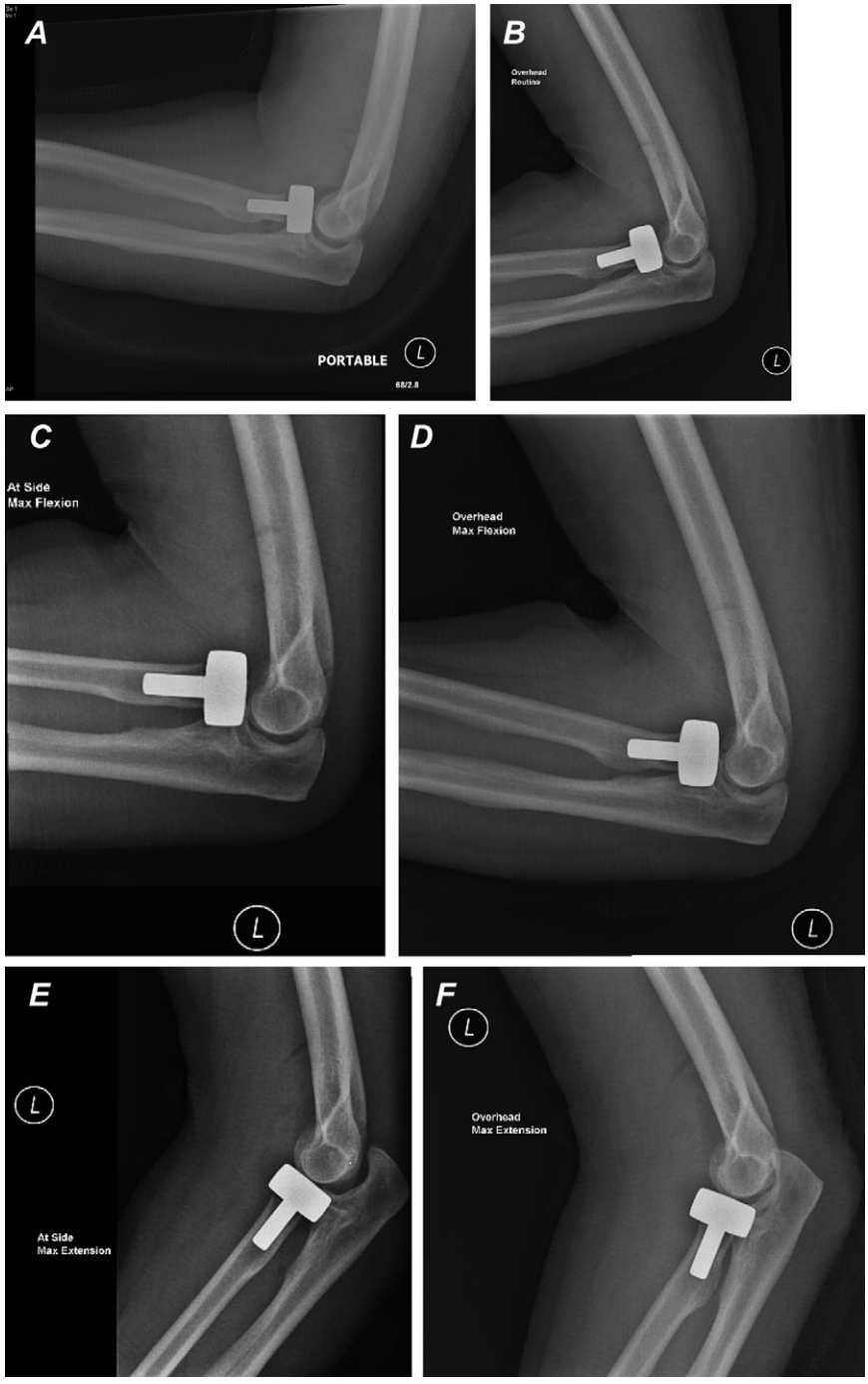

FIGURE 4. *Elbow and forearm range of motion exercises should be performed in an overhead manner in the presence of a radiographic drop sign. Overhead exercises will reduce the gravitational forces to the ulnohumeral joint. Comparison of figures* ***A*** *and* ***B*** *demonstrate that the drop sign is minimized when gravitational forces to the ulnohumeral joint are altered. Figure* ***A*** *is a standard lateral radiograph, whereas figure* ***B*** *is a lateral radiograph in the overhead position.* ***C.*** *Active elbow flexion performed with the elbow at the side increases ulnohumeral joint space and may cause joint hinging/perching especially the coronoid on the articular surface. This will cause pain and inflammation. Furthermore, perching of the coronoid over the articular surface may compromise coronoid fracture healing (especially in the presence of a tenous repair).* ***D.*** *Performing active elbow flexion in an overhead fashion significantly minimizes ulnohumeral joint hinging and impingement.* ***E.*** *Active elbow extension performed with the elbow at the side increases ulnohumeral joint space and causes posterior hinging and shearing of the coronoid.* ***F.*** *Performing elbow extension in the overhead position significantly improves joint alignment and tracking.*

flexion and extension exercises. This minimizes ulnohumeral joint sagging, joint hinging, and impingement during early ROM exercises.[18] *The importance of applying overhead exercise can best be appreciated in Figure 4, which demonstrates its effect on reducing ulnohumeral joint sagging. This patient sustained a complex elbow dislocation (terrible triad injury) and underwent open reduction and internal fixation which included lateral ulno-collateral ligament repair, radial head arthroplasty, and suture repair of the coronoid. This series of radiographs were taken on postoperative day 5.*

- *Caution with passive ROM applied to the ulnohumeral joint*. In the presence of radiographic drop sign, caution must be applied when implementing passive ROM to the ulnohumeral joint. This caution is essential in preventing anterior and posterior hinging of the articular structures causing further joint damage, pain, and inflammation. This is especially critical with combined fractures of the coronoid, as passive ROM will place undress stress *to the healing coronoid that may disrupt fracture healing or cause displacement*.
- *Active wrist and digital motion*. These exercises will also provide a compressive force to the ulnohumeral joint as the wrist, and digital flexors and extensors cross the elbow joint. However, as no ulnohumeral joint motion occurs with these exercises they do not need to be performed in an overhead fashion.

It is our experience that with the implementation of the above-mentioned rehabilitation approach, the radiographic drop sign reduces spontaneously within the first two to six weeks after its application (see Table 1). Once correction of the drop sign is observed radiographically, the patient can discontinue performing overhead and isometric exercises. At this time, the patient can be progressed to active ROM in all planes based on the stages of healing of the involved structures.

PROGRESSION OF ROM EXERCISES AND STRENGTHENING

Once correction of the drop sign is observed radiographically, joint stability is confirmed, and healing osseous and soft-tissue structures have attained sufficient tensile strength, patients can be progressed to active and passive ROM in all directions.

- *Weeks 2–4*. Strengthening the wrist flexors, wrist extensors, digital flexors, and digital extensors can begin depending on pain and inflammation within these structures. The patient should be instructed to perform 15–30 repetitions using a 1–2 lb weight to strengthen the wrist flexors and extensors. Digital flexors and extensors can be strengthened using a stress ball™ or thera-putty™. These exercises are performed with the elbow at 90°, resting on a table and the forearm in neutral rotation.
- *Weeks 6–12*. The protective orthosis can typically be discharged at six weeks. Patients are progressed to gentle strengthening of the elbow flexors, extensors, forearm rotators, and the shoulder beginning at eight weeks using lightweights and resistive elastic bands. Emphasis should be placed on triceps strengthening, as

***TABLE 1.* Overhead, Isometric, and Isotonic Exercise Regime**

Weeks	*Exercise Regime*	*Frequency*
0–6	1. Overhead active elbow flexion and extension within established safe arc of motion. Elbow extension is advanced by 10° increments on a weekly basis.	Exercises are performed every 1–2 h during the day for 10 to 20 repetitions.
	2. Overhead active pronation and supination with the elbow positioned at 90°.	
	3. Isometric co-contraction of brachialis, biceps, and triceps.	Exercises are performed 4 to 6 times per day for 5 to 10 repetitions. Each repetition is held for 5-10 sec in duration.
2–6	Isotonic exercise of the wrist flexors and extensors.	Exercises are performed 1 to 2 times per day for 15–30 repetitions using a 1–2 lb weight.
	Isotonic exercise of the digital flexors and extensors.	Exercises are performed 1 to 2 times per day for 15–30 repetitions using a stress ball or thera-putty.
Radiographic drop sign reduced and joint stability confirmed by physician		
6–8	AROM and PROM permitted in all directions.	Exercises are performed every 1–2 h during the day for 8–15 repititions.
8–12	Progressed to isotonic strengthening of the elbow flexors, extensors, forearm rotators, and shoulder.	Exercises are performed 1 to 2 times per day for 15–30 repetitions using lightweights or resistive bands.
	Mobilization splinting applied as necessary.	

this will aid in minimizing flexion contracture formation. Patients progress through a progressive resistive strengthening program, which includes graded functional activities.

Orthosis Intervention

Rehabilitation after elbow dislocation is challenging for the physician and therapist because the elbow is prone to joint stiffness and contracture formation. Patients who develop posttraumatic stiffness often require dynamic and/or static-progressive splinting to regain elbow and forearm motion. Several orthotic designs have been devised to regain elbow flexion, extension, and forearm rotation; however, mobilization orthotic application should not be implemented until sufficient osseous and soft-tissue healing has been confirmed.

Despite our best efforts when managing a drop sign, it may not spontaneously reduce within the first six weeks after reduction. In such instances, mobilization orthotic application must be implemented with caution to prevent hinging of the articular structures leading to joint damage, pain, inflammation, and greater stiffness.[19] Static-progressive elbow extension orthosis application should be used with caution with elbow flexion contractures 30° or less, as hinging may be profound with this orthotic application (Figure 5). Furthermore, static-progressive elbow flexion splinting may be contraindicated in patients who can achieve 130° of flexion, as profound hinging may occur between the coronoid and coronoid fossa (Figure 6A–C). However, this form of flexion splinting may be used with caution when the patient is unable to achieve 130° of flexion. In contrast,

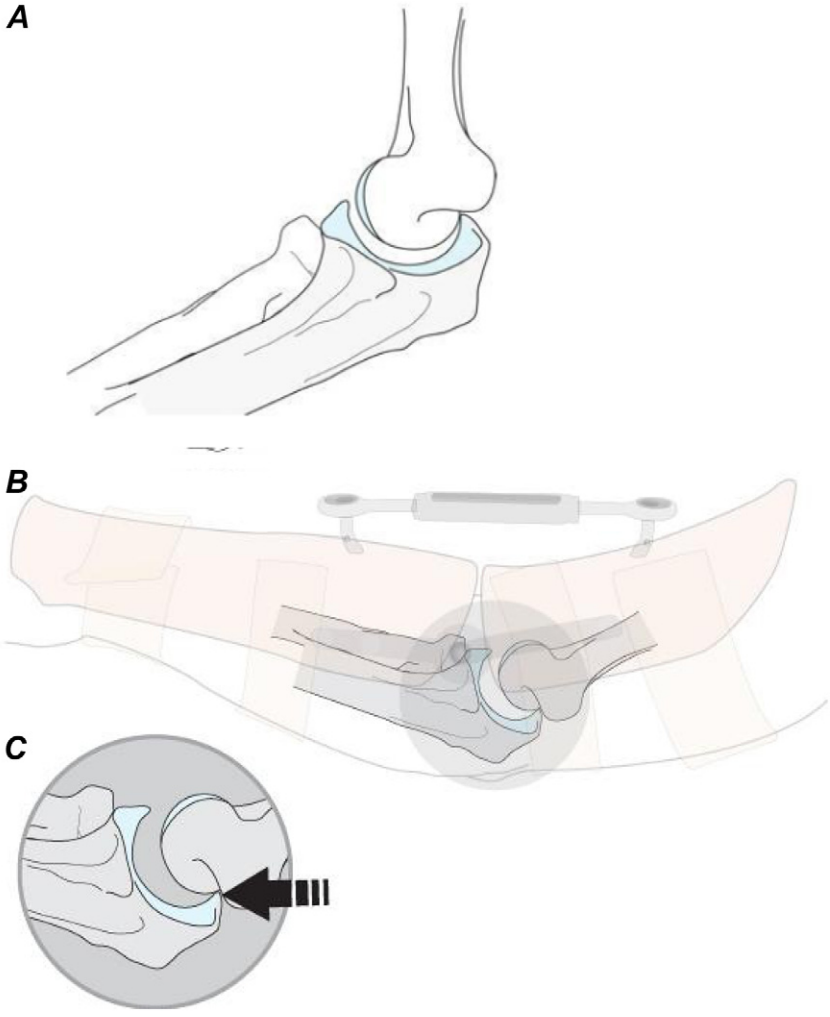

FIGURE 5. A. *Schematic of drop sign.* ***B.*** *Schematic of an elbow in approximately 30° of elbow extension with an unresolved drop sign.* ***C.*** *Schematic of static-progressive elbow extension orthosis with an unresolved drop sign. This form of splinting will likely cause posterior joint impingement, hinging, inflamation, and pain. (Reproduced With Permission of Techniques in Hand and Upper Extremity Surgery. 2011;15:198–208).*

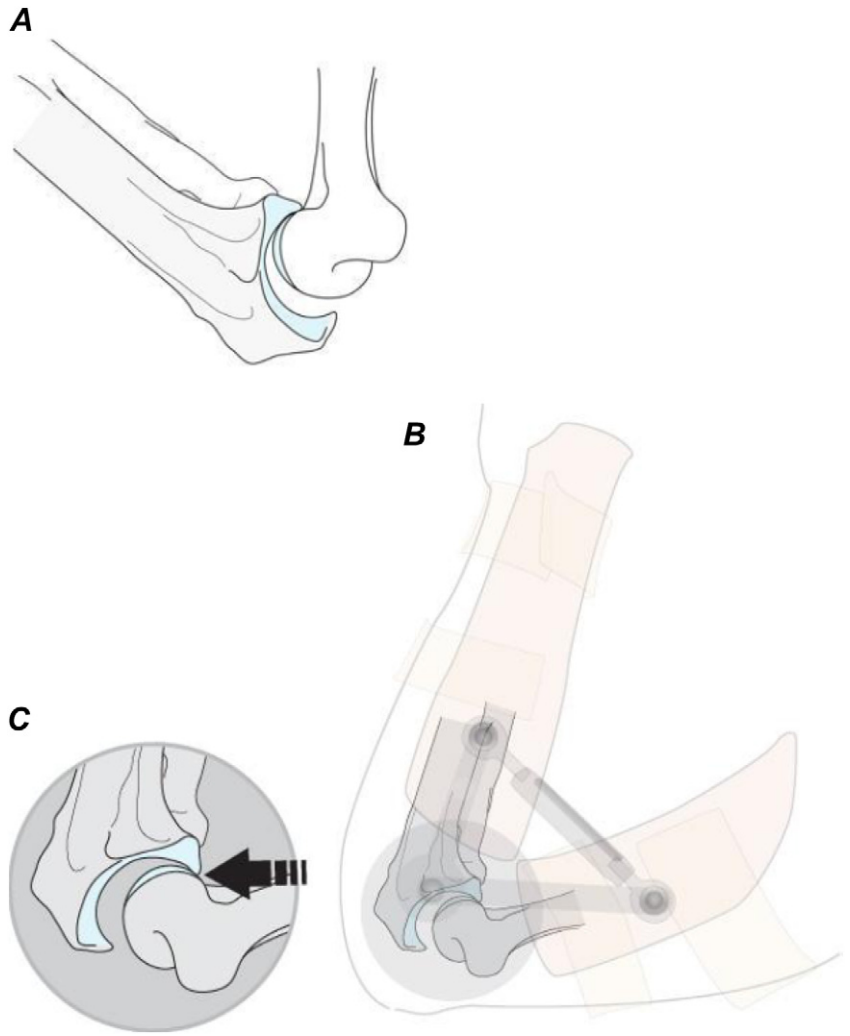

FIGURE 6. A. *Schematic of an elbow in approximately 115° of elbow flexion with an unresolved drop sign.* ***B.*** *Schematic of static-progressive elbow flexion splinting with an unresolved drop sign. Schematic demonstrating anterior joint impingement and hinging which will lead to inflammation and pain caused by this form of orthotic application. (Reproduced With Permission of Techniques in Hand and Upper Extremity Surgery. 2011;15:198—208.)*

forearm rotation splinting can be used to regain terminal rotation, as this motion occurs at the proximal and distal radioulnar joints, which should be in proper alignment.

CONCLUSION

There are limited descriptions of the ''drop sign'' in the literature and few reports describing the optimal rehabilitation strategies that can be used to correct it. In this article, we have identified the importance of recognizing the ''drop sign'' and have presented a rehabilitation guideline, which uses overhead elbow ROM, wrist and hand ROM, and isometric exercise of the elbow flexors/extensors to address this potentially devastating problem. This method of early mobilization can be applied to both simple and complex elbow dislocations. This approach can be implemented to successfully reduce ulnohumeral joint sagging while permitting a safe arc of early motion. A randomized clinical trial of this rehabilitation approach may provide further evidence that rehabilitation, which enhances joint compression and minimizes gravitational forces to the elbow, is beneficial to correct this radiographic finding.

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Quiz: Article #237

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#1. A positive elbow drop sign (as seen on a lateral x-ray) shows
   a. an ulnohumeral distance of approximately 2 mm
   b. an ulnohumeral distance of greater than 4 mm
   c. a radiocapitellar distance of approximately 2 mm
   d. a radiocapitellar distance of greater than 4 mm

#2. A cardinal principal of early rehab following lateral sided elbow dislocation is VSA, an acronym for
   a. Virtual Stress Avoidance
   b. Vertical Stress Avoidance
   c. Valgus Stress Avoidance
   d. Varus Stress Avoidance

#3. A major concern with a persistent drop sign is the possibility of developing
   a. radial nerve impingement
   b. ulnar nerve impingement
   c. degenerative changes of the ulnotrochlear joint
   d. degenerative changes of the radiocapitellar joint

#4. Early rehab ROM exercises following reduction of a simple dislocation should be performed with the
   a. arm at the side, and forearm supinated from the supine position
   b. arm overhead, and forearm pronated from the supine position
   c. arm overhead, and forearm pronated from the sitting position
   d. arm at the side, and forearm supinated from the sitting position

#5. An effective rehab program will often see a gradually reduced drop sign over time
   a. true
   b. false

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