2007

Rehabilitation following Pinning of an Ulnar Fracture with Radial Head Dislocation

Sandra R. Jungwirth
University of North Dakota

Rehabilitation Following Pinning of an Ulnar Fracture with Radial Head Dislocation

by

Sandra R. Jungwirth
Bachelor of Science in Physical Therapy
University of North Dakota, 1981

A Scholarly Project

Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Doctor of Physical Therapy

Grand Forks, North Dakota
October
2007

This Scholarly Project, submitted by Sandra R. Jungwirth in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Graduate School Advisor)

(Chairperson, Physical Therapy)

PERMISSION

Title	Rehabilitation Following Pinning of an Ulnar Fracture with Radial Head Dislocation
Department	Physical Therapy
Degree	Doctor of Physical Therapy

In presenting this Scholarly Project in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Department of Physical Therapy shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my work or, in her absence, by the Chairperson of the department. It is understood that any copying or publication or other use of this Scholarly Project or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and the University of North Dakota in any scholarly use which may be made of any material in this Scholarly Project.

Signature(s) Sandra R Fingerhut

Date 11-28-07

TABLE OF CONTENTS

LIST OF TABLES

Table Page

ACKNOWLEDGEMENTS

Thank you so much to the faculty of the University of North Dakota School of Medicine Physical Therapy Program for their time, knowledge, and expertise in preparing me for this scholarly project. Your passion and dedication to the physical therapy profession is evident!

Grateful appreciation to Dave Relling, P.T., Ph.D. and Peggy M. Mohr, Ph.D., P.T. for their assistance with this scholarly project.

Special thanks to my family, friends, colleagues, and coworkers for their words of encouragement and support along the way.

This scholarly project is dedicated to my husband, Michael and to our children, Amber, David, April, Dallas, Alicyn, and Autumn for their love and support.

ABSTRACT

Study design: Case report. Background and Purpose: Although upper extremity injuries and fractures are common in children, fractures of the ulna with dislocation of the radial head represent a small portion of the upper extremity fractures. The purpose of this case report is to describe the physical therapy intervention of such a fracture-dislocation in a child. Case Description: The patient was a 6-year-old girl diagnosed with a fracture of the ulna with dislocation of the radial head. She had a pinning of the ulnar fracture. Six and one half weeks after injury, physical therapy was initiated, consisting of 6 visits over a 3-week period. Physical therapy intervention included range of motion and strengthening exercises, manual therapy techniques, and instruction in a home exercise program. Outcomes: The patient demonstrated improved range of motion, strength, and functional use of her right arm. Discussion: The use of manual therapy techniques in combination with range of motion and strengthening exercises may lead to beneficial initial effects of elbow range of motion and arm function. Key Words: ulnar fracture, radial head dislocation, manual therapy, joint mobilization.

CHAPTER I

INTRODUCTION

Upper extremity injuries and fractures are extremely common in children.[1] In children, upper extremity fractures are much more common than those of the lower extremity. Fractures of the elbow represent approximately 10-12 %[1-3] of all pediatric fractures, whereas elbow dislocations account for less than 6% of pediatric elbow injuries.[4] Fractures of the ulna with dislocation of the radial head have been named after Monteggia as he first described this fracture pattern in 1814.[5,6]

Three main mechanisms of injury for this type of fracture have been suggested.[5] One mechanism of injury is a direct blow to the posterior forearm that first causes a break in the ulnar diaphysis and then forces the radial head into an anterior dislocation. However, there is no evidence to substantiate this mechanism of injury in children. A hyperpronation mechanism was proposed over a half century ago.[5,6] It was theorized that there was a hyperpronation force applied to the outstretched arm that fractured the ulnar shaft and forced the radial head to dislocate. This idea was based on fracture patterns experimentally produced by a single maximum load to failure model in dissected amuscular cadaver forearms. The ulnar fracture pattern is oblique as compared to the spiral seen from a rotational mechanism. Three decades ago a mechanism was proposed suggesting an elbow hyperextension mechanism of injury. This explanation is the most currently accepted one. This injury is thought to occur in three phases. First, elbow hyperextension occurs as the child tries to arrest a fall on an outstretched arm.[3,5,7,8] Secondly, during elbow hyperextension, the biceps contraction resists the extension moment dislocating the radial head. Lastly, after radial head dislocation, the body weight is transmitted

to the forearm, concentrated on the ulnar diaphysis which fails in tension, causing a complete oblique or a greenstick fracture.

Unlike fractures of the clavicle and proximal humerus, elbow fractures are more likely to require accurate surgical intervention.[1] Indications for surgical intervention are failure to maintain ulnar reduction and the radial head in an anatomic position. Radial head stability is directed by reduction and stability of the ulnar fracture.[5] Monteggia injuries can be caused by low–energy trauma, such as a fall from standing, or a high-energy mechanism, such as a motor vehicle accident or a fall from a height.[6,9] In the literature,[5,6,10] outcomes for Monteggia lesions are recognized to be quite good in children in comparison to adults. Early recognition of Monteggia-type fracture-dislocation is the key to a good outcome, as if missed, Monteggia lesions often result in long-term disability and pain.[4,6,11-13]

Although there is an abundance of literature on the reduction of the injury, a literature review yielded relatively scarce information of the physical therapy intervention for such injuries. [5,8,9] The purposes of this case study are to describe the rehabilitation of a patient following pinning of an ulnar fracture with radial head dislocation and the use of manual therapy in combination with range of motion and strengthening exercises.

CHAPTER II

CASE DESCRIPTION

Examination, Evaluation, and Diagnosis

This patient incurred an injury to the right elbow consisting of an ulnar fracture with radial head dislocation on 7-22-06. The mechanism of injury was a fall while trying to get out of a semi trailer. The patient had surgery for pinning of the ulnar fracture.

This patient was a six year old Caucasian female. She was left hand dominant, attended school full time, and was independent with age appropriate activities of daily living (ADL's) and recreational tasks. Functionally, she had limited use of her right upper extremity with ADL's. This child resided with her parents and three older siblings. Her family was supportive. They were able to transport her to her scheduled physical therapy sessions and assist her with her home exercise program (HEP).

The patient had no previous physical therapy treatment for this diagnosis. Patient and family goals were for her to be able to use her arm again. This patient was not taking any medications during this episode of physical therapy.

On initial observation, the patient held her right arm in a position of elbow flexion with forearm supination; when sitting, standing, and ambulating. She rated pain in her right arm at 0 on scale of 0-10 with 0 being no pain and 10 being the worst imaginable pain.

Range of motion (ROM) was measured with a universal goniometer. Refer to Table 1 for ROM measurements.

Table 1. Upper Extremity Range of Motion at Initial Evaluation		
	Right	**Left**
Elbow flexion	123°	155°
Elbow extension	-60°	10°
Forearm supination	99°	97°
Forearm pronation	21°	79°
Wrist flexion	WFL	WFL
Wrist extension	62°	90°

In a study by Solveborn and Olerud[14], the reliability of the measuring procedure with a simple goniometer for active and passive ROM of the elbow and wrist was established for high measurement precision. The standard deviation of the random error varied between 1 and 6° for the different joint motions, being best for elbow extension, elbow flexion, and wrist flexion, which could possibly be a function of a more distinct skeletal stop at the end point of the joint motion. Solveborn et al,[14] found the greatest variation was found for pronation, supination, and wrist extension, which may be due to the softer end feel. This study also concluded the use of a pen as a guideline and the use of sight lines may add a greater element of unreliability in determining reference points. Solveborn and Olerud also found consistency between both measurements of ROM in the healthy subjects in the reliability study and the ROM on the symptom-free limb in the subjects in the clinical series. Solveborn and Olerud concluded the total variation of measurement consisted of the sum of errors from several sources. The error from the measuring device itself (goniometer) was negligible. The two major contributors of measuring error were the error between different observers (intertester variation) and the error between different measurement recordings by the same observer (intratester variation).

Although the dominant arm is usually stronger than the nondominant, from a functional standpoint, studies[14,15] have found the ROM of the right and left arm vary by a minor number of degrees. Since this was a minor difference, findings indicate that joint motions of a patient's

healthy limb can routinely be used for comparison with the affected side in the presence of disease or lesion.

Strength of the elbow, forearm and wrist were tested using manual muscle testing (MMT). Grip and pinch strength were tested using hand and pinch dynamometers. Strength of the elbow, forearm, wrist and hand is summarized in Table 2.

Table 2. Upper Extremity Strength with Manual Muscle Testing at Initial Evaluation

	Right	**Left**
Elbow flexion	3/5	5/5
Elbow extension	3-/5	5/5
Forearm supination	3/5	5/5
Forearm pronation	3-/5	5/5
Grip	0#	10#
Pinch	5#	8#

As for the reliability of MMT, Bohannon [16] found that MMT was likely to confirm dynamometrically identified between side differences in strength less than 78% of the time. MMT was likely to confirm dynamometrically determined strength limitations less than 50% of the time. In Bohannon's study, dynamometry was likely to confirm a strength deficit found by MMT as excellent (>96%). Bohannon contended that in practice, there may be situations where MMT is an acceptable screening test. However, when determining precise differences in strength between sides, MMT may not be sufficient to show objective and measurable progress. Bohannon concluded that when comparing dynamometry to MMT, MMT is not especially sensitive or diagnostically as precise a measure of strength limitations, thus dynamometry is superior to MMT.

Peolsson et al,[17] evaluated intrarater and interrater reliability when determining grip force with a hand dynamometer and obtained intraclass correlation coefficients ranging from .85 to .98. Results from the reliability studies showed that a Jamar dynamometer to measure handgrip and indexgrip strength is a reliable method and may be recommended for use in clinical practice.

Peolsson et al concluded that the reference values for handgrip and indexgrip strength that were observed can be used in objective functional assessment and have practical value for the clinical evaluation, especially in rehabilitation in patients with cervical radiculopathy and upper extremity disorders.

A review of the integumentary system, indicated that the patient had a scab on her posterior elbow where the pin had been removed from the ulna. There was no significant swelling of the right elbow and forearm as compared to the left. Review of the musculoskeletal system for the assessment of gross symmetry, comparing the right and left elbows, revealed abnormal posturing of the right elbow with an excessive carrying angle. Gross assessment of ROM and strength of the bilateral elbows indicated a loss of ROM and strength of the right elbow as compared to the left. Gross sensation of the right upper extremity was intact and equal to the left arm. Gross assessment of height and weight of this patient indicated she was average height for her age. She had a thin frame with a lean body mass.

Review of the neuromuscular system was impaired coordination of movement of the right arm as compared to the left. Although she held her arm in an abnormal position during ambulation, transfers, and transitions, this posturing did not interfere with the gross completion of these tasks.

Based on results of the ROM measurements, the patient lacked functional ROM of the elbow. In studies,[18,19] functional elbow ROM has been reported to be 30° extension, 130° flexion, and 50° pronation and supination. This arc of range of motion allows positioning of the hand in various planes of motion for personal, vocational, and recreational activities.[19] The patient can compensate for the loss of extension by moving closer to the object, but cannot flex the neck and wrist enough to reach the face if flexion is less than 105-110°. A ROM deficit in

extension tends to be greater than the flexion deficit in most injuries; and is more challenging to restore for the patient and therapist.

Based on the results of the MMT and dynamometry tests, the patient had weakness of the elbow, forearm, grip, and pinch strength. The combination of impaired ROM and strength interfered with the patient's ability to use her right arm for ADL's and recreational tasks. The inability to use her right arm increased her dependence on others to do tasks for her and interfered with her ability to interact with her family and peers.

Using the *Guide to Physical Therapist Practice,*[20] the physical therapy diagnosis for this patient was consistent with practice pattern 4I: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated With Bony or Soft Tissue Surgery. The ICD 9 Codes are 813 and 832.

Prognosis and Plan of Care

It is anticipated that patients in this physical therapy practice pattern will, over the course of one to eight months, demonstrate optimal joint mobility, motor function, muscle performance, and range of motion. Potentially this will lead to an optimal level of functional improvement at home, work (job/school/play), community, and leisure environments. During this episode of physical therapy care, the patient will achieve the anticipated goals and outcomes of the interventions that are described in the plan of care and the global outcomes for patients who are classified in this practice pattern.

Long term goals for this patient included: (1) The patient will demonstrate active ROM of the right elbow from 10° of extension to 150° of flexion. (2) The patient will demonstrate active pronation of the forearm to 45°. (3) The patient will demonstrate right elbow strength in the four out of five range, and (4) The patient and her mother will report a 60% improved use of the right

arm with functional activities/ADL's. Short term goals for this patient included: (1) The patient will demonstrate active ROM of the right elbow from 30° of extension to 130° of flexion. (2) The patient will tolerate the progression of ROM, stretching, and strengthening exercises, and (3) The patient and her mother will demonstrate an understanding of and will be compliant with the HEP.

Intervention

The patient was referred to physical therapy by the treating orthopedist for evaluation and treatment. She was seen for physical therapy two times per week for three weeks. The rationale for use of intervention was based on the patient's need for ROM and strength to regain functional use of her right arm. The patient was treated with active ROM exercises for elbow flexion and extension, forearm supination and pronation, and wrist extension. Passive stretching exercises were done for elbow flexion and extension, forearm supination, and wrist flexors. Exercises were done using a one-pound dumbbell weight for strengthening of the elbow flexors and extensors, forearm supinators and pronators. Grip strengthening exercises were also done consisting of wringing a towel.

Additional interventions included joint mobilization and contract relax stretches to the elbow to facilitate ROM for elbow flexion, extension, and forearm pronation. A "magic" wand (fluid filled baton with glitter) was used as a distraction technique for the child to play with while doing her ROM exercises.

Patient and family instructions included education in the HEP on ROM, stretching, and strengthening exercises to do at home. The patient's mother was instructed in correct hand placement with passive exercises. The patient was instructed in how to give mom feedback as to pain and stretching for exercise to be effective.

Re-evaluation procedures included reassessment of ROM and strength attained, the patient's response and tolerance of the interventions, pain levels, observations of arm positioning, and the patient and mother's reports of patient's functional use of her right arm.

Outcomes at Discharge

The results of patient's ROM measurements at discharge are indicated in Table 3.

Table 3. Upper Extremity Range of Motion: Initial and Outcome Measurements

	Outcome-Right	**Initial-Right**	**Initial-Left**
Elbow flexion	141°	123°	155°
Elbow extension	1°	-60°	10°
Forearm supination	102°	99°	97°
Forearm pronation	45°	21°	79°
Wrist extension	80°	62°	90°

At discharge the patient's strength was retested using MMT for elbow and forearm strength and hand and pinch dynamometers for grip and pinch strength. The results of patient's strength at discharge are summarized in Table 4.

Table 4. Upper Extremity Strength with Manual Muscle Testing: Initial and Outcome

	Outcome-Right	**Initial-Right**	**Initial-Left**
Elbow flexion	4/5	3/5	5/5
Elbow extension	4/5	3-/5	5/5
Forearm supination	4/5	3/5	5/5
Forearm pronation	4/5	3-/5	5/5
Grip	13#	0#	10#
Pinch	7#	5#	8#

Physical therapy intervention resulted in increased ROM and strength of the patient's right elbow with improved functional ability to use the right arm to perform age appropriate ADL's. The increased ROM and strength of the patient's right upper extremity improved her functional ability to interact with her family and peers. It also decreased her dependence on others to do upper extremity tasks for her and increased her ability to do recreational tasks.

The Disability of the Arm, Shoulder, and Hand[21] (DASH) was completed at discharge by mom and with the physical therapist (PT) assisting child. The DASH scale was modified with

some items omitted as they were not age-appropriate for a child. The mother scored the child at 22 out of 95 and the child with assist of the PT scored 23 out of 95 on the modified DASH. Although the DASH is not age appropriate for a child, studies have shown the DASH to have excellent reliability.[21,22] In a study by Turchin et al[22], the intraclass correlation coefficient for the DASH was 0.92. According to the study by Turchin et al, the DASH questionnaire performed as well as or better than other elbow-scoring systems (the Mayo elbow-performance index and the systems of Broberg and Morrey, Ewald et al., The Hospital for Special Surgery, and Pritchard) in assessing the pain and functional loss perceived by the patients.

An age appropriate clinometric that could have been used for this child is the PedsQL Generic Core Scales.[23] This scale was designed to measure the core dimensions of health as described by the World Health Organization, as well as role (school) functioning. The PedsQL Generic Core Scales was found to be a reliable and valid clinometric, distinguishing between healthy children and children with acute and chronic health conditions in a study by Varni et al.[23] In the study by Varni et al, the internal consistency reliability for the total scale score was alpha = 0.88 child and 0.90 parent. The PedsQL Generic Core Scales was found to be responsive to clinical change over time, practical, easily administered, and cost effective. This clinometric is suitable for use in clinical settings, community, school, and clinical pediatric populations. The PedsQL Generic Core Scales is also multidimensional including the aspects of physical, emotional, social, and school functioning. Although this clinometric is more age appropriate, region-specific functional questionnaires have been shown to be more responsive to change in the function of the upper extremity than general health-status questionnaires.[22]

At discharge, the patient met all three short term goals. She met long term goals for active forearm pronation to 45° and right elbow strength in the four out of five range. At the

time of discharge, the patient and her mother were instructed in additional strengthening exercises to promote further functional use of the right UE. She and her mother were instructed to continue with the HEP. Although the patient did not attain full elbow ROM and strength at discharge, she demonstrated the elbow ROM needed to perform functional tasks.

CHAPTERIII

DISCUSSION

Elbow stiffness following an injury can be a challenging problem,[18,19] as the elbow has been described as a notoriously unforgiving joint, with considerable bony congruity and a joint capsule that thickens and tightens with trauma.[19] The purposes of this case study were to describe the rehabilitation of a patient following pinning of an ulnar fracture with radial head dislocation and the use of manual therapy in combination with ROM and strengthening exercises. Rehabilitation of this patient utilized a combination of joint mobilization techniques in conjunction with ROM and stretching exercises and contract relax techniques to enhance ROM. This combination of therapy interventions resulted in improved ROM for this patient. The positive outcomes for ROM in this case can in part be attributed to joint mobilization and therapist supervised exercise programs, such as a HEP. There is evidence to support that joint mobilization[24,25] and therapist supervised exercise programs[25] can increase joint ROM.

In addition to increased ROM, this patient also demonstrated improvement for elbow, forearm, grip, and pinch strength. The improved strength in this case may be due to the patient using her arm more for functional activities, strengthening exercises, and the HEP. In a literature search, there was relatively little information available in this area, especially of the upper extremity. However, pertaining to the lower extremity, progressive resistance exercise (PRE) after a fracture resulted in an improved ability to generate muscle force that carried over into improved functional activities, such as walking speed, going up and down stairs, and rising from a chair.[26] In addition, there was improved strength that enhanced functional activities. The results of this case study were similar as this patient experienced improved strength and functional ability of the upper extremity.

The DASH was selected as an outcome measure to gauge the patient's functional improvement. Selection of this outcome was based on its excellent reliability and ease of scoring.[22] Although the DASH is more responsive to change in the function of the upper extremity than general health-status questionnaires, a particular limitation of this outcome measure is that it is not age-appropriate.

Clinical implications of this case are the combined use of manual therapy with other physical therapy interventions. These combinations of physical therapy techniques are effective in restoring ROM following this type of fracture-dislocation. In researching this case, not only is this combined approach effective for the elbow joint for this type of injury, it is an effective intervention for other joints to restore ROM and to relieve pain.

Future studies are needed to resolve such questions as 1) is joint mobilization and exercise better than no intervention at all, 2) is one particular type of intervention more effective than another, 3) what should the intensity and frequency of intervention be, and 4) with regard to cost-effectiveness, who should provide the care, PT or the family?

The addition of manual therapy techniques was not intended to replace other aspects of physical therapy such as ROM and strengthening for this patient; rather it was intended to augment the other interventions. Based on the positive outcomes of using joint mobilization with this patient, and the literature on the use of joint mobilization techniques to facilitate ROM of various other joints, further investigation of joint mobilization to the elbow and other joints is warranted. The addition of joint mobilization techniques to other therapy interventions may decrease recovery times, allowing patients to return to normal activity sooner.

REFLECTION

Based on the results and findings of this case, I would have the patient complete an outcome measure at the initial examination, as well as at discharge. Since there is sufficient evidence to support the use of a dynamometer to measure strength, I would use a dynamometer to obtain a more objective measurement of strength.

As to the plan of care, I would write the short and long term goals to be more objective and measurable. Other than returning to the orthopedist for a follow-up visit, the patient in this case study did not see any other disciplines as there were no issues that required additional care. Referring a patient to another discipline would be determined on a case by case basis, taking into consideration their specific problem.

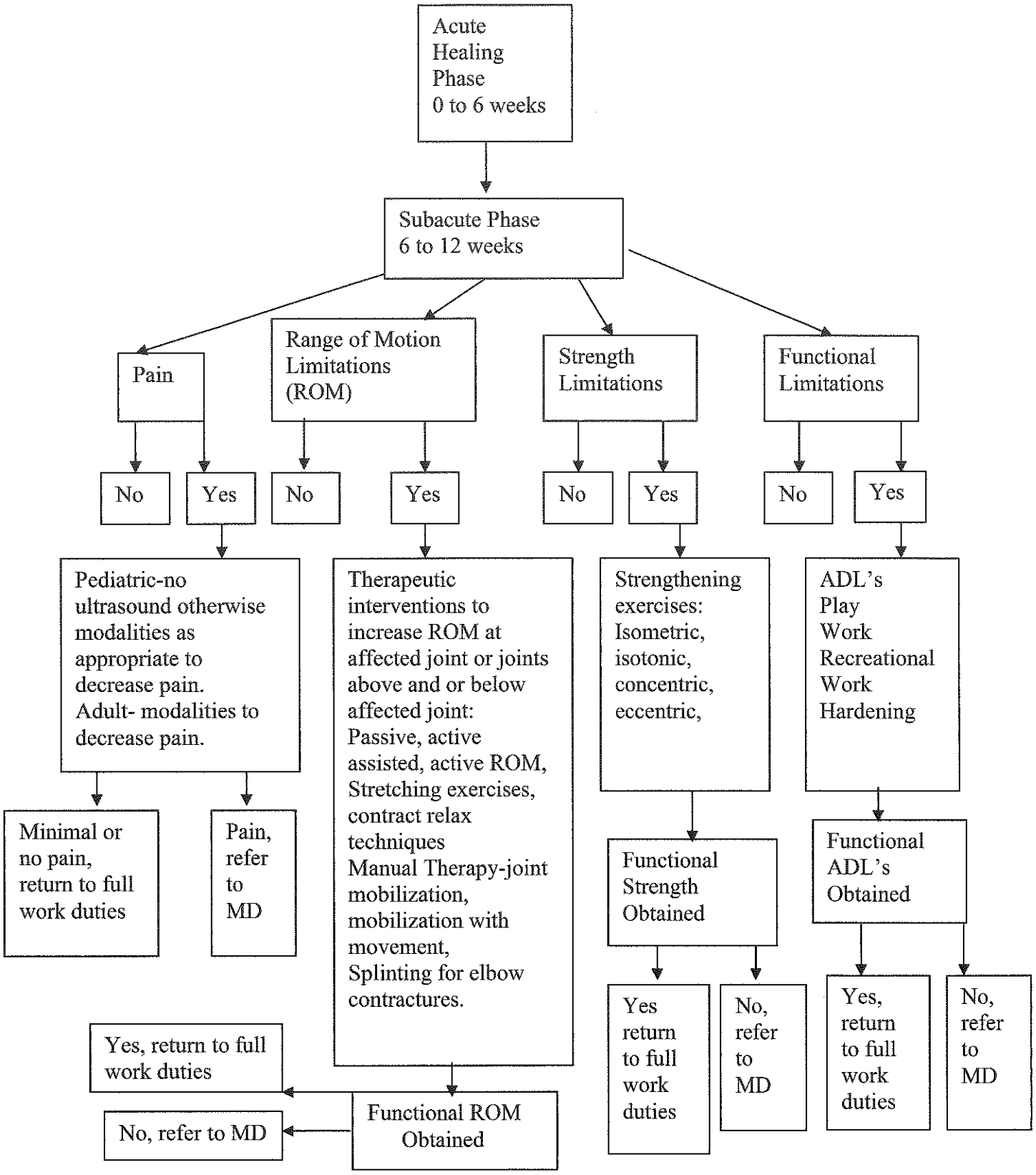
The total cost for this episode of physical therapy care was $499.00. After the deductible was met, Blue Cross Blue Shield paid 80% which would have been $399.20. If patient paid 20% of the bill it would have been $99.80. Based on the outcomes, I feel the cost is reasonable for this episode of physical therapy care. In a study[27] on the effectiveness of manual therapy, positive results were obtained with 30 and 45 minutes per treatment session and used a duration of four to nine weeks of treatment. Since this patient was seen for less than four weeks of physical therapy treatment, I do not believe it would have been feasible to do fewer therapy sessions to reduce costs and achieve the same outcomes.

This case has influenced my professional development goals to learn more about the effectiveness of manual therapy for other joints and conditions. The use of a clinometric in this case and the research of outcome measures have influenced me to use a clinometric when assessing patients. In addition to using a clinometric, this case has compelled me to do research

to find reliable and valid outcome measures. The research for this project has intrigued me to search the literature on other conditions for evidence to support or refute what I do as a clinician.

APPENDIX

Appendix
Examination & Intervention Algorithm
Rehabilitation Following Pinning of an Ulnar Fracture with Radial Head Dislocation



REFERENCES

1. Hart ES, Grottkau BE, Rebello GN, Albright MB. Broken Bones: Common Pediatric Upper Extremity Fractures-Part II. *Orthopaedic Nursing*. 2006:25;311-323.

2. Ward WT, Rihn JA. The impact of trauma in an urban pediatric orthpaedic practice. *J Bone Joint Surg Am*. 2006;88:2759-64.

3. John SD, Wherry K, Swischuk LE, Phillips WA. Improving Detection of Pediatric Elbow Fractures by Understanding Their Mechanics. *Radiographics*. 1996;16:1443-1460.

4. Milbrandt TA, Copley LAB. Common elbow injuries in children: evaluation, treatment, and clinical outcomes. *Curr Opin Orthop*. 2004;15:286-294.

5. Wilkins KE. Changes in the Management of Monteggia Fractures. *J Pediatr Orthop*. 2002;22:548-554.

6. Perron AD, Hersh RE, Brady WJ, KeatsTE. Orthopedic Pitfalls in the ED: Galeazzia and Monteggia Fracture- Dislocation. *Am J Emerg Med*. 2001;19:225-228.

7. Mann C, Parminder J, et al. Combined Galeazzi and Monteggiia foearm fracture. *J R Soc Med*. 2000;93:144-5.

8. Hui JH, Sulaiman AR, Lee HC, Lam KS, Lee EH. Open Reduction and Annular Ligament Reconstruction With Fascia of the Forearm in Chronic Monteggia Lesions in Children. *J Pediatr Orthop*. 2005;25:501-506.

9. Beredjiklian PK, Bozentka DJ, Ramsey ML. Ipoilateral Intercondylar Distal Humerus Fracture and Monteggia Fracture-Dislocation in Adults. *J Orthop Trauma*. 2002;16:438-440.

10. GivonU, Pritsch M, Levy O, Yosepovich A, Amit Y, Horoszowski H. Monteggia and equivalent lesions. A study of 41 cases. *Clin Orhtop Relat Res*. 1997;337:208-15.

11. Eathiraju S, Mudgal CS, Jupiter JB. Monteggia fracture-dislocations. *Hand Clinic*. 2007;23:165-77.

12. Ring D, Jupiter JB, Waters PM. Monteggia fractures in children and adults. *J Am Acad Orthop Surg*. 1998;6:215-24.

13. Ring D, Waters PM. Operative fixation of Monteggia fractures in children. *J Bone Joint Surg Br*. 1996;78:734-9.

14. Solveborn SA, Olerud C. Radial Epicondylalgia (Tennis Elbow): Measurement of Range of Motion of the Wrist and the Elbow. *JOSPT*. 1996;23:251-257.

15.Boone DC, Azen SP. Normal range of motion of joints in male subjects. *J Bone Joint Surg.* 1979;61A:756-759.

16. Bohannon RW. Manual muscle testing: does it meet the standards of an adequate screening test? *Clin Rehab.* 2005;19:662-667.

17. Peolsson A, Hedlund R, Oberg B. Intra-And Inter-Tester Reliability and Reference Values For Hand Strength. *J Rehab Med.* 2001;33:36-41.

18. Davila SA, Johnston-Jones K. Managing the Stiff Elbow: Operative, Nonoperative, and Postoperative Techniques. J Hand Ther. 2006;19:268-81.

19. Chinchalkar SJ, Szederes M. Rehabliltatioon of elbow trauma. *Hand Clin.* 2004;20:363-374.

20. American Physical Therapy Association. Guide to Physical Therapist Practice. 2nd ed. Alexandria, VA. *Phys Ther.* 2001;81:277-294.

21. Beaton DE, Katz JN, Fossel AH, Wright JG, Tarasuk V, Bombardier. Measuring the Whole or the Parts? Validity, Reliability, and Responsiveness of the Disabilities of the Arm, Shoulder and Hand Outcome Measure in Different Regions of the Upper Extremity. *J Hand Ther.* 2001;14:128-46.

22. Turchin DC, Beaton DE, et al. Validity of Observer-Based Aggregate Scoring Systems as Descriptors of Elbow Pain, Function, and Disability. *J of Bone Joint Surg.* 1998;80-A:154-162.

23. Varni JW, Seid M, et al. PedsQL 4.0: Reliability and Validity of the Pediatric Quality of Life Inventory Version 4.0 Generic Core Scales in Healthy and Patient Populations. Med Care. 2001;39(8):800-812.

24. Vermeulen HM, Rozing PM, Obermann WR, Cessie S, Vliet Vlieland TPM. Comparison of High-Grade and Low-Grade Mobilization Techniques in the Management of Adhesive Capsulitis of the Shoulder: Randomized Controlled Trial. *Phys Ther.* 2006;86:355-368.

25. Michlovitz SL, Harris BA, Watkins MP. Therapy Interventions for Improving Joint Range of Motion: A Systematic Review. *J of Hand Ther.* 2004;17:118-131.

26. Taylor NF, Dodd KJ, Damiano DL. Progressive Resistance Exercise in Physical Therapy: A Summary of Systematic Reviews. Phys Ther. 2005;85:1208-1223.

27. Sran MM. To treat or not to treat: new evidence for the effectiveness of manual therapy. Br J Sports Med. November 2006;issue 38. Available at: http://bjsm.bmj.com.Accessed November 14, 2006.