Case Report

Implications of Elbow Arthrodesis for Individuals with Paraplegia

Jennifer Hunsaker Young

A 38-year-old woman who had a recent injury resulting in T-3 Frankel Class C paraplegia and a comminuted fracture of the right elbow is described in this case report. The elbow required an arthrodesis, but the position in which the elbow should be fused was not initially known. To illustrate to the rehabilitation team and the patient the advantages and disadvantages of each of two elbow positions under consideration for the arthrodesis, the author recruited an individual with paraplegia to demonstrate some activities of daily living with two elbow splints that simulated the two positions of fusion being considered. The patient and the rehabilitation team concluded that the 30-degree flexion fusion offered more functional mobility than the 90-degree flexion fusion. At the completion of her initial rehabilitation, the patient was a full-time manual wheelchair user. She was independent in all self-care and transfers, including uneven transfers to heights of 22.9 cm (9 in) over and 45.7 (18 in) lower than the wheelchair seat. She drives a four-wheel-drive vehicle and is independent in stowing her wheelchair. [Young JH. Implications of elbow arthrodesis for individuals with paraplegia. Phys Ther. 1993;73:194–201.]

Key Words: *Arthrodesis, Elbow, Functional activities, Paraplegia.*

Elbow range of motion (ROM) has been examined from the perspective of functional range for activities of daily living (ADLs), primarily as it relates to feeding and hand-to-mouth activities.[1–3] Few articles address the need for ROM to allow adequate use of assistive devices for ambulation or for rising from a sitting to a standing position.[2] Very few reports in the literature have addressed elbow function in individuals with spinal cord injury, except as this function pertains to tendon transfer surgeries.[4,5] The elbow joint that primarily functions for hand-to-mouth and face activities in the nondisabled population becomes for patients with spinal cord injuries a critical link with weight-bearing functions for the upper extremities (UEs) during transfers and bed mobility activities. The bilateral activity of wheelchair propulsion also requires significant ROM at the elbow.

Saface-Rad et al[1] established that an arc of motion for the elbow during feeding tasks was 70 to 130 degrees of flexion. Packer et al[2] reported similar values for feeding tasks and observed that 100 to 15 degrees of flexion was required for the activity of rising from a sitting to a standing position. Amis et al[3] found that loss of extension of the elbow significantly affected 32 of 40 ADLs, whereas lack of flexion interfered with only 11 ADLs. Individuals with spinal cord injury perform differently, however, than do persons without injuries. These ROM measures, therefore, cannot be used to predict function in persons with paraplegia.

In patients with paraplegia, the possibility of loss of ROM exists because of trauma, contractures, imbalanced muscle activity caused by reflex influences, and heterotopic bone formation. Therapists working with patients who have spinal cord injury should recognize the prognostic implications of limited or painful ROM in a UE joint on the patient's independence.

An individual with uncomplicated paraplegia can be expected to be

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Figure 1. *The 90-degree cast used in the reenactment of the demonstrations.*

independent in all activities from a manual wheelchair. Loss of the use of the elbow or loss of elbow extension, however, will greatly impair the individual's independence. In persons with quadriplegia at higher spinal levels, loss of ROM at the elbow may result in greater losses of function than would occur with lower-level lesions. It is my experience that, in an individual with C-6 quadriplegia who has no function of the triceps brachii muscles, a flexion contracture of 10 to 15 degrees can eliminate the person's ability to lock the elbow mechanically. This loss of function would eliminate the possibility of independence in transfers.

Following orthopedic trauma to the UE, surgical repair is frequently necessary. Decision making does not always include consideration of functional implications when considering surgical options. This problem is frequently due to the lack of rehabilitation team involvement in the preoperative assessment of the patient.

Purpose

The primary purpose of this case report is to illustrate the use of a biomechanical/functional assessment in a preoperative period for a spinal cord injured individual with multiple injuries. The case report provides an example of how a simulated patient scenario helped guide treatment. The modifications that can be made to a wheelchair to accommodate the residual deformity of the fused elbow are described.

Case Report

The patient in this case study was 38 years of age at the time of her injury. She was single, living with a roommate in a home they jointly owned. She was employed full-time, prior to injury, as a benefits processor and was taking classes part-time toward a real estate license. She had a diagnosis of partial T-3 Frankel Class C paraplegia, sustained in a fall from a five-story structure. She sustained multiple internal injuries, which resulted in 6 weeks of hospitalization prior to any attempts for spinal or other definitive orthopedic stabilization. The patient was 1 month postinjury at the time she was admitted to the Seattle (Wash) Veteran's Administration Medical Center's Spinal Cord Injury Service for rehabilitation.

Orthopedic Injury

Radiographs of the patient's thoracic spine were read by the Radiology Department, and she was diagnosed with burst fractures of the T-3 and

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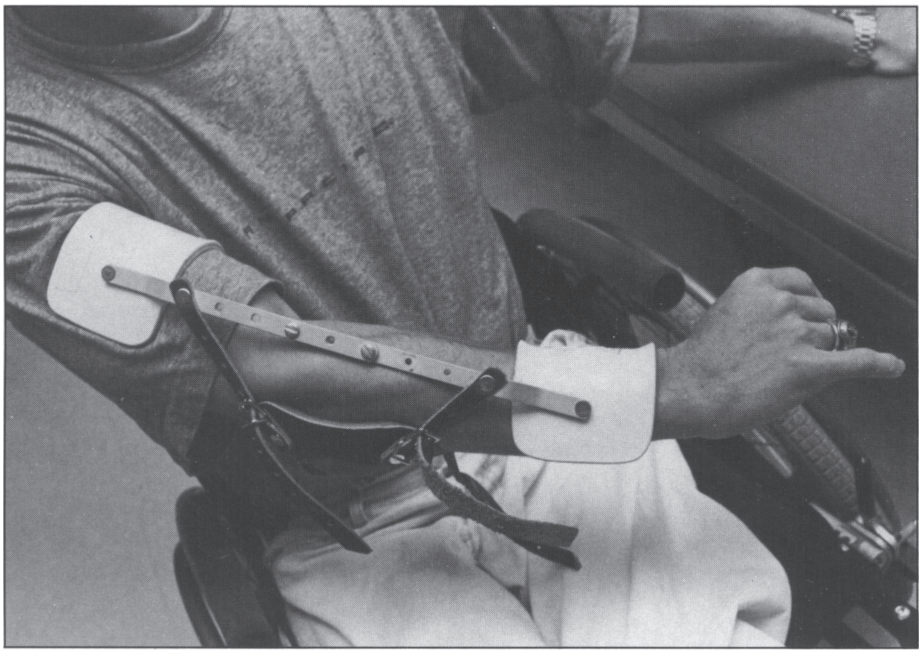

Figure 2. *The three-point extension splint used in the demonstrations. The splint maintains the elbow at approximately 30 degrees of flexion.*

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Figure 3. *Individual demonstrating transfer from wheelchair to mat using the 30-degree extension splint. Note the full body lift that this elbow position allows.*

T-6 vertebrae, transverse fractures of the T-2 through T-8 vertebrae, and fractures of eight ribs, with resultant incomplete T-3 Frankel Class C paraplegia. She had right comminuted fractures of the olecranon and of the proximal radius and ulna, with resultant palsy of all ulnar muscles, which was verified by electromyographic studies. She also had a fracture dislocation of the left acetabulum and bilateral pubic rami fractures.

Initial Orthopedic Treatment

The patient underwent a T-6 laminectomy at 6 weeks postinjury, and she was fitted for a cervical-thoracic-lumbar-sacral orthosis (CTLSO) 10 days later. Prior to this, she had no external stabilization of the spine. Approximately 3 weeks postinjury, the patient underwent an open reduction-internal fixation procedure to her right elbow, with a postoperative ROM of 60 to 90 degrees of flexion. She was placed in skeletal traction of the left lower extremity (LE), with pins in the distal tibia, and was given bed rest for 6 weeks.

Neurological Examination

Sensation. The patient exhibited a Brown-Séquard pattern of intact pain sensation in her right LE and absent pain sensation in her left LE. Her light touch sensation was intact, but localization was generally better down the left trunk and left LE. She had loss of light touch sensation and loss of pain sensation in the ulnar nerve distribution of her right UE distal to the elbow.

Reflex status. The patient had hyperactive deep tendon reflexes throughout her LEs that were greater on the right than on the left. An asymmetrical pattern of extensor spasms in her right LE and flexor spasms in her left LE developed. The increased extensor tone was of a tonic nature, whereas the flexor spasms were primarily dynamic.

Manual muscle test. The patient's UE muscle strength was generally intact bilaterally, with manual muscle test (MMT) grades in the Good to Normal range. There was weakness about the right triceps brachii and biceps brachii muscles (which I thought was consistent with disuse weakness) and the right forearm and hand, with Poor minus strength in the

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Figure 4. *Individual demonstrating transfer from wheelchair to mat using the 90-degree cast. The lack of weight bearing of the right upper extremity eliminates the ability to lift the buttocks, and this transfer is a series of pushes.*

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Figure 5. *Illustration of unavailability of the right arm for propping for balance in the short-sitting position with the 90-degree cast.*

flexor carpi ulnaris and flexor digitorum profundus muscles to digits 4 and 5 (which I thought was consistent with ulnar injury at the elbow). Throughout the patient's LEs, her muscles were innervated, with MMT grades ranging from Trace to Poor plus. This was the patient's early motor picture, and this motor picture remained unchanged despite time and attempts at strengthening the LE muscles.

During the patient's initial rehabilitation, after several weeks of recurrent pressure ulcers on the lateral aspect of her right elbow secondary to protruding hardware, there was a consensus among the orthopedic physicians that the initial fixation of the patient's elbow would not suffice and that a fusion would be needed. A surgery date was set with the plan to fuse the elbow at 90 degrees of flexion with the radioulnar joint in neutral pronation/supination.

I felt that this surgical plan was problematic for the following reasons:

1. The position would interfere with bilateral manual wheelchair propulsion.

2. The position would limit the use of the arm in transfer activities.

3. The position would not allow for functional tasks (eg, moving from a supine to a seated position, supported long or short sitting) or activities such as independent dressing that require propping on one extremity while reaching with the contralateral extremity.

4. The position would not allow good support for use of an assistive device with ambulation.

My concern was that the functional implications listed above (ie, mobility and ADLs) were not considered in developing the surgical plan. This issue, therefore, was discussed with the orthopedic and rehabilitation teams, as well as with the patient.

In an effort to provide the patient with the information and experience regarding the elbow surgery, I arranged a simulation using an individual with T-7 paraplegia. This individual was 2 years postrehabilitation and fully independent. I fabricated a fiberglass cast, set at 90 degrees of elbow flexion and neutral pronation and supination (Fig. 1). A three-point extension splint was used to simulate approximately 30 degrees of flexion with slight supination (Fig. 2).

The recruited individual was then asked to perform manual wheelchair propulsion, to complete a level transfer out of and into a wheelchair, and to don and doff a pair of long pants independently. In all activities, the recruit was able to perform the task independently with the 30-degree elbow position, but was unable to perform the task or was significantly impaired with the use of the cast at 90 degrees of flexion. (Note: This demonstration was reenacted for the purpose of obtaining photographs for this publication.) Another individual with T-7 paraplegia who was approximately 2 years postrehabilitation was also recruited for the reenactment. The results mirrored those of the initial demonstration, although the second recruit was better able to complete the task of independent LE dressing than the first recruit.

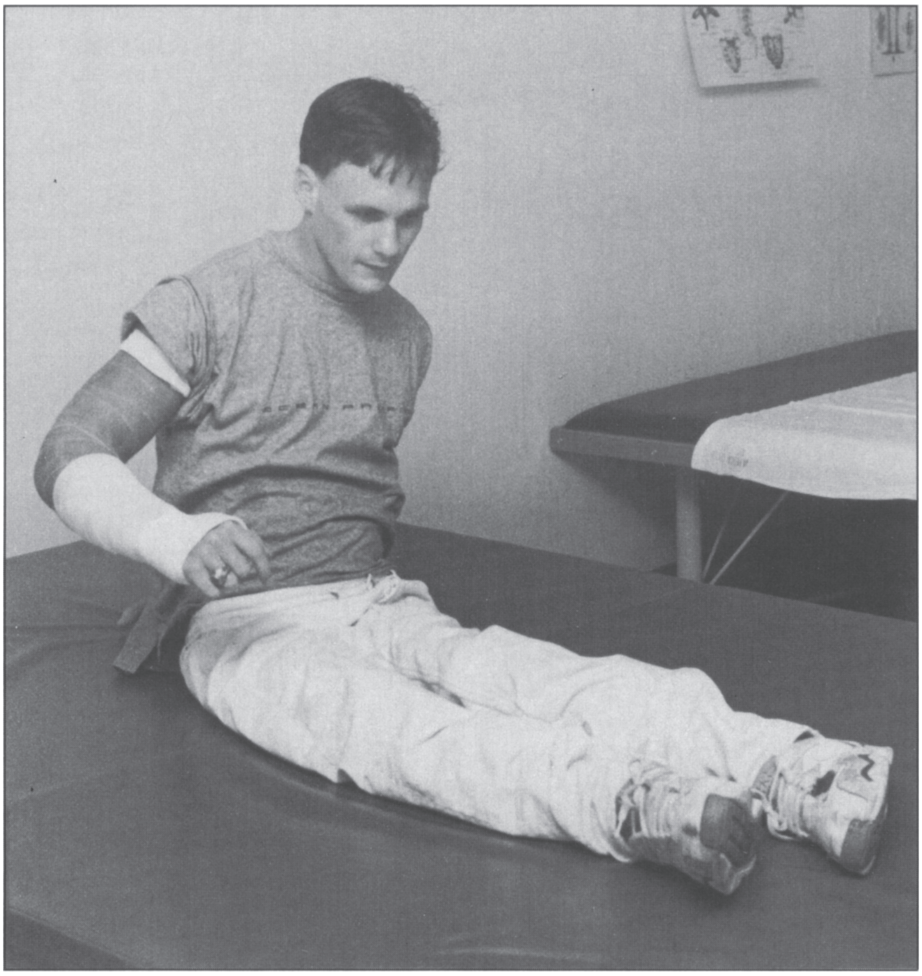

Figure 6. *Illustration of the person's inability to use a bilateral propped position while positioned long sitting with the 90-degree cast.*

Figure 3 illustrates a transfer with the 30-degree splint in place. Note the individual's ability to use the arm in a full lifting mode. Figure 4 illustrates the same transfer with a 90-degree position of the elbow. The individual was able to complete the transfer using a series of pushes with his left arm because of the close proximity of the surfaces and the level aspect of the transfer. He was unable, however, to fully lift his buttocks, and his buttocks rubbed across the rear wheel of the wheelchair during this transfer. Though not shown in these photographs, a transfer toward the left is not possible without a slide board with the 90-degree position of the elbow. The 30-degree position of the elbow allows for transfers in either direction without a slide board. There was a lack of availability of the right arm for balance in the short-sitting position on the mat (Fig. 5).

Figures 6 and 7 compare the inability of a person with T-7 paraplegia to perform bilateral propping with the 90-degree elbow position and the ability to perform bilateral propping with the 30-degree elbow position. Figure 7 shows the advantages of propping and reaching in the 30-degree elbow position. This position allows for independent dressing.

As a result of the demonstration, the patient was convinced of the need for increased extension and signed a surgical consent statement with a stipulation that fusion be in 30 degrees of elbow flexion.

After the elbow arthrodesis procedure, the patient was refitted in a CTLSO and began active rehabilitation. The primary goal for rehabilitation was the same as that set for any otherwise healthy person with paraplegia seen at the Seattle Veteran's Administration Medical Center's Spinal Cord Injury Service: full independence in a manual wheelchair (which includes the secondary goals of independent management of architectural barriers, maneuvering up and down curbs, descending stairs with a railing, independent transfers including transfers off the floor and in and out of a car with wheelchair storage, and the ability to perform all self-care activities independently). These goals were felt to be realistic, and my plan was to modify the goals only if it became clear that a goal was blocked by the patient's added deficits.

The rehabilitation process was initially slowed by the non–weight-bearing, casted status of the patient's right UE. Bed mobility, such as rolling and moving from a sitting to a supine position, was an early goal. Pretransfer skills of short-sitting balance were worked on as well as general strengthening of the patient's left UE and both LEs. She was limited at this time to using a power wheelchair. During this phase, occupational therapists worked with the patient on her oral/facial hygiene and her self-feeding skills.

When the patient had gained short-sitting balance, she was instructed in a slide-board transfer toward her non–weight-bearing UE and was able to perform this transfer with assistance for board placement only. When the patient's right UE was determined by orthopedic review of radiographic films to be capable of weight bearing and full activity, she was instructed in wheelchair mobility skills, including performing "wheelies" and maneuvering up and down curbs (this skill was limited to 5.1-cm [2-in] curbs until her CTLSO was removed). She was also enrolled in a swimming program for full body conditioning, and she continued to work on the general strengthening activity as well as hydrostatically supported standing and

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Figure 7. *Illustration of the advantages of a prop-and-reach maneuver allowed by the 30-degree elbow position for independent dressing.*

pregait activities. The patient was then instructed in the bilateral use of her UEs, and the use of a slide board was discontinued. Transfer skills were advanced to 22.9 cm (9 in) above and 45.7 cm (18 in) below the seat of the wheelchair once her CTLSO was discontinued. At this time, the patient was instructed in independent passive range of motion exercises, higher-level curb jumping, and how to stow a wheelchair into her car. Occupational therapists also worked with the patient on independent dressing in bed and in her wheelchair as well as on driving.

The final issue addressed during the patient's initial rehabilitation was ambulation. Because of the MMT grades of Good minus and lower throughout the patient's LEs, she required bilateral knee-ankle-foot orthoses for standing. She attained the ability to independently perform the sit-to-stand maneuver in the parallel bars and was able to ambulate inside the parallel bars with a reciprocal gait pattern. The patient, however, was never able to attain independent unsupported balance, and she never advanced out of the parallel bars.

The 30-degree fusion position did present some difficulty in manual wheelchair propulsion. The effect of the fused elbow is to shorten the UE (ie, to have a functional UE length discrepancy in a closed kinetic chair and conversely to have a longer UE in activities requiring flexion). The ramification for wheelchair propulsion is to have a diminished arc of the hand on the rim for propulsion. The inability to bend the elbow causes the individual to lean away from the restricted side on the backswing in order to keep the hand on the rim over the top of the wheel during wheelchair propulsion (Fig. 8). The amount of body lean required can be lessened by lifting the seat up out of the wheels (ie, lowering the axle plate on an adjustable lightweight wheelchair). This change, however, limits the arc of push, and a great number of short pushes are needed for functional speed. Additionally, low axle plates do not promote good balance in the wheelchair, and the preferred setup for individuals with paraplegia at the mid to high thoracic spinal cord levels is with the axle plates high to give a positive angle off the floor of the plane of the wheelchair seat (Fig. 9). To allow a balanced posture and a good arc of push, a smaller-diameter hand rim can be used. In this case study, we went a step further and provided asymmetrical hand rims with a 5.1-cm smaller diameter on the side of the patient's fusion. The "gear effect" equalized her push, and the resting hand-to-rim position allowed for level shoulders (Fig. 10).

Discussion

This case study illustrates four difficult issues that can be encountered when working with individuals with multi-

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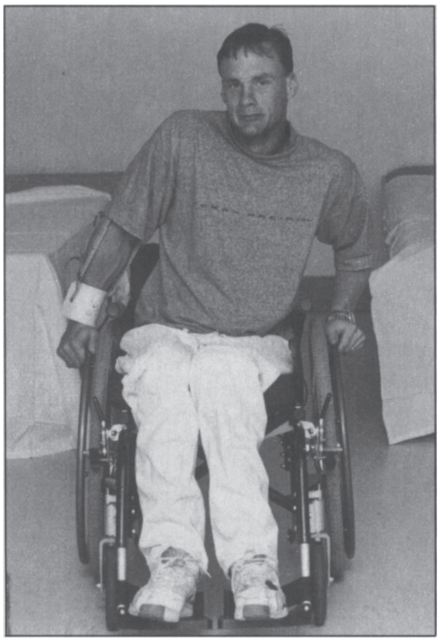

Figure 8. *Illustration of the body lean necessary to keep hand on rim for wheelchair propulsion with a 30-degree position of the elbow and a traditional wheelchair hand rim.*

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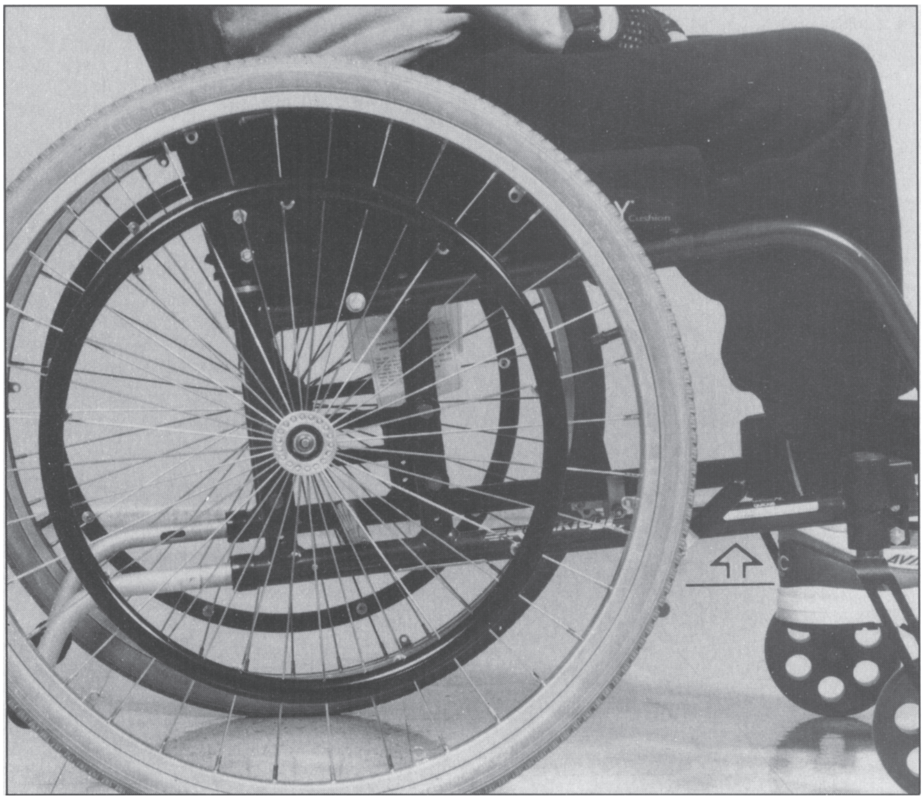

Figure 9. *Illustration of a high axle plate adjustment and the positive angle off the floor of the plane of the wheelchair seat (indicated by arrow).*

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Figure 10. *Original patient shown in her definitive wheelchair. The asymmetrical hand rims allow for level shoulders with wheelchair propulsion. The smaller-diameter hand rim is on the patient's right.*

ple injuries. First, all aspects of patient function are not always considered in surgical decision making. Second, surgeons who make these decisions often have inadequate experience in evaluating the functional implications of a surgical plan. Third, the rehabilitation team is often not involved in the preoperative assessment. Fourth, informed decisions are difficult for patients to make early in the rehabilitation process.

The patient in this case study required elbow fusion for comminuted fractures of the olecranon, the radius, and the ulna of her right UE. Because she was paraplegic, I was concerned that she could not know her needs for functional mobility, and I believed that the 90-degree flexion position of fusion as initially suggested would be detrimental to her independence.

A difficult issue in our management of this patient was her ability to make informed decisions regarding her surgery. True informed consent during the early rehabilitation process is controversial. Does the patient understand the medical and functional consequences of a particular intervention when confronted with a new disability? This issue is particularly difficult because the patient has not achieved his or her new level of function. Therefore, how can an individual weigh the implications of yet another intervention. In this case study, the patient was out of bed on a gurney only, potentially unaware of her future functional needs for upper-extremity mobility. To illustrate to the rehabilitation team and to the patient the advantages and disadvantages of each of two elbow positions under consideration for an arthrodesis, I recruited an individual with paraplegia to demonstrate some ADLs with two elbow splints that simulated the two positions of fusion being considered.

The 90-degree fusion position offers the patient ease of moving her right hand to her mouth or face and therefore no need to change her handedness for eating. This fusion position allows a relaxed resting posture with both hands on the lap. The position, however, makes the independent skills of manual wheelchair propulsion, transfer activities, and dressing either impossible or significantly more difficult to perform. Dependence in these tasks would require the patient to utilize a personal care attendant for daily living.[6,7]

The 30-degree fusion position greatly enhances the use of the arm in transfers and dressing and in sitting and balance activities. This fusion position, however, also presents some difficulties. As stated earlier, the 30-degree fusion position required the patient to change her handedness for self-feeding, oral/facial hygiene, makeup application, and so forth. Another change dictated by the 30-degree fusion position was to have the patient's hand controls set up on right side of the steering column to allow her the freedom of steering with her fully functional left UE. It was not demonstrated whether a 90-degree fusion would allow for driving. It is possible that the patient would have been able to drive with left-hand controls and a spinner knob on the right side for steering.

The individual in this case study had partial paraplegia at a high thoracic spinal cord level, with no functional musculature below the level of injury.[8] I chose to use individuals with complete paraplegia in the demonstration of tasks with both elbow fusion positions to illustrate that the need for extended elbow fusion would exist in most cases of paraplegia. The motor difference between T-3 and T-7 paraplegia is minimal, with four more levels of intercostal muscles and small back extensors innervated in the T-7 condition. Individuals with paraplegia at low thoracic and lumbar spinal cord levels may have enough trunk musculature to be able to compensate for some of the deficits that occur with a 90-degree fusion of the elbow (notably, the sitting balance and dressing activities that require propping for balance with a higher level of injury). Transfers could be functionally independent for many individuals with low-level paraplegia, and at our facility, we have often instructed individuals with an UE fracture or rotator cuff tear to perform single arm transfers toward the non–weight-bearing side. Persons with low-level paraplegia can usually accomplish uneven transfers in this way, however, not to the extent of off the floor. The manual wheelchair propulsion needs are not changed with lower-level paraplegia, and the 30-degree fusion will offer independent ability that the 90-degree fusion does not offer. I believe, therefore, that the 30-degree fusion position should be the position of choice in cases of paraplegia in which there is a need for elbow fusion.

Conclusions

The physical therapist will often have the most insight into the functional implications of musculoskeletal changes in an individual following trauma. The therapist, therefore, will also have the most insight into the functional implications of an orthopedic procedure that will result in a residual deformity or limitation. Physical therapists should be involved in the preoperative assessment and discussion to ensure that the patient's biomechanical needs are considered in the decision-making process when options in surgical decisions are available.

Recognizing that all patients are individual in their lifestyles, preferences, and needs, there are still biomechanical factors that are universal to a population of individuals with a set disability. The use of individuals with similar disabilities to demonstrate functional needs in simulated scenarios, therefore, can be a useful tool in educating a patient or an interdisciplinary team as to the implications of surgical outcomes.

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