

Comparing Two Devices Used to Regain Full Range of Motion Following Arthroscopic Subacromial Decompression for Shoulder Impingement

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■ ABSTRACT

A rigid cane is commonly used after arthroscopic subacromial decompression and distal clavicle excision to assist in regaining range of motion in the shoulder. However, the fixed hand placement on the cane does not allow for the normal glenohumeral mechanics of elevation with rotation to occur and some patients experience pain with this device. The Upper Extremity Ranger (UER) (Rehab Innovations, Inc, Omaha, Nebraska) contains a floating end to place the hand in promoting more normal upper extremity kinematics when passive motion exercises are performed. This prospective, randomized study compared outcomes of patients who used the UER with those who used a cane postoperatively. Patients in the UER group achieved full motion and were released to full activity significantly earlier than patients in the cane group. The UER appears to be a satisfactory tool to be used as an adjunct for postoperative rehabilitation following shoulder decompression procedures.

Subacromial impingement syndrome is a common form of shoulder pathology.^{1,2} Patients typically suffer from pain symptoms that worsen with time and eventually disrupt sleep and prevent overhead activities.³ In a study of 81 patients who had impingement syndrome, Chipchase et al³ found that 91% were unable

to lift 5 kg over their head, 98% were unable to throw a ball overhead, and 73% were unable to work full time in their occupation. Although conservative measures may be effective in alleviating symptoms, patients with unresolved pain are candidates for arthroscopic subacromial decompression. The procedure typically involves antero-inferior acromioplasty, excision of the coracoacromial ligament, and excision of the subacromial bursa. Concomitant partial or small full-thickness rotator cuff tears may be encountered and are treated accordingly. The mid-term (5 years) to long-term (10 years and longer) results of this procedure are generally favorable.⁴⁻¹⁰

Regaining full passive range of motion (PROM) of the shoulder after surgical procedures has been recognized for many years as essential by rehabilitation professionals and surgeons. Klintberg et al⁹ followed up with 99 patients 8 to 11 years after arthroscopic subacromial decompression and noted that ROM in external rotation was the strongest variable that predicted pain-free shoulders during activity. Regardless of the shoulder pathology, surgical intervention, or postoperative protocol, the team (comprised of the surgeon, rehabilitation staff, and patient) must work together to regain full PROM in all planes.^{9,11-14} These specific shoulder motions include glenohumeral flexion, scapular abduction, and internal-external rotations. The ability of the patient to regain these motions results in full functional use of the upper extremity and improved postoperative outcomes.^{9,11,12,15-19}

There are many tools and exercises available to facilitate regaining full PROM after shoulder operations. These include Codman's exercises, table slides, overhead pulleys, and a straight cane. Although all of these exercises and devices are helpful, none have been shown to be superior in achieving full PROM in ran-

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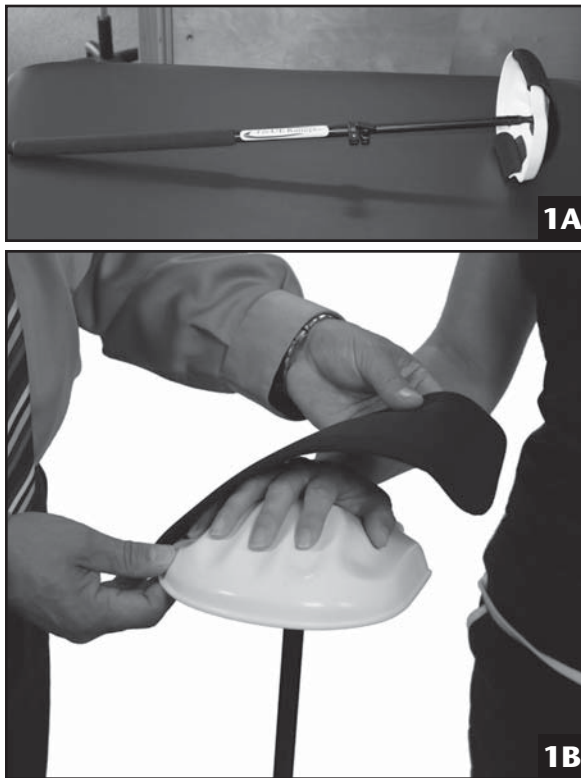


Figure 1. The Upper Extremity Ranger (Rehab Innovations, Inc, Omaha, Nebraska) uses a telescoping pole (A) with one formed end that accommodates the entire hand (B).

domized studies. The straight cane is commonly used to assist in regaining overhead flexion and external rotation. The problem with this device is that the fixed hand placement on the cane does not allow for the normal glenohumeral rotation required for shoulder flexion to occur during the exercise. The need for the humerus to rotate as flexion increases is limited, resulting in compressive forces acting on the soft tissue of the subacromial space that may produce pain.

The Upper Extremity Ranger (UER) (Rehab Innovations, Inc, Omaha, Nebraska) uses a telescoping pole with one formed end that accommodates the entire hand (Figure 1). An elastic strap secures the hand on the end. The formed end allows freedom of motion between the hand holding the piece and the pole. The rationale is that by allowing the hand and forearm to be relaxed and rotate with passive flexion and external rotation, patients should be able to perform PROM exercises with less pain than that experienced when using a rigid cane.

We used the UER in a small series of patients and were encouraged with the results in terms of comfort

and achievement of full PROM. Therefore, we decided to conduct a formal clinical study to compare the effectiveness of the UER with the straight cane as a tool to regain full PROM equal to the opposite side postoperatively. The null hypothesis was that no significant difference would exist between patients who used the UER and those who used a straight cane in the degrees of passive shoulder flexion and external rotation, visual analogue scale (VAS) pain scores, the time for full ROM to be achieved, and the time patients were released to full activity (equivalent to the preinjury level). The hypothesis was that patients using the UER would regain full PROM earlier postoperatively, would have less pain during rehabilitation, and would return to full function earlier postoperatively than those using a straight cane.

METHODS

Patients

All patients diagnosed with shoulder impingement who underwent arthroscopic subacromial decompression and distal clavicle excision by one author (T.N.L.) between July 2006 and December 2008 were considered for inclusion in this study. Exclusionary criteria were prior or associated humeral fracture; concomitant procedures, such as labral repair or rotator cuff repair; prior failed rotator cuff repair or subacromial decompression; concurrent glenohumeral instability; arthrofibrosis or severe limitation in passive motion (under anesthesia, firm end point with less than 150° of flexion) compared with the opposite shoulder; diabetes mellitus; and in receipt of Worker's Compensation insurance. Of the 35 patients who were considered for this investigation, 20 were excluded according to the above criteria, leaving 15 patients who were assigned to either the rigid cane group ($n = 7$) or the UER group ($n = 8$). All participants signed informed consent prior to participation in the study. The study was approved for use of human subjects by our research foundation, and the rights of all participants were protected at all times.

Sample Size Determination

The sample size and power calculations were performed using Power and Precision (Biostat, Englewood, New York). The calculations were based on detecting a mean difference (effect size) of 10% of passive flexion and external rotation between groups, a 2-tailed t test, an alpha

level of .05, and a desired power of 0.80. The estimated desired sample size was calculated to be 7 patients in each group.

Procedure

Patients underwent a history and physical examination by an experienced physical therapist (M.A.M.) approximately 1 week before the operation. Data collected included documentation of the dominant upper extremity, history of injury (trauma versus insidious onset of pain), duration of symptoms, patient age, degrees of passive flexion and external rotation of both shoulders measured with a manual goniometer in the supine position,^{20,21} documentation of previous conservative physical therapy program, and presence of pain at night. During the preoperative visit, patients were informed of this study and, if they agreed to participate, were randomly assigned (using closed envelopes) to receive either a rigid cane or the UER to perform PROM exercises. Patients received instruction on the use of these devices for supine PROM for glenohumeral flexion, abduction, and external rotation.

The degrees of passive flexion and external rotation of both shoulders were also measured by the surgeon after induction of anesthesia but before the arthroscopic subacromial decompression procedure. The surgeon also documented whether any concomitant procedures were performed.

Surgical Procedure and Postoperative Rehabilitation

All patients underwent interscalene block preoperatively. General anesthesia was induced, and the patients were placed in the beach chair position. Through a standard posterior portal, all intra-articular structures were inspected. The subacromial space was entered. A complete subacromial bursectomy was performed, and the bursal surface of the rotator cuff was inspected. A lateral portal was used to perform the subacromial decompression, flattening, and smoothing of the anterior one-third of the acromion. The coracoacromial ligament was resected. An anterior portal was used to resect 5-6 mm of distal clavicle in women and 6-7 mm in men. The resection was viewed through the anterior portal to confirm a complete resection of the distal clavicle. The patients' arms were placed in a simple sling.

The postoperative physical therapy program was identical for all patients, with the exception of the device used to regain full PROM equal to the opposite

side. The program was conducted in the clinic under the direct supervision of the therapist 2 times per week for 6 weeks, and then 1 time per week until discharge. The program was supplemented with home exercises that were performed twice daily when the patient was not treated in the clinic. The sequence and content of the exercises for the supervised and home programs were the same.

On the first postoperative day, the dressing was removed and wound care performed as indicated. Passive range of motion exercises were begun with either the rigid cane or UER for glenohumeral flexion and external rotation in the supine position. Patients in the straight cane group were instructed to hold one end of the cane with each hand and to use the uninvolved extremity to "lead" or pull the surgical extremity into flexion. For external rotation, the patients were positioned supine with the surgical arm at their side and elbow bent to 90°. One flat edge of the cane was placed in the palm of the surgical hand while the uninvolved arm was used to provide pressure into external rotation of the glenohumeral joint. This process was repeated at 45° and 90° of glenohumeral abduction, based on patient tolerance. The patients were instructed to stop and hold the stretch at the sensation of tightness or discomfort and to avoid pain at all times. Patients in the UER group performed the same exercises, with the exception that the hand of the surgical extremity was placed on the hand mold and stabilized into position. For flexion exercises, the patients placed the hand of the uninvolved extremity on the open end of the UER to lift and push the surgical arm into flexion. External rotation was performed in the same manner and position as the straight cane, with the same exception of the hand stabilization in the UER.

In addition, gentle PROM of the hand, wrist, and elbow, active and active-assisted ROM, table slide exercises for flexion and abduction, and clinical-directed passive ROM were initiated. These exercises were performed under the supervision of the therapist at every session to ensure correct technique and form were used. The ROM devices and pulleys were used at home 2 times per day (10 repetitions in each direction, held for 10 seconds). Cryotherapy was used for 15 minutes following every supervised therapy session and was also recommended for the home program. Electrical modalities for pain modification were implemented as

TABLE 1

Baseline Demographics for Both Groups^a

VARIABLE	CANE GROUP (n = 7)	UER GROUP (n = 8)
Operated shoulder		
Right	6	3
Left	1	5
Dominant shoulder		
Yes	5	4
No	2	4
Experienced night pain	6	8
Pain: insidious	5	7
Pain: trauma	2	1
Attempt conservative treatment first	7	8
Gender		
Male	4	5
Female	3	3
Age (years)		
Mean ± standard deviation	49 ± 11	48 ± 15
Range	36–67	31–66

Abbreviation: UER, Upper Extremity Ranger (Rehab Innovations, Inc, Omaha, Nebraska).

^a No difference between groups for all variables.

required, but these were not used for muscle reeducation or activation.

Progressive strengthening exercises for the rotator cuff and scapular stabilizers were also included in the rehabilitation program. The timing of the progression of these exercises was based on patient tolerance. Patients initially performed shoulder shrugs, bicep curls with hand weights, and theraband-resisted standing scapular retraction, elbow extension, and internal and external rotation. This was followed by serratus punches and triceps kick-back exercises with hand weights, and theraband-resisted scapular retraction and latissimus pull-downs as tolerated. Manual rhythmic stabilization and proprioceptive neuromuscular facilitation exercises were performed as tolerated. Closed chain exercise progression included wall push-up plus, ball circles on a wall, and overhead rotation exercises. Isokinetic testing was performed at intervals of 8 (if tolerable), 12, and 16 (if required) weeks.

The surgeon determined when return to full activity was allowed with the criteria of full passive and active ROM equal to the opposite extremity without pain,

full strength as graded by manual muscle techniques of 5/5 (or achieving normal strength scores via isokinetic testing for the more active patients), demonstration of performance of pain-free work or sport activities, and recommendation for release by the therapist.

Outcome Measures

At postoperative weeks 1, 2, 3, 4, and 6, one physical therapist (M.A.M.) measured the degrees of passive shoulder flexion and external rotation. Patients completed a visual analogue scale (VAS) for pain severity.²² The VAS was a 100-mm line with *no pain* indicated at one end and *worse pain imaginable* indicated at the other end. The instructions for the scale were “Make a slash on the line below that best indicates the amount of pain you are feeling in your shoulder.”

Patient compliance with the home physical therapy program was documented by the physical therapist using direct questioning of the exercises performed and the frequency and duration of each exercise. The postoperative week when patients achieved full motion was recorded, along with the week of release to full activity. Full activity was defined as return to preinjury level of function, including sport and occupational activities.

Statistical Analysis

Data were analyzed with StatView (SAS Institute, Cary, NC) by an independent senior researcher (S.D.B.-W.) not involved in the direct care of the patients. All baseline variables described in the Procedure section were compared between groups using unpaired *t* tests for continuous data and chi-square tests for categorical data. Analysis of variance (ANOVA) was conducted to determine whether significant differences existed within each group for ROM and VAS scores between postoperative weeks 1, 2, 3, 4, and 6. Unpaired 2-tailed *t* tests were used to determine whether significant differences existed between groups for each of the postoperative week evaluations for ROM and VAS scores. Repeated measures ANOVA was used to determine whether significant differences existed between groups for ROM and VAS scores across all postoperative time periods. The level of significance was set at .05.

RESULTS

The baseline characteristics between the cane and UER groups were similar for all variables (Table 1). All pa-

TABLE 2

TIME PERIOD	CANE GROUP		UPPER EXTREMITY RANGER GROUP ^b	
	INVOLVED	NONINVOLVED	INVOLVED	NONINVOLVED
Preoperative clinic examination				
Flexion	169°±17°	180°±0°	172°±12°	177°±7°
External rotation	87°±11°	91°±6°	86°±11°	89°±13°
Preoperative under anesthesia				
Flexion	175°±12°	180°±0.7°	177°±7°	179°±5°
External rotation	89°±10°	91°±6°	87°±10°	90°±11°
Postoperative week 1				
Flexion	152°±21°		148°±50°	
External rotation	74°±7°		74°±20°	
Visual analogue scale	25±18		22±17	
Postoperative week 2				
Flexion	167°±9°		169°±12°	
External rotation	85°±7°		89°±1°	
Visual analogue scale	28±18		31±28	
Postoperative week 3				
Flexion	174°±7°		177°±2°	
External rotation	87°±4°		90°±0°	
Visual analogue scale	18±8		20±16	
Postoperative week 4				
Flexion	179°±2°		178°±2°	
External rotation	90°±0°		90°±0°	
Visual analogue scale	23±6		10±11 ^c	
Postoperative week 6				
Flexion	179°±2°		180°±5°	
External rotation	91°±2°		90°±0°	
Visual analogue scale	8±6		9±10	

^aData shown are mean±standard deviation. Visual analogue scale scores ranged from 0 to 100.

^bManufactured by Rehab Innovations, Inc (Omaha, Nebraska).

^c $P < .05$.

tients reported satisfactory compliance with the home exercise program. Before the operation, a limitation of passive flexion in the involved shoulder compared with the contralateral shoulder was detected on clinical examination in 3 patients in the cane group (from 10° to 45°) and in 3 patients in the UER group (from 2° to 20°). A limitation of passive external rotation in the involved shoulder was measured in 2 patients in the cane group (from 5° to 28°) and in 4 patients in the UER group (from 5° to 15°). The examination under anesthesia detected a limitation of passive flexion in 1 patient in the cane group and 3 patients in the UER group, and a

limitation of passive external rotation in 2 patients in the cane group and 4 patients in the UER group.

The mean values for ROM measured preoperatively, before the operation while under anesthesia, and postoperatively are shown in Table 2. There was no significant difference between groups in the mean amount of motion measured within each postoperative week. However, patients in the UER group achieved full motion significantly earlier postoperatively than those in the cane group (mean±SD, 3.0±1.7 and 5.3±1.3 weeks, respectively, $P = .004$) (Figure 2). All patients but 1 achieved 175° to 180° of flexion and 90°

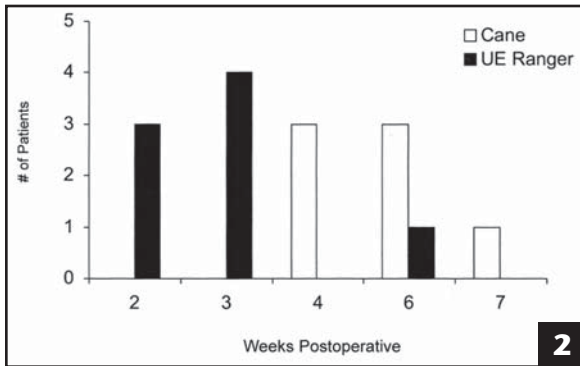


Figure 2. The distribution of the postoperative week that return of full motion was achieved for each group is shown. There was a significant difference in the mean time full motion was achieved between the groups (5 ± 1 and 3 ± 1 weeks, respectively, $P = .004$). Abbreviation: UE Ranger, Upper Extremity Ranger (Rehab Innovations, Inc, Omaha, Nebraska).

of external rotation; one patient had 185° of flexion and 95° of external rotation.

The mean postoperative values for the pain VAS are shown in Table 2. There was no significant difference between groups in the mean value recorded for postoperative weeks 1, 2, and 3. In postoperative week 4, patients in the UER group had significantly lower mean VAS scores than those in the cane group (mean \pm SD, 10 ± 11 and 23 ± 6 , respectively, $P = .04$). There were no significant differences between the groups in the mean VAS values after postoperative week 4.

Patients in the UER group were released to full activity significantly earlier postoperatively than those in the cane group (mean \pm SD, 5 ± 1 and 10 ± 3 weeks, respectively, $P = .002$) (Figure 3). In the UER group, 3 patients returned to recreational sports and 5 patients returned to work activities that were rated as light in intensity in 3 and moderate in 2. Three patients were retired. In the cane group, 2 returned to recreational sports and 5 returned to work activities that were rated as light in 1 patient and moderate in 4. Two patients were retired.

DISCUSSION

Subacromial impingement syndrome is a common form of shoulder pathology, with a higher incidence noted with increasing age.^{1,2,23} In our study, 4 patients were younger than 40 years, 8 patients were between 42 and 56 years, and 3 patients were between 61 and 67 years. Thirteen patients (87%) experienced symptoms for at least 6 months prior to surgery and 14 (93%) experienced night pain. All patients underwent conservative therapeutic measures that failed to relieve their symptoms. A limitation of motion has been commonly noted

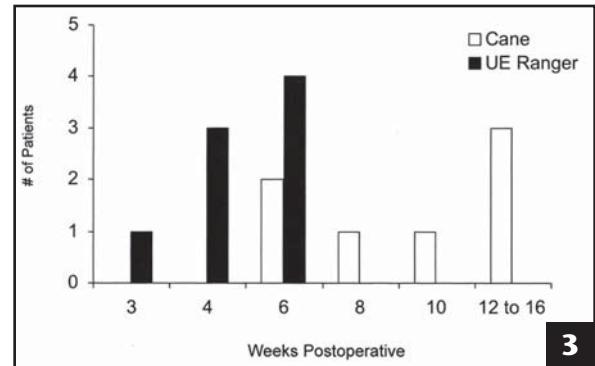


Figure 3. The distribution of the postoperative week that release to full activity was permitted is shown. There was a significant difference in the mean time patients were allowed to resume full activity between the groups (10 ± 3 and 5 ± 1 weeks, respectively, $P = .002$). Abbreviation: UE Ranger, Upper Extremity Ranger (Rehab Innovations, Inc, Omaha, Nebraska).

in patients with chronic impingement syndrome.^{23,24} In our study, 8 patients had a limitation of passive shoulder flexion or external rotation (or both) during the preoperative clinical examination compared with the opposite side. In 7 of these patients, the limitation of motion was also documented under anesthesia.

Regaining full PROM following shoulder surgery is a priority for the patient and rehabilitation team because a limitation of motion prevents achievement of full strength of the rotator cuff and scapular muscles and compromises postoperative function.^{17,18} Klintberg et al⁹ followed up with 99 patients 8 to 11 years after arthroscopic subacromial decompression and noted that ROM in external rotation was the strongest variable that predicted pain-free shoulders during activity. In the study by Klintberg et al,⁹ 84% of the patients were very satisfied or quite satisfied with the outcome of the procedure. Mancuso et al¹⁹ studied preoperative patient expectations of the outcomes of various shoulder operative procedures in 409 individuals. Patients diagnosed with impingement reported that achieving full range of motion after surgery was the fourth most important category among 38 options.

There are many tools to assist patients in regaining full PROM after surgery, including Codman's exercises, table slides, overhead pulleys, and a straight cane. We have found that use of a cane may lead to pain related to the limitation of normal glenohumeral mechanics in elevation that causes impingement of the subacromial soft tissue. The UER was developed as tool to use for the same motions as the straight cane; however, a floating head was created to accommodate the need for gle-

nohumeral rotation with elevation. We hypothesized that patients using the UER would regain full PROM equal to the opposite side earlier postoperatively, have less pain during rehabilitation, and would return to full function at a faster rate than those using a straight cane. This hypothesis was generated after our initial clinical experience in which we noted differences in patient responses between these 2 devices.

Empirically, patients appeared more comfortable and had less difficulty performing PROM exercises with the UER than those who used a cane. The results of this study appear to support our hypothesis because patients who used the UER regained full PROM sooner postoperatively than patients who used a straight cane. This difference was most evident in the 4-5 postoperative week time frame, which correlates to the time frame when gaining end ranges of flexion and external rotation at 90° abduction are paramount. Specifically, in the UER group full motion was achieved by 2-3 weeks in 7 patients and by 6 weeks in 1 patient. This is in comparison with full motion in the cane group being achieved by 4 weeks in 3 patients and by 6-7 weeks in 4 patients.

Patients in the UER group returned to full activities earlier postoperatively than those in the cane group. In the UER group, release to activities was allowed in week 3 in 1 patient, week 4 in 3 patients, and week 6 in the remaining 4 patients. In the cane group, release to activities occurred in week 6 in 2 patients, week 8 in 1 patient, week 10 in 1 patient, week 12 in 2 patients, and week 16 in 1 patient. The type of work or sports activities patients returned to did not appear to affect the time of release. The 2 retired individuals in the cane group were allowed to return to full activities at 8 and 12 weeks postoperative, whereas the 3 retired patients in the UER group returned between 3 and 6 weeks postoperative. However, the cohort sample size precludes definite conclusions regarding this factor.

One limitation of this study was that the treating therapist and surgeon were not blinded to the treatment groups. The clinician who conducted the PROM measurements did not undergo intrarater reliability testing. However, the same physical therapist, who has 22 years of clinical experience, performed all of the measurements. Patients performed additional motion exercises to those accomplished with the cane or UER and, therefore, the effect of just the devices on regaining passive elevation and external rotation alone

cannot be established. The results are applicable only to arthroscopic subacromial decompression and distal clavicle excision. It was not the purpose of this investigation to provide a detailed account of all of the outcome variables of the operative procedure.

Future Considerations

In this study, patients underwent a procedure in which PROM was recommended but not considered paramount to successful rehabilitation, as would be the case in more complex procedures. Future studies should examine the effectiveness of the UER for rehabilitation following more complex operative procedures, such as rotator cuff repair, labral repair, anterior stabilization, and total shoulder arthroplasty. In addition, future studies may entail analyzing to what degree the UER is truly passive by assessing muscular activity with electromyography during its use. The use of larger patient groups will allow for an assessment of the effect of the types of work and sports activities patients return to on the time postoperatively they are released to full activity.

CONCLUSION

In this study, we compared the use of a rigid cane to the UER as a tool for PROM exercise following arthroscopic subacromial decompression and distal clavicle excision. The results demonstrated that the UER assisted in facilitation of regaining full PROM equal to the opposite side and release to normal activities earlier postoperatively than the straight cane. The UER appears to be a satisfactory tool to use as an adjunct to postoperative rehabilitation following isolated shoulder decompression procedures.

IMPLICATIONS FOR CLINICAL PRACTICE

This study demonstrates that the UER is a practical tool to assist patients in regaining full PROM and release to full activities earlier postoperatively than a standard rigid cane. The results apply only to patients who undergo arthroscopic subacromial decompression and distal clavicle resection. Patients appeared to be more comfortable and had less difficulty performing PROM exercises with the UER compared with those who used a cane. Although the straight cane is one of the most commonly used tools to assist patients in regaining overhead flexion and external rotation, clinicians should consider the UER as an alternative and perhaps superior device for these exercises. ■

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