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case report

Pulsed Shortwave Diathermy and Joint Mobilizations for Achieving Normal Elbow Range of Motion After Injury or Surgery With Implanted Metal: A Case Series

David O. Draper, EdD, ATC, FNATA

Exercise Science Department, Brigham Young University, Provo, UT

Context: Regaining full, active range of motion (ROM) after trauma to the elbow is difficult.

Objective: To report the cases of 6 patients who lacked full ROM in the elbow because of trauma. The treatment regimen was thermal pulsed shortwave diathermy and joint mobilizations.

Design: Case series.

Setting: University therapeutic modalities laboratory.

Patients or Other Participants: Six patients (5 women [83%], 1 man [17%]) lacked a mean active ROM of 24.5° of extension approximately 4.8 years after trauma or surgery.

Intervention(s): Treatment consisted of 20 minutes of pulsed shortwave diathermy at 800 pulses per second for 400 microseconds (40–48 W average power, 150 W peak power) applied to the cubital fossa, immediately followed by 7 to 8 minutes of joint mobilizations. After posttreatment ROM was recorded, ice was applied to the area for about 30 minutes.

Main Outcomes Measure(s): Changes in extension active ROM were assessed before and after each treatment. Once the patient achieved full, active ROM or failed to improve on 2 consecutive visits, he or she was discharged from the study.

Results: By the fifth treatment, 4 participants (67%) achieved normal extension active ROM, and 2 of the 4 (50%) exceeded the norm. Five participants (83%) returned to normal activities and full use of their elbows. One month later, the 5 participants had maintained, on average, (mean ± SD) 92% ± 6% of their final measurements.

Conclusions: A combination of thermal pulsed shortwave diathermy and joint mobilizations was effective in restoring active ROM of elbow extension in 5 of the 6 patients (83%) who lacked full ROM after injury or surgery.

Key Words: deep heat, therapeutic modalities, rehabilitation

Key Points

- Pulsed shortwave diathermy can increase the viscoelastic properties of collagen.
- Combined pulsed shortwave diathermy and joint mobilizations increased active elbow range of motion in 5 of 6 patients nearly 5 years after injury or surgery.

Individuals who have reduced active range of motion (AROM) in 1 or more limbs for extended periods have their lives altered. A person who can only extend the elbow halfway will find it difficult to throw objects or to reach a high shelf to retrieve a book. The elbow should extend to a full AROM (0°) as measured by a goniometer.[1]

Many[1–6] are of the opinion that using heat in concert with joint mobilizations can increase accessory and physiologic movements. In 2010, I[7] reported on the treatment protocol for 6 patients who lacked full AROM in wrist flexion and extension due to injury. The treatment regimen was thermal ultrasound followed by joint mobilization. All 6 patients had at least 90% of their wrist-flexion and -extension range of motion (ROM) restored. Another heating modality, pulsed shortwave diathermy (PSWD), uses high-frequency electromagnetic waves to heat tissues up to 5 cm deep. Heat is produced by the resistance of tissue to the passage of energy.[8] Although it heats to the same depth as 1-MHz ultrasound, PSWD heats a much larger area than ultrasound does,[9] making it ideal to heat larger joints, such as the elbow, shoulder, hip, knee, and ankle.[1,3,5] With today's modern PSWD devices, tissues at the elbow can be heated up to 4°C, or a peak temperature of more than 40°C,[4] which is ideal for increasing the viscoelastic properties of collagen.[10]

In this case series, a unique treatment protocol is presented, which combines PSWD and joint mobilizations. I used this protocol in 6 patients who had sustained severe elbow injuries.

CASE DESCRIPTIONS

History

Each patient's history is summarized in Table 1. The patients included in this case series were referred to the laboratory because of long-term, significant decreases in elbow extension that were present after rehabilitation, which limited their daily and recreational activities. Two patients (33%) were referred by friends, 1 (17%) by a physical therapist, and 3 (50%) were self-referred. Patients were excluded if they had compromised circulation, decreased sensation in the elbow, or an implanted pacemaker or neurostimulator. The human subjects review board of Brigham Young University approved the methods used in this case series, and all patients signed informed consent forms.

Table 1. Patients' Histories

Patient	Time Since Injury or Surgery, mo	Injury	Treatment
1	6	Radial-head fracture	Rest
2	96	Humerus fracture	Cast
3	3	Ulna fracture	Cast
4	12	Dislocation/radial-head fracture	Surgery
5	180	Humerus fracture	Surgery
6	14	Humerus and ulna fracture	Surgery

On the first visit, patients were asked the following:

- What is your injury?
- Describe how the injury occurred.
- If you are in pain, point to where it hurts.
- If you were immobilized in a cast or brace, how long were you immobilized?
- Describe any rehabilitation treatments you underwent.
- What was the duration of the treatment?
- How long has it been since your injury?

All but 2 of the patients (4 of 6; 67%) had full AROM in elbow flexion, so their top priority was to regain full, pain-free AROM for extension. If more information was needed, physician's notes or a radiograph was requested, which were available for 3 of the 6 patients (50%). The next section presents a short history of each patient. All listed motions are AROM.

Patient 1. Patient 1 was a male, 48-year-old paramedic/firefighter and helicopter pilot in the National Guard. He fractured his radial head and scapula when his 4-wheel all-terrain vehicle overturned. He insisted on not having his elbow immobilized in a cast but wore a sling obtained from his paramedic kit. After 2 weeks, he tried self-designed exercises to regain AROM and strength, 1 of which included holding a bucket full of rocks while trying to extend his elbow. All of his elbow-flexion ROM was restored. At 6 months after the injury, he self-reported lacking the last 17° of AROM of elbow extension.

Patient 2. Patient 2 was a 20-year-old, female student. She fractured her elbow after falling off gymnastics equipment in grade school at age 12. Her elbow was in a cast for 6 weeks. She had little therapy and lacked the last 25° of elbow extension but had normal flexion ROM.

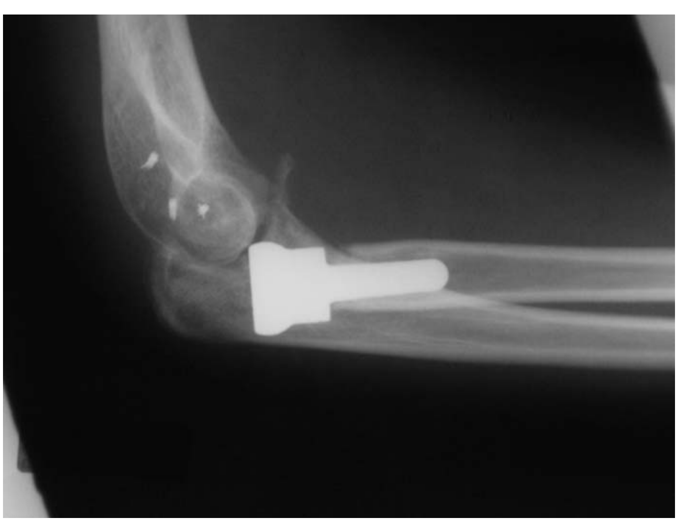

Figure 1. Radiograph of patient 4 showing the surgically implanted titanium radial-head prosthesis.

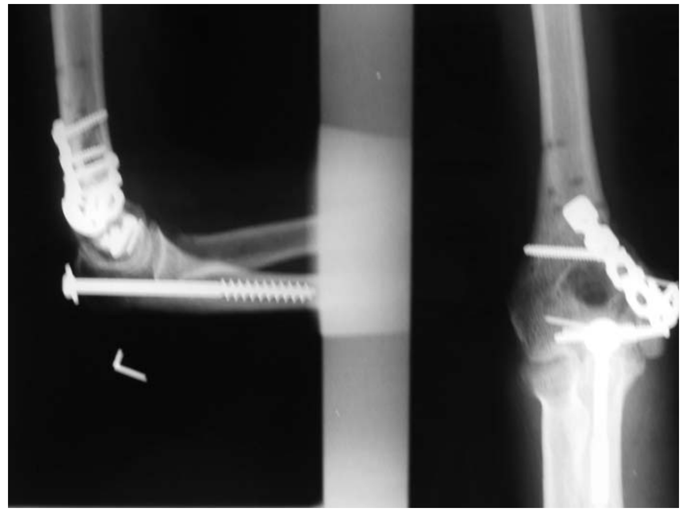

Figure 2. Radiograph of patient 6 showing the surgically implanted metal plates and screws.

Patient 3. Patient 3 was a 22-year-old, female student who fell off her bicycle 3 months earlier. The fall resulted in 3 fractures to her olecranon process. Her elbow was in a cast for 8 weeks, and she did little rehabilitation for the injury. She lacked the last 36° of elbow extension and the last 7° of elbow flexion.

Patient 4. Patient 4 was a 21-year-old, female student. When she was 20, she fell off a trampoline, which resulted in a dislocated elbow and a fractured radial head. She had 3 surgeries for the condition, the first 2 of which failed. During the third surgery, the surgeon inserted a titanium radial-head prosthesis (Figure 1). After several weeks of rest, she underwent basic physical therapy of whirlpool and stretching. All of her flexion ROM was restored. She was referred to our clinic by an athletic training student. She lacked the last 20° of elbow extension.

Patient 5. Patient 5 was a 21-year-old, female student who fractured her elbow after falling off a trampoline when she was 6 years old. She had surgery to repair the fracture, which included screw insertion, and was immobilized for 8 weeks. She underwent extensive physical therapy, which included ball throwing, ultrasound, and passive stretching. She was self-referred to the laboratory, and she lacked the last 21° of elbow extension, whereas her flexion was normal.

Patient 6. Patient 6 was a 38-year-old, female, high-school English teacher. Fourteen months earlier, she fractured her elbow in an automobile accident. The surgeon tried to repair the nonunion of the humerus and ulna; however, the first surgery failed. Ten days later, she underwent another surgery; a metal plate, six 2-cm screws, and an 8-cm screw were used to repair the fracture (Figure 2). After the injury, she was immobilized for 10 weeks. She was referred by her physical therapist, who had provided 48 treatments to try to restore ROM. The therapy regimen consisted of ultrasound, whirlpool, stretching, and wearing a dynamic splint to increase elbow extension. She lacked 12° of flexion and 28° of extension.

Table 2. Patients' Progress

	Range of Motion, Flexion/Extension, °			
		Injured Side		
Patient No.	Uninjured Side	Initial	Discharge	No. of Visits
1	145/0	145/17	145/−2	4
2	145/0	145/25	145/0	4
3	147/0	138/36	140/18	5
4	143/0	144/20	144/0	6
5	147/0	146/21	146/0	5
6	144/0	132/28	144/3	6

Examinations

I measured extension and flexion of the elbow. All but 2 of the patients (4 of 6; 67%) had all of their elbow-flexion ROM restored with the previous therapy. All AROM measurements were assessed using a standard goniometer (scale marked in 1° increments; model 01135; Lafayette Instrument Co Inc, Lafayette, LA) for increased validity of measurement.[11] Validity, however, may range from approximately 4° to 6° when using a goniometer.[12] I measured AROM 3 times and recorded the average of the 3 measurements. The ROM measurement was performed as follows:

- Extension. The patient rested the upper arm on a table so that the humerus was level with the table. The axis of the goniometer was placed on the lateral epicondyle while the 2 arms of the goniometer rested on the humerus and radius. The patient then extended the elbow as far as possible.
- Flexion. The patient rested the upper arm on the table so that the humerus was level with the table. The axis of the goniometer was placed on the lateral epicondyle while the 2 arms of the goniometer rested on the humerus and radius. The patient then flexed the elbow as far as possible.

Landmarks were standardized for each patient, ensuring reliability and validity of measurement, and were based on entry-level goniometric measurements.[12–14] I used the same goniometer for all measurements to limit error from differences among goniometers. The goniometer was not masked during the measurements.

Intervention

After the initial examination, I provided the treatment protocol of PSWD followed by 7 to 8 minutes of joint mobilizations and concluded with a 30-minute application of a crushed-ice pack. During each treatment session, AROM was measured before the PSWD application and after the joint mobilizations but before the ice-pack application. Participants were instructed not to start any new or additional home-exercise programs during the study.

With the elbow extended as far as possible, 27.12-MHz PSWD (Megapulse; Accelerated Care Plus, Reno, NV) was applied to the cubital fossa area of the elbow for 20 minutes at 800 pulses per second for 400 microseconds. These settings increase the tissue temperature by approximately 4°C and maintain half of that increase for up to 20 minutes.[4] Joint mobilizations were then applied to the elbow for 7 to 8 minutes.

Joint mobilizations were applied depending on each patient's tolerance, which was determined subjectively (asking the patient to identify his or her pain level and whether the pressure should be decreased) and objectively (noting the tissue response, including muscle guarding, muscle spasm, and muscle contraction). The joint mobilizations started at Maitland level III (large-amplitude movements as long as resistance was encountered in that range) and progressed to Maitland grade IV (small-amplitude movements at the end of the available motion).[5] More specifically, to restore elbow extension and flexion, all joint mobilizations were restored using the concave–convex rule.[8] The following joint mobilizations were performed: traction, anterior glides of the distal humerus on the ulna, and radial-head glides in both directions. Most of the glides focused on restoring extension because the olecranon process of the ulna provides a bony block to posterior glides of the distal humerus. Each additional oscillatory mobilization was performed for a minimum of 20 seconds, with 6 repetitions. Patient 5 had very little pronation and supination ROM compared with the other participants. For her, I applied 2 ultrasound treatments to the area of the radial head, followed by joint mobilizations to that area. That technique restored full ROM in pronation and supination.

After the posttreatment measurements, a crushed-ice pack was applied for about 30 minutes with the elbow extended as far as tolerated. The purpose of the ice-pack application was 3-fold. First, it reduced pain caused by any microtrauma during the treatment.[15] Second, it helped to limit any secondary, ischemic injury if inflammation occurred from the stress on the joints, and third, it enhanced plastic elongation of the tissues (ie, the ability of the tissues to stay at the ROM reached during the joint mobilizations).[16] The interventions were applied 3 times a week for 4 to 6 treatments for each patient. A patient was discharged if ROM did not improve after 2 consecutive visits or when ROM was reached.

RESULTS

At the end of 6 or fewer sessions, all patients except 1 (5 of 6; 83%) had greatly improved their ROM: 4 of the 5 (80%) reached the same AROM as the opposite elbow (Table 2). Overall, patients improved their extension AROM by 19° (patient 1), 25° (patient 2), 18° (patient 3), 20° (patient 4), 21° (patient 5), and 25° (patient 6). At 1 month after the final treatment, patients maintained (mean ± SD) 92% ± 6% of their discharge ROM.

DISCUSSION

A regimen of PSWD and joint mobilizations improved the ROM of all participants, and 4 of the 6 (67%) had 100% of their ROM restored. No pain, discomfort, or burning was reported during treatment.

The most interesting and challenging cases were patients 4 and 6, who had implanted metal in their joints (Figures 1 and 2). Many experts[17–20] believe that metal in the treatment field is a contraindication for PSWD. The shunting of the radio frequency field through a metal implant may increase the current density around the implant and increase local temperature more than in tissue without metal implants.[18–20] Although implanted metal is a contraindication for micro-

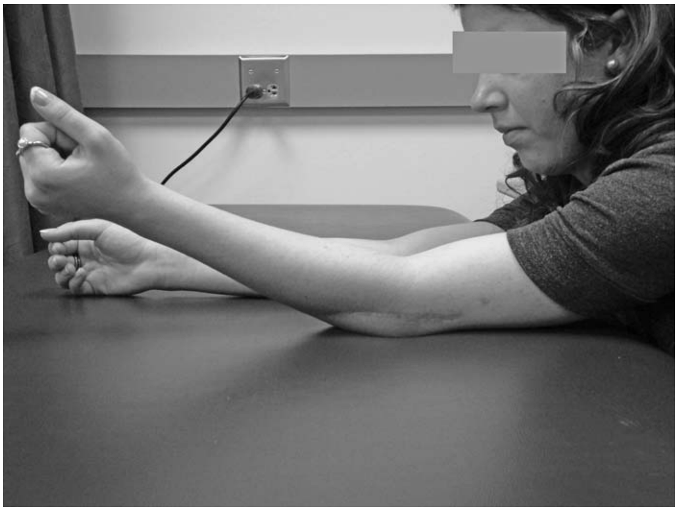

Figure 3. Photograph of patient 4 showing beginning active range of motion of 20° of extension.

wave and continuous diathermy, I have found that the metal does not heat when the intensity is 100 W or less.[18,20] With this treatment protocol, patients 4 and 6 had most or all of their AROM restored (Figures 3 through 6). Previous researchers[3] demonstrated similar findings when PSWD and joint mobilizations were used to restore dorsiflexion and plantar flexion in the ankle joint.

I selected elbow mobilizations because of their effectiveness in improving AROM for both contractile and noncontractile tissues, such as hypomobile joint contractures and scar tissue.[1,5] Joint mobilizations were performed immediately after the PSWD treatment because the heat dissipates rapidly with thermal conduction away from the site via the vascular system.[9] The temperature rise in skeletal muscle decreases fairly rapidly after a PSWD treatment but not as rapidly as with ultrasound.[9,16] However, the current study was performed on noncontractile tissue, in which the cooling might be slower, allowing more time to perform joint mobilizations. Regardless, a better outcome is possible when the clinician can start mobilizing the joint soon after heating the tissues.

Figure 4. Photograph of patient 4 showing full active range of motion in extension after 6 treatments.

Figure 5. Photograph of patient 6 showing beginning active range of motion of 28° of extension.

I did not focus on passive stretching because it does not address the gliding component that is often missing when a joint has contracted.[1,5] According to Kaltenborn et al,[5] more ROM is gained in a hypomobile joint when joint mobilizations are performed than when basic stretching is performed. Stretching works only the angular motions (ie, flexion and extension), whereas joint mobilizations work the accessory components—the most important being gliding.

Indications for joint-glide mobilizations include hypomobility and immobility, the characteristics I focused on during these treatments. The *restrictive barrier* prevents movement in the direction of lost motion.[1] Thus, the goal in using elbow-joint mobilizations was to move the restrictive barrier as far into the direction of the motion loss as possible. To identify hypomobility, clinicians must understand normal and pathologic end-feels. Normal extension at the elbow joint is "hard" when the olecranon contacts the olecranon fossa. A pathologic end-feel requiring glide mobilizations at the elbow occurs when extension is arrested before full extension is reached. The halting does not feel hard, as with bone to bone but firm, as if the capsule is tight.[10] At the elbow joint, normal flexion is associated with a "soft" end-feel because the biceps brachii meets the forearm muscles. A pathologic end-feel for elbow

Figure 6. Photograph of patient 6 showing active range of motion of 3° of extension after 6 treatments.

flexion occurs when flexion is halted before full flexion is obtained. The halting does not feel soft but firm, as if the capsule is tight.[10]

Kaltenborn et al[5] stated that mobilization preceded by heat often produces greater mobility gains. They even listed diathermy as an effective heat application to be used in deep tissues.[5] Although used frequently in the United Kingdom and Brazil,[8] diathermy is rarely used in other parts of the world. Surveys of physical therapists in Australia[21] and Canada[22] indicate that ultrasound (another deep-heating agent) was used daily by 93% and 94%, respectively, yet diathermy was used daily by only 8% and 0.6% of them, respectively. No data are available on the use of diathermy in the United States, but I believe that PSWD use is limited. I have used PSWD for more than 15 years to treat joint contracture and adhesions and have observed and published evidence demonstrating the clear efficacy of this modality.[3]

This study was performed to investigate the efficacy of a regimen consisting of PSWD and joint mobilizations in patients whose elbows had reduced extension-elastic barriers. This treatment was effective with 5 patients (83%). Patient 3 improved her extension AROM only by 50%. It is possible that she did not regain 90% to 100% of her lost elbow extension because of the severity and location of her fracture. Her radiographs demonstrated 3 fractures in the olecranon fossa, which might have resulted in excessive calcium formation in the area, thus providing a hard or bone-to-bone end-feel when the olecranon meets the olecranon fossa before full elbow extension.

LIMITATIONS

Although these results were quite good, some limitations are evident. A lack of blinding of the goniometric measurements could have decreased the validity of the study. The patients were not blinded to their treatment conditions and I did not include a control group.

To determine the full implications of this case series, additional research is needed to identify the effectiveness of this protocol with more patients in a randomized experiment and with a control group and outcome measures, including ROM, pain, edema, and function. Future researchers need to blind clinicians to the experimental group and to the goniometric measurements.

CONCLUSIONS

Thermal PSWD used with joint mobilizations was an effective regimen aimed at restoring AROM in patients with hypomobile joints after injury or surgery. In my experience, caution should be exercised when using PSWD on a patient with implanted metal. If the patient senses that the treatment area is too hot, the PSWD treatment should be terminated.

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Address correspondence to David O. Draper, EdD, ATC, FNATA, Exercise Science Department, Brigham Young University, 106 SFH, Richards Building 120-C, Provo, UT 84602. Address e-mail to david_draper@byu.edu.