ORIGINAL CONTRIBUTION

ANALYSIS OF PHYSICIANS' REFERRALS: IS FURTHER DIAGNOSIS NEEDED?

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ABSTRACT

Background. As physical therapy gradually evolves into a more autonomous profession, physicians continue to play a major role in the clinical practice of physical therapists, particularly as a source of patient referral. The analysis of physicians' referrals to physical therapy may be a practical and effective way to study the relationship between physicians and physical therapists.

Objectives. The objective of this study was to identify the primary reasons for physicians' referrals to an outpatient physical therapy clinic and to determine whether further diagnosis by the physical therapist is necessitated prior to treatment.

Methods. Between January 1, 2001 and March 31, 2003, 544 consecutive physicians' referrals were received in a rural physical therapy outpatient clinic. Physicians' specialties, diagnosis on referral (or reason for referral, if diagnosis not provided), and prescribed orders on referral were all reviewed by the authors.

Results. One-third (33%) of the referrals were sent to physical therapy with no medical diagnosis (non-specified referrals – NSRs), and the most common reason for the referral in this NSR category was "pain" (88%). Commonly recommended treatments accompanying the NSRs included: evaluation & treatment (60%) and routine rehabilitation protocol (24%) for the relevant joints.

Conclusion. One-third (33%) of the referrals sent to physical therapy included no medical diagnosis, with the most common reason for the referral listed as "pain." Evaluation and treatment was the most recommended treatment accompanying these non-specific referrals (almost 2/3). Physical therapists cannot properly manage patients based on a physician referred diagnosis of "pain," therefore, it is necessary for physical therapists to make further diagnoses.

Key Words: physical therapy, decision-making, autonomy.

INTRODUCTION

Over 20 years ago, physicians played a dominant role in interaction between the physician and the physical therapist (PT). The PT functioned as a technician in a prescriptive role by following the order from the referring physician.[1] The referring physician assumed the responsibilities and duties of evaluation, diagnosis, and determination of specific therapeutic interventions and modalities.[1] Most physicians perceived the PT as a technician rather than a professional colleague.[2-4] Physicians believed that the PT lacked the most complex criteria of medical professionalism: examination and evaluation skills and autonomy of judgment.[3]

However, the role of physical therapy has been changing rapidly in the past 5 to 10 years. In 2000, the American Physical Therapy Association (APTA) adopted Vision 2020, in which five key areas became the focus of the APTA to make physical therapy a more autonomous profession by the year 2020.[5] These key areas include professionalism, direct access, the doctor of physical therapy degree, evidence-based practice, and the PT as the practitioner of choice.[5] Achieving significant progress in these key areas will prepare and enable PTs to interact with physicians on a more collegial level and less as "subservient followers of orders".[6] Currently, the PT is assuming greater responsibility for initial assessment and management of musculoskeletal conditions.[7-10] Actually, the PT has been functioning as the primary evaluator of neuromusculoskeletal conditions with success in the United States Army since the early 1970s.[1] In reaction to this decades-long history of the PT

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being the autonomous practitioner of choice in the Army, some researchers have suggested that the PT must demonstrate that they have the expertise in examination and treatment of musculoskeletal conditions to assume new roles in healthcare, to increase visibility within healthcare organizations, and to gain more autonomy as professionals.[1,9]

Ritchey et al[11] reported that the role expansion of physical therapy is not likely to occur easily because of the "turf battle" with physicians. The PT is seldom placed in a position to dispute or challenge a physician's decision, or make a physician feel his/her competency is being questioned by subordinates.[11] While physical therapy has a long history of clinical practice with some level of autonomy regarding patient intervention, an equally long tradition of consulting with physicians also exists. Additionally, the cognitive and evaluative tasks the PT performs have tended to be secondary or supportive, if not supplementary, to a physician's examination, evaluation, and diagnosis.

The American Medical Association and the American Academy of Orthopedic Surgeons oppose independent practitioner status for the PT because of concerns about improper diagnosis, inappropriate care, and the potential for increased costs.[12] Ironically, several physician survey studies indicated that the majority of responding physicians did not know enough about physical therapy services.[2,3,13,14] One study identified two areas that physicians lacked familiarity with physical therapy; the first being knowledge of how the PT evaluates their patients and the second being knowledge of modalities used by the PT and how such treatments are performed.[13] Recently, physicians' knowledge of physical therapy was surveyed again revealing similar findings.[14] These studies advocate for continuing education courses for physicians to increase their knowledge about physical therapy; suggestions that have been supported by the physician participants in the survey studies.[2,13,14]

Recently, a trend has developed for states to pass laws allowing patients to have direct access to physical therapy. Also, an increasing number of physical therapy education programs in the United States are progressing to the doctor of physical therapy degree program. Physical therapy autonomy is becoming one of the most discussed issues related to daily physical therapy practice. According to the APTA Board of Directors, physical therapy autonomy is characterized by independent and self-determined professional judgment and action during practice.[15] In other words, under direct access, the PT needs to be able to independently examine, evaluate, diagnose, and treat patients within their scope of practice.

All of these issues suggest there might be a "turf battle" between the PT and the physician, with one side trying to gain greater professional autonomy and role expansion and the other side opposing such expansion. Thus, analysis of physicians' referrals to physical therapy may be a practical and effective way to study the relationship between the physician and the PT. The purpose of this study was to identify the primary reasons for physicians' referrals to an outpatient physical therapy clinic and to determine whether further diagnosis by the PT is necessary prior to treatment.

METHODS

Between January 1, 2001 and March 31, 2003, 544 consecutive physicians' referrals were received in a physical therapy outpatient clinic located between two metropolitan settings in the southeastern United States. For each referral, physician's specialty, referral diagnosis (or reason for referral, if diagnosis was not provided), and prescribed orders on the referral were reviewed by the authors. No informed consent or institutional review board approval was required because the data collection did not require an intervention or an interaction with a living person and no identifiable private information was obtained or contained for this study in a form associable with any individual(s).

RESULTS

Specialty of the Physician

Among 544 referrals from 78 physicians (67 medical doctors, 9 doctors of osteopathy, and 2 podiatrists), 59% of the referrals (321 of 544) were from orthopedists, and 32% (176 of 544) were from family or internal medicine practitioners.

Orthopedic surgeons, family physicians, and internal medicine physicians combined accounted for 91% of the total referrals. The remaining 9% of referrals came from physicians who specialized in neurology (2%), rehabilitation medicine (2%), pain management/anesthesiology (2%), podiatry (1%), general surgery (1%), and otolaryngology (1%).

Reason Provided on Referral

Out of the 544 referrals, 67% (367 of 544) included a specific medical diagnosis in the referral and for purposes of this study were categorized as specified referrals (SRs). *(Table 1)*. The other 33% (177 of 544) did not include a specific medical diagnosis and were categorized as non-specified referrals (NSRs). Since theses NSRs included symptoms (pain, dizziness, weakness) rather than a specific medical condition, these referrals are considered "reasons for referral" rather than diagnoses. Of these 177 NSRs, in 88% (156 of 177) the reason for referral was "pain" (knee pain, back pain, etc).

To further analyze the data, referrals specifically related to surgery were separated from non-surgical referrals. Among all referrals, 22% (118 of 544) specifically were related to post surgery and had a specific diagnosis included in the referral. The most common post-surgical referrals were for knee arthroscopy, total knee replacement, and rotator cuff repair. In contrast, 78% of all referrals (426 of 544) were non-surgical related referrals.

TABLE. Reasons for Referral to Physical Therapy

Reason	Frequency	Percentage (%) of Total Referrals
Pain only or specified referral	367	67%
Non-specified referral	177	33%
Total	544 referrals	100%

Of the 426 non-surgery related referrals, 249 (58.4%) of them were referred with a specific medical diagnosis (SRs), and 177 (41.6%) were referred without any medical diagnosis (NSRs). Based on the anatomical location of the reason for the referral, the lower back, ankle-foot, shoulder, knee, and neck were the top five locations across all non-surgery related referrals (*NSRs and SRs combined; Table 2*). Among the 249 SRs, the lower back, ankle-foot, shoulder, knee, and neck were the top five sites of complaints. According to the medical diagnoses on the 249 SRs, lumbar strain, rotator cuff tendonitis/impingement, ankle sprain, cervical strain, and knee osteoarthritis were the top five diagnoses on the specified referrals. (Listed in Table 3 are the three most common physicians' diagnoses for each anatomical location for the SRs.) Further analysis of the 177 NSRs revealed that the low back was the most frequent anatomic location for the reason for the referral. *(Figure)*

TABLE 2. Location of Non-Surgery Related Referrals

	Low Back	Ankle-Foot	Shoulder	Knee	Neck	Upper Back	Wrist-Hand	Hip	Elbow	Other area(s)	Total
Specified Referrals	67	53	43	26	17	8	10	8	4	15	**249**
Non-specified Referrals	71	6	11	18	23	9	7	7	5	20	**177**
Subtotal	138	59	54	44	40	17	17	13	9	35	**426**

Prescribed Orders on Referrals

As seen in Table 4, the most commonly prescribed orders made by physicians on the 544 referrals were evaluation and treatment (47%), routine rehabilitation protocol (22%) for the relevant joints (i.e. routine knee rehab), strengthening and range of motion (15%), and specified modalities (13%). The most commonly recommended orders on the 177 NSRs included evaluation and treatment (60%), routine rehabilitation protocol (24%), and strengthening and range of motion (9%). Among those 22% (118 of 544) of referrals (including both SRs and NSRs) with routine rehabilitation protocol as the prescribed order, 11 of the 118 (9%) were accompanied with either a copy of the treatment protocol (9 of 11) or a reference to a published book or article (2 of 11). However, 107 of the 118 (91%) referrals presented no details of the treatment protocol. Of these 109 referrals, most came from orthopedists (51%) or family/internal medicine physicians (39%).

DISCUSSION

Physician Specialties

More and more states are passing direct access to physical therapy laws, but the long-standing trend continues to be that third parties such as Medicare, Medicaid, and private insurance companies reimburse physical therapy services only if the physical therapy service is prescribed by a physician.[16] Therefore, physicians continue to play a major role in referral of patients to physical therapy and the prescription of physical therapy services seems to be determined, in part, by physician specialties and patients' insurance status. Namely, orthopedic surgeons, followed by general practitioners and internal medicine specialists, are still the main referral sources for physical therapy.[11,17,18]

Likewise, this study showed similar results with orthopedists (59%) and family and internal medicine practitioners (32%) accounting for 91% of the total referrals.

FIGURE. Location on Non-Specified Referrals

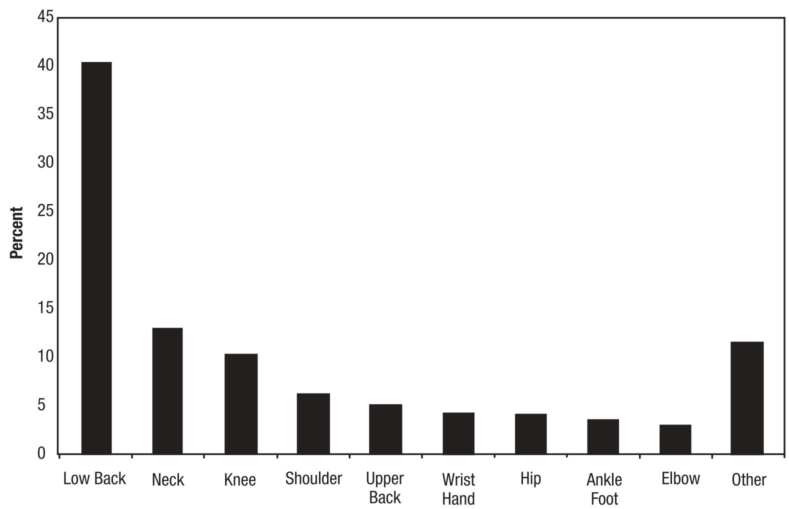

TABLE 3. Categorization of Diagnoses on the Specified Referrals

Pain Area	Most Commonly Referred Diagnoses
Neck	cervical strain, cervical degenerative disease, cervical disk hernia
Upper Back	trapezius spasm/strain, whiplash, thoracic strain
Low Back	lumbar strain, post diskectomy (> 1 year post-surgery), lumbar radiculopathy
Shoulder	rotator cuff tendonitis, impingement, humeral fracture, rotator cuff tear
Elbow	elbow tendonitis, radial head fracture
Wrist-Hand	cubital tunnel syndrome, fracture, tendonitis
Hip	trochanteric bursitis, ischial tuberosity bursitis, sacroiliac joint dysfunction
Knee	osteoarthritis, patellofemoral syndrome, patellar subluxation/dislocation
Ankle-Foot	ankle sprain, plantar fasciitis, achilles tendonitis
Systemic/Other	fibromyalgia, temporomandibular joint dysfunction, post-polio syndrome, rheumatoid arthritis

Reason for Referral and Physical Therapy Autonomy

The physician members of the American Medical Association and the American Academy of Orthopedic Surgeons have traditionally opposed increased autonomy by physical therapists in the practice of physical therapy.[12] Yet, as the primary source of referrals to physical therapy, their non-specified referrals from physicians are somewhat inconsistent with this viewpoint. This study identified pain, muscle weakness, and decreased range of motion (all of which are impairments/symptoms) as the three most common reasons physicians referred their patients to outpatient physical therapy. Interestingly, one-third (33%) of the referrals did not have a medical diagnosis with the most frequent location of the complaint being the lower back and the most frequent reason for the referral being "pain." Clearly, additional skillful, independent examination and assessment of the patient by the PT is warranted in such instances. Two things may potentially be inferred from this finding. First, referring physicians may view the PT as a consultant/expert rather than as a subordinate with regard to management of some patients with musculoskeletal conditions. Secondly, a PT may be empowered to view him/herself more as a physician's colleague rather than a technician or subordinate. Such ideals are also facilitated by the progression of physical therapy education to the doctor of physical therapy degree level, characterized by greater breadth and depth of content and instruction in skilled, proactive, and independent clinical decision making. Physical therapists do not identify disease in the sense of pathology, but they do identify clusters of signs, symptoms, and other relevant information from subjective and objective examination of the patient. These clusters can be labeled as classifications or diagnoses by the PT.[19] Based on the present study, pain is the most common impairment that the PT encounters in an outpatient setting. Thus, the ability to understand and differentiate the multitude of signs and symptoms relevant to pain and then to be able to synthesize this information with data from patient history, and radiology and lab test results will greatly assist the PT in the management of their patients, especially in instances where medical diagnosis information from the referring physician is lacking.

Brogan[17] reported that physicians probably do not recognize the extent to which their patients need physical therapy services and, in addition, may not adequately refer their patients for such physical therapy services. This might be due to the lack of physicians' knowledge of physical therapy, which was indicated by a study performed 20 years ago by Stanton et al,[14] and also by another similar but more recent study by English et al.[13] These studies recommended increased and enhanced communication between the physician and the PT and that the physician should learn more about physical therapy. Olsen[20] encouraged increased communication between the PT and their referral sources not only for marketing purposes, but also for improved patient management. A study by Hendriks et al[21] suggested that primary care physicians seek a one-time physical therapy consultation as an appropriate and beneficial component of the primary care patient management process.

Physician referrals to physical therapy have been studied by others.[4,11,22] Twenty years ago, physicians often did a physical therapy referral for patients with the assumption that the patient was not in need of any further assessment, evaluation, or decision-making by the PT.[22] Several years later, Ritchey et al[11] found that 30% of physicians gave no diagnosis on the physical therapy referral, which is similar to results of this study (29%). Hulme et al[22] reported that although both physicians and physical therapists agreed that inclusion of the medical diagnosis on physical therapy referrals was a priority, many physical therapists reported the diagnosis was often omitted from referrals, was incomplete, or was a list of impairments/symptoms rather than a medical diagnosis. In the view of the PT, even a preliminary diagnosis was important for the purposes of serving as a starting place for the examination and evaluation and for assistance in excluding many pathological conditions that may cause the symptoms.[22]

TABLE 4. Recommended Action/Orders on Referrals

Orders	All Referrals		Only Non-Specified Referrals	
	Frequency	Percentage	Frequency	Percentage
Evaluate & Treat	254	47%	107	60%
Routine Rehab Protocol	118	22%	42	24%
Strengthening & Range of Motion	82	15%	16	9%
Modalities Only	14	13%	8	5%
Other	16	3%	4	2%
Total	544	100%	177	100%

Further discussion regarding physician support of greater autonomy in physical therapy practice relates to decision-making regarding plan of care and interventions. According to this study, a substantial number of referrals state "evaluate and treat" (47% of all referrals). Among the NSRs, the percentage is 60% of NSR referrals. These observations seem to add additional support to the notion that greater autonomy of the PT, regarding all aspects of patient management, is being encouraged by physicians by the nature of their physical therapy referrals.

Future Study

In future research, data should be collected on a larger number of referrals from both rural and urban outpatient physical therapy clinical settings in different geographic areas of North America. Any association between physicians' years of working experience and the frequency of specified and non-specified referrals should be investigated. Also, future research should focus on the relationship between physician specialty and any prescribed orders, recommended treatment duration, radiological or laboratory documentation, and treatment precautions stated on referrals. Such investigations, in combination with the results of the present study, will further assist both physicians and physical therapists in understanding their roles in the contemporary healthcare environment and may also serve to identify some continuing education needs of both professions.

CONCLUSION

Review of 544 physician referrals to a physical therapy outpatient clinic indicated that 1/3 (33%) of the referrals included no medical diagnosis. Within these non-specified referrals, "pain" was the reason listed most frequently (88%) and the low back was the most frequent location (40%). However, pain is a symptom/impairment rather than a medical diagnosis. Physical therapists cannot properly manage patients based on a referred diagnosis of "pain," making it necessary for the PT to make further diagnoses. Greater independence and involvement in the diagnostic process, as well as patient management in general, is indirectly encouraged through non-specific physician referrals.

REFERENCES

1. James JJ, Stuart RB. Expanded role for the physical therapist. *Phys Ther.* 1975;55:121-131.
2. Dunkel RH. Survey of attitudes of Arkansas physicians and physical therapists toward the professional capacity of the physical therapist. *Phys Ther.* 1974;54:584-587.
3. Silva DM, Clark SD, Raymond G. California physicians' professional image of physical therapists. *Phys Ther.* 1981;61:1152-1157.
4. Uili RM, Shepard KF, Savinar E. Physician knowledge and utilization of physical therapy procedures. *Phys Ther.* 1984;64:1523-1530.
5. Massey BF. Making vision 2020 a reality. *Phys Ther.* 2003;83:1023-1026.
6. Rothstein JM. Autonomy or professionalism? *Phys Ther.* 2003;83:206-207.
7. Monahan B. Autonomy, access and choice: New models of primary care. *PT Magazine.* 1996;4:54-58.
8. Monahan B. Physical therapists as primary care providers. *PT Magazine.* 1994;2:46-49.
9. Smith KL, Tichenor CJ, Schrodeer M. Orthopaedic residency training: A survey of the graduates' perspective. *J Orthop Sports Phys Ther.* 1999; 29:635-655.
10. Tichenor CJ. Kaiser Permanente moves forward with physical therapists in primary care. *Orthop Phys Ther Pract.* 1998;10:19.
11. Ritchey FJ, Pinkston D, Goldbaum JE, et al. Perceptual correlations of physician referral to physical therapists: Implications for role expansion. *Soc Sci Med.* 1989;28:69-80.
12. Barr J. It's time to be direct about direct access. *Physical Therapy Today*. Spring, 1991.
13. Stanton PE, Fox FK, Franfos KM, et al. Assessment of resident physicians' knowledge of physical therapy. *Phys Ther.* 1985;65:27-30.
14. English ML, Rudy DL, Castle JM, Mesnard C. Collaborative education in an internal medicine residents' clinic. *Proceedings of the American Physical Therapy Association, Combined Sections Meeting, Nashville, TN, February 2004.*
15. American Physical Therapy Association Board of Directors. Autonomous physical therapist practice: Definition and privileges. In: Professional and Societal Policies, Positions, and Guidelines. Alexandria, VA: American Physical Therapy Association; July, 2004.
16. Jette AM, Davis KD. A comparison of hospital-based and private outpatient physical therapy practices. *Phys Ther*. 1991;71:366-75; discussion 376-81.
17. Brogan DR. Rehabilitation service needs: Physicians' perceptions and referral. *Arch Phys Med Rehab.* 1981; 62:215-219.
18. Freburger JK, Holmes GM, Carey TS. Physician referrals to physical therapy for the treatment of musculoskeletal conditions. *Arch Phys Med Rehab.* 2003;84:1839-1849.
19. Delitto A, Snyder-Mackler L. The diagnostic process: Examples in orthopedic physical therapy. *Phys Ther*. 1995;75:203-211.
20. Olsen D. A descriptive survey of management and operations at selected sports medicine centers in the United States. *J Orthop Sports Phys Ther*. 1996;24:315-322.
21. Hendriks EJ, Kerssens JJ, Nelson RM, et al. One-time physical therapist consultation in primary health care. *Phys Ther*. 2003;83:918-931.
22. Hulme JB, Bach BW, Lewis JW. Communication between physicians and physical therapists. *Phys Ther*. 1988;68:26-31.

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INVITED CLINICAL COMMENTARY

NON-OPERATIVE REHABILITATION FOR TRAUMATIC AND ATRAUMATIC GLENOHUMERAL INSTABILITY

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ABSTRACT

Glenohumeral joint instability is a common pathology encountered in the orthopaedic and sports medicine setting. A wide range of symptomatic shoulder instabilities exist ranging from subtle subluxations due to contributing congenital factors to dislocations as a result of a traumatic episode. Non-operative rehabilitation is utilized in patients diagnosed with shoulder instability to regain their previous functional activities through specific strengthening exercises, dynamic stabilization drills, neuromuscular training, proprioception drills, scapular muscle strengthening program and a gradual return to their desired activities. The specific rehabilitation program should be varied based on the type and degree of shoulder instability present and desired level of function. The purpose of this paper is to outline the specific principles associated with non-operative rehabilitation for each of the various types of shoulder instability and to discuss the specific rehabilitation program for each pathology type.

Keywords: Dynamic stabilization, neuromuscular control, shoulder joint

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INTRODUCTION

Shoulder instability is a common pathology often seen in the orthopaedic and sports medicine setting. The glenohumeral joint allows tremendous amounts of joint mobility to function, thus, making the joint inherently unstable and the most frequently dislocated joint in the body.[1] Due to the joint's poor osseous congruency and capsular laxity, it greatly relies on the dynamic stabilizers and neuromuscular system to provide functional stability.[2] Therefore, differentiation between normal translation and pathological instability is often difficult to determine. A wide range of shoulder instabilities exist from subtle subluxations to gross instability. Often the success of the rehabilitation program is based on the recognition and treatment program designed to treat the specific type of instability present.

TABLE. Seven key factors to consider in the rehabilitation of the unstable shoulder

1. Onset of the pathology
2. Degree of instability – subluxation vs. dislocation
3. Frequency of dislocation – chronic vs. acute
4. Direction of instability – anterior, posterior, multidirectional
5. Concomitant pathologies
6. End range neuromuscular control
7. Premorbid activity level

Non-operative rehabilitation is often implemented in patients diagnosed with a variety of shoulder instabilities. These instability patterns can range from congenital multidirectional instabilities to traumatic unidirectional dislocations. We have classified glenohumeral joint instabilities into two broad categories: traumatic and atraumatic. Based on the classification system of glenohumeral instability, as well as several other factors, a non-operative rehabilitation program may be developed. The purpose of this paper is to discuss and overview these factors along with the non-operative rehabilitation programs for the various types of shoulder instability in order to return the patient to their previous level of function.

REHABILITATION FACTORS

Seven key factors should be considered when designing a rehabilitation program for a patient with an unstable shoulder *(Table)*. These factors and their significance to the rehabilitation program will be presented.

Onset of Pathology

The first factor to consider in the rehabilitation of a patient with shoulder instability is the onset of the pathology. Pathological shoulder instability may result from an acute, traumatic event or chronic, recurrent instability. The goal of the rehabilitation program may vary greatly based on the onset and mechanism of injury. Following a traumatic subluxation or dislocation, the patient typically presents with significant tissue trauma, pain, and apprehension. The patient who has sustained a dislocation often exhibits more pain due to muscle spasm than a patient who has only subluxed their shoulder. Furthermore, a first-time episode of dislocation is generally more painful than the repeat event. Rehabilitation for the patient with a first-time traumatic episode will be progressed based on the patient's symptoms with emphasis on early controlled range of motion, reduction of muscle spasms and guarding, and relief of pain.

Conversely, a patient presenting with atraumatic instability often presents with a history of repetitive injuries and symptomatic complaints. Often the patient does not complain of a single instability episode but, rather, a feeling of shoulder laxity or an inability to perform specific tasks. Rehabilitation for this patient should focus on early proprioception training, dynamic stabilization drills, neuromuscular control, scapular muscle exercises, and muscle strengthening exercises to enhance dynamic stability due to the unique characteristic of excessive capsular laxity and capsular redundancy in this type of patient.

Degree of Instability

The second factor is the degree of instability present in the patient and the effect on their function. Varying degrees of shoulder instability exist such as a subtle subluxation or gross instability. The term subluxation refers to the complete separation of the articular surfaces with spontaneous reduction. Conversely, a dislocation is a complete separation of the articular surfaces and requires a specific movement or manual reduction to relocate the joint, resulting in underlying capsular tissue trauma. The degree of trauma to the soft tissue of the glenohumeral joint with a shoulder subluxation is can be quite extensive. Speer et al[3] has reported that in order for a shoulder dislocation to occur, a Bankart lesion and soft tissue trauma must be present on both sides of the glenohumeral joint capsule. Thus, in the situation of an acute traumatic dislocation, the anterior capsule may be avulsed off the glenoid (Bankart lesion) and the posterior capsule may be stretched, allowing the humeral head to dislocate. Warren et al[4] refer to this damage to both the anterior and posterior capsule as the "circle stability concept."

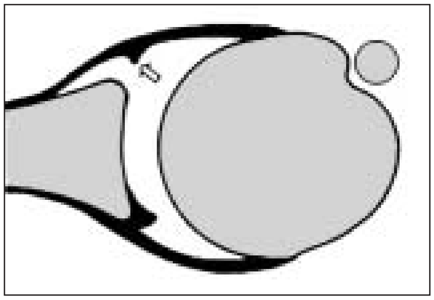
The rate of progression of the rehabilitation program will vary based upon the degree of instability and persistence of symptoms. For example, a patient with mild subluxations and muscle guarding may initially tolerate strengthening exercises and neuromuscular control drills more than a patient with a significant amount of muscular guarding.

Frequency of Dislocation

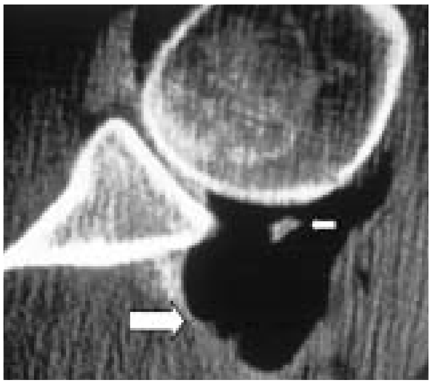
The next factor to influence the rehabilitation program is the frequency of dislocation or subluxation. The primary traumatic dislocation is most often treated conservatively with immobilization in a sling and early controlled passive range of motion (ROM) exercises, especially with first time dislocations. The incidence of recurrent dislocation ranges from 17-96% with a mean of 67% in patient populations between the ages of 21-30 years old.[1,5-15] Therefore, the rehabilitation program should progress cautiously in young athletic individuals. It should be noted that Hovelius et al[8,16,17] has demonstrated that the rate of recurrent dislocations is based on the patient's age and not affected by the length of post-injury immobilization. Individuals between the ages of 19 and 29 years are the most likely to experience multiple episodes of instability. Hovelius et al[8,16,17] noted patients in their 20's exhibited a recurrence rate of 60%, whereas, patients in their 30's to 40's had less than a 20% recurrence rate. In adolescents, the recurrence rate is as high as 92%[18] and 100% with an open physes.[19]

Chronic subluxations, as seen in the atraumatic, unstable shoulder may be treated more aggressively due to the lack of acute tissue damage and less muscular guarding and inflammation. Rotator cuff and periscapular strengthening activities should be initiated while ROM exercises are progressed. Caution is placed on avoiding excessive stretching of the joint capsule through aggressive ROM activities. The goal is to enhance strength, proprioception, dynamic stability and neuromuscular control, especially in the specific points of motion or direction which results in instability complaints.

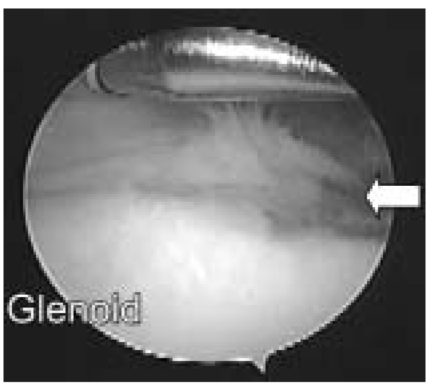
Figure 1
Bankart lesion commonly observed with a traumatic dislocation.



1a.
Drawing illustrating a Bankart lesion. The arrow denotes the avulsed capsule from the glenoid.



1b.
CT arthrogram of a bony Bankart lesion. The large arrow shows the dye that has leaked out of the capsule. The small arrow shows the bony lesion which has pulled away from the glenoid rim.



1c.
An arthroscopic view of a Bankart lesion.

Direction of Instability

The fourth factor is the direction of instability present. The three most common forms include anterior, posterior, and multidirectional. Anterior instability is the most common traumatic type of instability seen in the general orthopaedic population, representing approximately 95% of all traumatic shoulder instabilities[12]. Following a traumatic event in which the humeral head is forced into extremes of abduction and external rotation, or horizontal abduction, the glenolabral complex and capsule may become detached from the glenoid rim resulting in anterior instability. This type of detachment is referred to a Bankart lesion.*(Figure 1)* Baker et al[20] have identified four types of Bankart lesions based on the size and the degree of tissue involvement. Conversely, rarely will a patient with atraumatic instability due to capsular redundancy dislocate their shoulder. It is the author's opinion that these patients are more likely to repeatedly sublux the joint without complete separation of the humerus from the glenoid rim. Capsular avulsions can occur on the glenoid side (Bankart lesion) or on the humeral head side referred to as a HAGL lesion (humeral avulsion of the inferior glenohumeral ligament).[21-23]

Posterior instability occurs less frequently, only accounting for less than 5% of traumatic shoulder dislocations.[24,25] This type of instability is often seen following a traumatic event such as falling onto an outstretched hand or from a pushing mechanism. However, patients with significant atraumatic laxity may complain of posterior instability especially with shoulder elevation, horizontal adduction and excessive internal rotation due to the strain placed on the posterior capsule in these positions. In professional or collegiate football, the incidence of posterior shoulder instability appears higher than the general population. This is especially true in linemen. Mair et al[26] reported on nine athletes with posterior instability in which eight of nine were linemen and seven were offensive linemen. Often, these patients require surgery as Mair et al[26] also reported 75% required surgical stabilization. Kaplan et al[27] reported in a study of collegiate football players that 78% required surgical stabilization.

Multidirectional instability (MDI) can be identified as shoulder instability in more than one plane of motion. Patients with MDI have a congenital predisposition and exhibit ligamentous laxity due to excessive collagen elasticity of the capsule. Furthermore, Rodeo et al[28] reported that this type of patient turns over collagen at a faster rate. The authors consider an inferior displacement of greater than 8-10mm during the sulcus maneuver *(Figure 2)* with the arm adducted to the side as significant hypermobility, thus suggesting significant congenital laxity.[2]

Figure 2
Sulcus maneuver to assess inferior capsular laxity

Due to the atraumatic mechanism and lack of acute tissue damage, ROM is often normal to excessive. Patients with recurrent shoulder instability due to MDI generally have weakness in the rotator cuff, deltoid muscle, and scapular stabilizers with poor dynamic stabilization and inadequate static stabilizers. Initially, the focus of the rehabilitation program is on maximizing dynamic stability, scapula positioning, proprioception, and improving neuromuscular control in mid ROM. Also, rehabilitation should focus on improving the efficiency and effectiveness of glenohumeral joint force couples through co-contraction exercises, rhythmic stabilization, and neuromuscular control drills. Isotonic strengthening exercises for the rotator cuff, deltoid muscle, and scapular muscles are also emphasized to enhance dynamic stability. Morris et al[29] reported the EMG activity of the rotator cuff and deltoid muscle in MDI and asymptomatic subjects. The authors noted the most significant difference was in the deltoid muscles compared to the rotator cuff muscles in their groups.

Concomitant Pathologies

The fifth factor involves considering other tissues that may have been affected and the premorbid status of the tissue. Disruption of the anterior capsulolabral complex from the glenoid commonly occurs during a traumatic injury resulting in an anterior Bankart lesion. Often osseous lesions may be present such as a concomitant Hill Sach's lesion caused by an impaction of the posterolateral aspect of the humeral head as it compresses against the anterior glenoid rim during relocation. This Hill Sach's lesion has been reported in up to 80% of dislocations.[30-32] Conversely, a reverse Hill Sach's lesion may be present on the anterior aspect of the humeral head due to a posterior dislocation.[33] Occasionally, a bone bruise may be present in individuals who have sustained a shoulder dislocation as well as pathology to the rotator cuff. In rare cases of extreme trauma, the brachial plexus may become involved as well.[34] Other common injuries in the unstable shoulder may involve the superior labrum (SLAP lesion) such as a type V SLAP lesion characterized by a Bankart lesion of the anterior capsule extending into the anterior superior labrum.[35] These concomitant lesions may significantly slow down the rehabilitation program in order to protect the healing tissue.

Neuromuscular Control

The sixth factor to consider is the patient's level of neuromuscular control, particularly at end range. Neuromuscular control may be defined as the efferent, or motor, output in reaction to an afferent, or sensory input.[2,10] The afferent input is the ability to detect the glenohumeral joint position and motion in space with resultant efferent response by the dynamic stabilizers as they blend with the joint capsule to assist in stabilization of the humeral head. Injury with resultant insufficient neuromuscular control could result in deleterious effects to the patient. As a result, the humeral head may not center itself within the glenoid, thereby, compromising the surrounding static stabilizers. The patient with poor neuromuscular control may exhibit excessive humeral head migration with the potential for injury, an inflammatory response, and reflexive inhibition of the dynamic stabilizers.

Several authors have reported that neuromuscular control of the glenohumeral joint may be negatively affected by joint instability. Lephart et al[10] compared the ability to detect passive motion and the ability to reproduce joint positions in patients with normal, unstable, and surgically repaired shoulders. The authors reported a significant decrease in proprioception and kinesthesia in the shoulders with instability when compared to both normal shoulders and shoulders undergoing surgical stabilization procedures. Smith and Brunoli[36] reported a significant decrease in proprioception following a shoulder dislocation. Blasier et al[37] reported that individuals with significant capsular laxity exhibited a decrease in proprioception compared to patients with normal laxity. Zuckerman et al[38] noted that proprioception is affected by the patient's age with older subjects exhibiting diminished proprioception than a comparably younger population. Thus, the patient presenting with traumatic or acquired instability may present with poor neuromuscular control.

Activity Level

The final factor to consider in the non-operative rehabilitation of the unstable shoulder is the arm dominance and the desired activity level of the patient. If the patient frequently performs an overhead motion or sporting activities such as a tennis, volleyball, or a throwing sport, then the rehabilitation program should include sport specific dynamic stabilization exercises, neuromuscular control drills, and plyometric exercises in the overhead position once full, pain free ROM and adequate strength has been achieved. Patients whose functional demands involve below shoulder level activities will follow a progressive exercise program to return full ROM and strength. The success rates of patients returning to overhead sports after a traumatic dislocation of their dominant arm are extremely low.[39] Arm dominance can also significantly influence the successful outcome. The recurrence rates of instabilities vary based on age, activity level, and arm dominance. In athletes involved in collision sports, the recurrence rates have been reported between 86-94%.[6,40-42]

REHABILITATION GUIDELINES

Patients may be classified into two common forms of shoulder instability – traumatic and atraumatic. Specific guidelines to consider in the rehabilitation of each patient population will be outlined. A four-phase rehabilitation program will be discussed for traumatic shoulder instability, followed by an overview of variations and key rehabilitation principles for atraumatic shoulder instability (congenital and acquired laxity).

Traumatic Shoulder Instability

Phase I-Acute Phase

Following a first time traumatic shoulder dislocation or subluxation, the patient often presents in considerable pain, muscle spasm, and an acute inflammatory response. The patient usually self-limits their motion by guarding the injured extremity in an internally rotated and adducted position against the side of their body to protect the injured shoulder. The goals of the acute phase are to 1) diminish pain, inflammation, and muscle guarding 2) promote and protect healing soft tissues, 3) prevent the negative effects of immobilization, 4) re-establish baseline dynamic joint stability, and 5) prevent further damage to glenohumeral joint capsule. *(Appendix 1)*

Immediate limited and controlled motion is allowed following a traumatic dislocation in patients between the ages of 18-28 years but immobilize patients between the ages of 29-54 years old. However, motion is restricted so as to not to cause further tissue attenuation. A short period of immobilization in a sling to control pain and to allow scar tissue to form for enhanced stability may be necessary for 7-14 days although no long-term benefits regarding recurrence rates and immobilization have been made in younger patients between the ages of 18-28 years old.[8,43] Individuals above the age of 28 are usually immobilized for 2-4 weeks to allow scarring of the injured capsule. Potential complications with immobilization may include a decrease in joint proprioception, muscle disuse and atrophy, and a loss of ROM in specific age groups. Therefore, prolonged use of immobilization following a traumatic dislocation may not be recommended in all patients.

The ideal position to immobilize the glenohumeral has traditionally been in internal rotation with the arm close to the body. Recent studies by Itoi et al[44,45] examined positional differences of immobilization and compared the rates of recurrent dislocations. The authors concluded that immobilization in external rotation significantly reduced the recurrence rate of instability in chronic and first-time dislocators. Itoi et al[45] has recommended immobilization with the arm in 30 degrees of abduction and external rotation, compared to a group of patients immobilized in internal rotation. The results indicated a 0% recurrence rate in external rotation and 30% incidence of instability in the group immobilized in internal rotation. The authors stated that the resultant Bankart lesion had improved coaptation to the glenoid rim with immobilization in external rotation versus conventional immobilization in a sling.

Passive ROM is initiated in a restricted and protected range based on the patient's symptoms. The early motion is intended to promote healing, enhance collagen organization, stimulate joint mechanoreceptors, and aid in decreasing the patient's pain through neuromuscular modulation.[14,46-48] Painfree active-assisted ROM exercises such as pendulums and external/internal rotation at 45 degrees of abduction using an L-bar (Breg Corp. Vista, CA) may also be initiated. Passive ROM exercises are also performed in a painfree arc of motion. Modalities such as ice, transcutaneous electrical nerve stimulation (TENS), and high voltage stimulation may also be beneficial to decrease pain, inflammation, and muscle guarding.

Strengthening exercises are initially performed through submaximal, painfree isometric contractions to initiate muscle recruitment and retard muscle atrophy. Electrical stimulation of the posterior cuff musculature may also be incorporated to enhance the muscle fiber recruitment process early on in the rehabilitation process and also in the next phase when the patient initiates isotonic strengthening activities.*(Figure 3)* Reinold et al[49] believe that the use of electrical stimulation may improve force production of the rotator cuff particularly the external rotators immediately after an acute injury.

Dynamic stabilization exercises are also performed to re-establish dynamic joint stability. The patient maintains a static position as the rehabilitation specialist performs manual rhythmic stabilization drills to facilitate muscular co-contractions. These manual rhythmic stabilization drills are performed for the shoulder internal and external rotators in the scapular plane at 30 degrees of abduction and are performed at painfree angles which do not compromise the healing capsule. Rhythmic stabilization for flexion and extension may also be performed with the shoulder at 100 degrees of flexion and 10 degrees of horizontal abduction. Strengthening exercises are also performed for the scapular retractors and depressors to reposition the scapula in its proper position. Scapula strengthening is critical for successful rehabilitation. Closed kinetic chain exercises such as weight shifting on a ball are performed to produce a co-contraction of the surrounding glenohumeral musculature and to facilitate joint mechanoreceptors to enhance proprioception. Weight shifts are usually able to be performed immediately following the injury unless posterior instability is present.

Phase II-Intermediate phase

During the intermediate phase, the program emphasizes regaining full ROM along with progressing strengthening exercises of the rotator cuff, and re-establishing muscular balance of the glenohumeral joint, scapular stabilizers, and surrounding shoulder muscles. Before the patient enters Phase II, certain criteria must be met which include diminished pain and inflammation, satisfactory static stability, and adequate neuromuscular control.

Figure 3
Electrical stimulation to the posterior rotator cuff during exercise activity to improve muscle fiber recruitment and contraction

To achieve the desired goals of this phase, passive ROM is performed to the patient's tolerance with the goal of attaining nearly full ROM. Active-assisted ROM exercises using a rope and pulley along with flexion and external/internal rotation exercises at 90 degrees of abduction using an L-bar may be progressed to tolerance without stressing the involved tissues. External rotation at 90 degrees of abduction is generally limited to 65-70 degrees to avoid overstressing the healing anterior capsuloligamentous structures for approximately 4-8 weeks but eventually increasing ROM to full motion as the patient tolerates.

Isotonic strengthening exercises are also initiated during this phase. Emphasis is placed on increasing the strength of the internal and external rotators and scapular muscles to maximize dynamic stability. The ultimate goal of the strengthening phase is to re-establish muscular balance following the injury. Kibler[1] noted that scapular position and strength deficits have been shown to contribute to glenohumeral joint instability. Exercises initially include external and internal rotation with exercise tubing at 0 degrees of abduction along with sidelying external rotation and prone rowing. During the latter part of this phase, isotonic exercises are progressed to emphasize rotator cuff and scapulothoracic muscle strength. Manual resistive exercises such as sidelying external rotation and prone rowing may also prove beneficial by having the clinician vary the resistance throughout the ROM. Incorporating manual concentric and eccentric manual exercises and rhythmic stabilization drills at end range to enhance neuromuscular control and dynamic stability is also recommended.*(Figure 4)*

Closed kinetic chain exercises are progressed to include a hand on the wall stabilization drills in the plane of the scapular at shoulder height as the patient tolerates. *(Figure 5)* Push-ups are performed first with hands on a table then progressed to a push-up on a ball or unstable surface while the rehabilitation specialist performs rhythmic stabilization to the involved and uninvolved upper extremity along with the trunk to integrate dynamic stability and core strengthening (tilt board, ball, etc.).*(Figure 6)* Caution should be placed while performing closed kinetic chain exercises in patients with posterior instability for 6-8 weeks at allow for adequate healing and strength gains. Furthermore, patients with significant scapular winging should perform push-ups until adequate scapular strength is accomplished. Core stabilization drills should also be performed to enhance scapular control. Additionally, strengthening exercises may be advanced in regards to resistance, repetitions, and sets as the patient improves. End range rhythmic stabilization drills with the arm at 0 degrees of adduction or at 45 degrees of abduction are also performed. Exercises such as tubing with manual resistance and end range rhythmic stabilization drills are also performed.*(Figure 7)* The goal of these exercise drills is to improve proprioception and neuromuscular control at end range.

Phase III- Advanced Strengthening

In the advanced strengthening phase, the focus is on improving strength, dynamic stability, and neuromuscular control near end range through a series of progressive strengthening exercises for a gradual return to the patient's activity. Criteria to enter this phase include: 1) minimal pain and tenderness, 2) full range of motion, 3) symmetrical capsular mobility, 4) good (at least 4/5 manual muscle test) strength, endurance and dynamic stability of the scapulothoracic and upper extremity musculature.

Muscle fatigue has also been associated with a decrease in neuromuscular control. Carpenter et al[50] observed the ability to detect passive motion of shoulders positioned at 90 degrees of abduction and 90 degrees of external rotation. The investigators reported a decrease in both the detection of external and internal rotation movement following an isokinetic fatigue protocol. Therefore, exercises designed to enhance endurance in the upper extremity such as using low resistance and high repetitions (20-30 repetitions per set) are incorporated during this phase. Also, exercise sets utilizing time may be incorporated, such as 30 second or 60 second exercise bouts. These exercises may include tubing external and internal rotation, plyoball wall dribbling, and submaximal manual resistance drills.

Figure 4
Sidelying manual external rotation while the clinician imparts rhythmic stabilization drills at end range

Figure 5
Wall stabilization drills in the plane of the scapula

Aggressive upper body strengthening through the continuation of a progressive isotonic resistance program is recommended. A gradual increase in resistance as well as a progression to a more functional position by performing tubing exercises at 90 degrees of abduction to strengthen the external and internal rotators is also recommended. Additionally, more aggressive isotonic strengthening exercises such as bench press, seated row, and latissimus pulldowns may be incorporated in a protected range of motion during this phase. During bench press and seated rows, the patient is instructed to not extend the upper extremities beyond the plane of the body to minimize stress on the shoulder capsule. Latissimus pulldowns are performed in front of the head and the patient is instructed to avoid full extension of the arms to minimize the amount of traction force applied to the shoulder joint. Also during this phase, the patient continues to perform rhythmic stabilization drills with the rehabilitation specialist and gradually progresses to a position of apprehension utilizing tubing at 90 degrees of abduction with end range rhythmic stabilization drills to enhance dynamic stability.

A patient wishing to return to athletic participation may be instructed to perform plyometric exercises for the upper extremity. These activities are incorporated to regain any remaining functional ROM as well as improving neuromuscular control and to train the extremity to produce and dissipate forces. Initially, 2-handed drills close to the body such as chest pass, side-to-side and overhead soccer throws *(Figure 8)* using a 3-5 pound medicine ball may be performed to enhance dynamic stabilization of the glenohumeral joint. Exercises are initiated with 2-hand drills close to the center of gravity and gradually progressed to longer lever arms away from the patient's body. Drills are progressed to challenge the dynamic stabilizers of the shoulder.

After approximately two weeks of pain free 2-handed drills, the athlete progresses to 1-handed plyometric drills using a small medicine ball (1-2 lbs) and throwing into a plyoback. Plyoball wall dribbles in the 90/90 position *(Figure 9)* to improve overhead muscle endurance may also be incorporated.

Phase IV- Return to Activity Phase

In the return to activity phase, the goal is to increase, gradually and progressively, the functional demands on the shoulder in order for the patient to return to unrestricted, sport or daily activities. Other goals of this phase are to maintain the patient's muscular strength and endurance, dynamic stability and functional range of motion. The criteria to progress into this phase include: 1) full functional ROM, 2) adequate static stability, 3) satisfactory muscular strength and endurance, 4) adequate dynamic stability, and 5) a satisfactory clinical exam.

The general orthopaedic patient continues to perform a maintenance program to improve strength, dynamic stability, and neuromuscular control as well as maintaining full, functional and painfree ROM. The athlete continues to perform aggressive strengthening exercises such as plyometrics, proprioceptive neuromuscular facilitation drills, and isotonic strengthening. In addition, the athlete may begin functional sport activities through an interval return to sport program. These activities are designed to gradually return motion, function, and confidence in the upper extremity by progressing through graduated sport-specific activities.[51-53] These interval sport programs are set up to minimize the chance of re-injury while training the patient for the demands of each individual sport. Each program should be individualized based on the patient's injury, skill level, and goals. The duration of each program is based on several factors including the extent of the injury, the sport and level of play, along with the time of season. The athlete is allowed to return to unrestricted sports activities after completion of an appropriately designed rehabilitation program and a successful clinical exam including full ROM, strength along with adequate dynamic stability and neuromuscular control.

Figure 6
Rhythmic stabilization drills on an unstable surface to further challenge the patient's neuromuscular control.

Figure 7
External rotation with tubing while the therapist applies an external force throughout the ROM

We routinely perform a combination of isokinetic testing for our overhead athletes, which we refer to as the "Thrower's Series."[54,55] Criteria to begin an interval sport program includes an external rotation/internal rotation strength ratio of 66-76% or higher at 180°/second, an external rotation to abduction ratio of 67-75% or higher at 180°/second.[54,55] Patients returning to contact sports such as hockey, football, rugby, etc may be required to wear a shoulder stability brace (Don-Joy) for the initiation of the sport return.*(Figure 10)*

Rehabilitation for Atraumatic Shoulder Instability

Rehabilitation of the patient with congenital shoulder instability poses a significant challenge for the rehabilitation specialist. The patient typically presents with several episodes of instability which limits them from performing certain tasks which may include daily work tasks as well as recreational or sports activities. This type of instability may arise from several factors including excessive redundancy and capsular laxity, poor osseous configuration such as a flattened glenoid fossa, or weakness in the glenohumeral and scapular musculature resulting in poor neuromuscular control. Any of these factors, individually or in combination, may contribute to pathological glenohumeral instability.

The focus of the rehabilitation program for the patient with atraumatic instability is similar to the traumatically unstable shoulder, however, this program involves a slower progression with careful consideration to avoid excessive stretching to the capsular tissue. Furthermore, early goals include improving proprioception, dynamic stability, neuromuscular control, and scapular muscle strengthening to gradually return the patient to functional activities without limitations. As previously mentioned, the early phase of rehabilitation involves reducing shoulder pain and muscular inhibition while abstaining from activities that cause apprehension.

Shoulder muscle activation has been shown to differ in patients with congenital laxity versus in a normal, stable shoulder.[29,56-59] Normal force coupling that exists to dynamically stabilize the glenohumeral joint is altered resulting in excessive humeral head migration and a feeling of subluxation by the patient. Rockwood and Burkhead[39] found that an exercise program was effective in the management of 80% of atraumatic instability. A recent study by Misamore et al[60] found improved results in 49% (28 of 59) of patients in a long term follow up study of atraumatic, athletic patients.

The rehabilitation program *(Appendix 2)* for the patient with atraumatic instability involves regaining full ROM without excessive stress to the involved tissues. The patient often presents with excessive ROM, therefore, passive ROM activities are not the focus of the rehabilitation program. Special attention is placed to avoid excessive stretches to the involved tissues. Modalities such as cryotherapy, phonophoresis, high voltage stimulation, and TENS may be used to minimize pain and inflammation. The reduction of shoulder pain may also be accomplished through gentle motion activities to neuromodulate pain, NSAIDs prescribed by the physician and abstaining from painful arcs of active and passive ROM.

Figure 8
2- handed plyometric throw into a trampoline

Figure 9
Wall dribbles in the 90/90 position

Figure 10
Don Joy brace used during sports activities to prevent excessive shoulder ROM

The focus of the early phase of the rehabilitation program is to minimize any further muscle atrophy and reflexive inhibition resulting from disuse, repeated subluxation episodes, and pain. Isometric contraction exercises may be performed for the glenohumeral muscles particularly the rotator cuff. Rhythmic stabilization drills may also be performed to facilitate a muscular co-contraction/co-activation to improve neuromuscular control and enhance the sensitivity of the afferent mechanoreceptors.[10] *(Figure 11)* The goal is to create a more efficient agonist/antagonist co-contraction to improve force coupling and joint stability during active movements.

The authors of this paper believe that exercises such as rhythmic stabilization drills and closed kinetic chain exercises to promote a co-contraction and an improvement in proprioception are beneficial for this patient population. Axial compression exercises are progressed from standing weight shifts on a table top to then include the quadruped and tripod positions (Note - this position should be avoided if posterior instability is present). Rhythmic stabilization of the involved extremity as well as at the core and trunk may be applied during these closed kinetic chain drills to further challenge the patient's dynamic stability and neuromuscular control. Unstable surfaces such as tilt boards, foam, large exercise balls, and the Biodex stability system (Biodex Corp., Shirley, NY) may be incorporated to further challenge the patient's dynamic stability while in the closed chain position to further promote a co-activation or cocontraction of the surrounding musculature.*(Figure 12)*

Patients with congenital laxity often present with significant rotator cuff and scapular strength deficits, particularly the external rotators, scapular retractors, and scapular depressors. A progressive isotonic strengthening program may be initiated to improve rotator cuff and scapular musculature strength, endurance, and dynamic stability. Proper scapula stability and movement is vital for asymptomatic function. Scapula strengthening will improve proximal stability and therefore enable distal segment mobility for during the patient's functional tasks. These exercises may include external rotation at 0 degrees of abduction, sidelying external rotation, standing external rotation at 90 degrees of abduction, prone external rotation, prone rowing, prone extension and prone horizontal abduction at 100 degrees with external rotation. Other scapular training exercises commonly incorporated include supine serratus punches and a dynamic hug for serratus anterior strengthening. Bilateral external rotation with scapular retraction and table lifts may also be performed to strengthen the lower trapezius. Neuromuscular control drills are performed for the scapular musculature by having the rehabilitation specialist manually resist scapula movements. The goal of these drills is to enhance strength, endurance, and scapula proprioception.

Figure 11
Manual rhythmic stabilization drills to promote a co-contraction and improve dynamic stability

Figure 12
Axial compression drill on an unstable surface while the rehabilitation performs rhythmic stabilizations to the patient's involved shoulder and trunk.

The function of neuromuscular control system must not be overlooked in this patient population. Functional exercise drills that include positions of instability to induce a reflexive muscular response may protect against future injury or recurring episodes of instability. [2,61,62] Active joint repositioning tasks, proprioceptive neuromuscular facilitation (PNF) and plyometric exercises may be beneficial as well to evoke a neuromuscular response.

Once sufficient strength of the scapular stabilizers and posterior cuff has been achieved, the patient is encouraged to use the shoulder only in the most stable positions; those in the plane of the scapular during humeral elevation. Activities that promote a feeling of joint instability with or without subluxation or dislocation should be avoided. Only when coordination and confidence are achieved through progressive strengthening should the patient attempt activities in an intrinsically unstable position. Bracing of the glenohumeral joint for return to sporting activities may also be necessary to provide immobilization or controlled ROM to protect against further injury.

The primary focus of the rehabilitation program for the congenitally unstable shoulder patient is to enhance strength and balance in the rotator cuff, improve scapular position and core stability, along with improved proprioception and neuromuscular control. Once symptoms have subsided and sufficient strength has been achieved, the patient may resume normal shoulder function, which may include sport activities.

CONCLUSION

The glenohumeral joint is an inherently unstable joint that relies on the interaction of the dynamic and static stabilizers to maintain stability. Disruption of this interplay or poor development of any of these factors may result in instability, pain, and a loss of function. Rehabilitation will vary based on the type of instability present and the key principles described. A comprehensive program designed to establish full range of motion, balance capsular mobility, along with maximizing muscular strength, endurance, proprioception, dynamic stability and neuromuscular control is essential. A functional approach to rehabilitation using movement patterns and sport specific positions along with an interval sport program will allow a gradual return to athletics. The focus of the program should minimize the risk of re-injury and ensure that the patient can safely produce and dissipate forces at the glenohumeral joint.

REFERENCES

1. Kibler WB. The role of the scapular in athletic shoulder function. *Am J Sports Med.* 1998;26:325-337.
2. Wilk KE, Arrigo CA, Andrews JR. Current concepts: The stabilizing structures of the glenohumeral joint. *J Orthop Sports Phys Ther.* 1997;25:364-379.
3. Speer KP, Deng X, Borrero S, et al. Biomechanical evaluation of a simulated Bankart lesion. *J Bone Joint Surg.* 1994;76A:1819-1826.
4. Warren RF, Kornblatt IB, Marchand R. Static factors affecting posterior shoulder instability. *Orthop Trans.* 1984;89.
5. Aronen JG, Regan K. Decreasing the incidence of recurrence of first time anterior dislocations with rehabilitation. *Am J Sports Med.* 1984;12:283-291.
6. Henry JH, Genung JA. Natural history of glenohumeral dislocation revisited. *Am J Sports Med.* 1982;10:135-137.
7. Hoelen MA, Burgers AMJ, Rozing PM. Prognosis of primary anterior dislocations in young adults. *Arch Orthop Trauma Surg.* 1990;110:51-54.
8. Hovelius L, et al. Primary Anterior dislocation of the shoulder in young patients: A ten-year prospective study. *J Bone Joint Surg.* 1996;78A:1677-1684.
9. Kazar B, Relouszky E. Prognosis of primary dislocation of the shoulder. *Acta Orthop Scand.* 1969;40:216-219.
10. Lephart SM, Warner JJP, Borsa, PA, Fu FH. Proprioception of the shoulder joint in healthy, unstable, and surgically repaired shoulders. *J Shoulder Elbow Surg.* 1994;3:371-380.
11. McLaughlin HL, MacLellan DI. Recurrent anterior dislocation of the shoulder: A comparative study. *J Trauma.*1967;7:191-201.
12. Rowe CR. Prognosis in dislocations of the shoulder. *J Bone Joint Surg.* 1956;38A:957-977.
13. Simonet WT, Colfield RH. Prognosis in anterior dislocation. *Am J Sports Med.* 11084:12:19-23.
14. Tipton CM, MattesRD, Maynard JA. The influence of physical activity on ligaments and tendons. *Med Sci Sports Exerc.* 1975;7:165-175.
15. Yoneda B, Welsh RP, MacIntosh DL. Conservative treatment of shoulder dislocations in young males. *J Bone Joint Surg.* 1982;64B:254-255.
16. Hovelius L. Anterior dislocation of the shoulder in teen-agers and young adults. Five year prognosis. *J Bone Joint Surg.* 1987;69A:393-399.
17. Hovelius L, Eriksson K, Fredin H, et al. Recurrences after initial dislocation of the shoulder. Results of a prospective study of treatment. *J Bone Joint Surg.* 1983;65:343-349.
18. Postacchini F, Gumini S, Cinotti G. Anterior shoulder dislocation in adolescents. J *Shoulder Elbow Surg.* 2000;9:470-474.
19. Marans HJ, Angel KR, Schmeitsch EH, et al. The fate of traumatic anterior dislocation of the shoulder in children. *J Bone Joint Surg.* 1992;74A:1242-4.
20. Baker CL, Uribe JW, Whitman C. Arthroscopic evaluation of acute initial anterior shoulder dislocations. *Am J Sports Med.* 1990;18:25-28.
21. Richards DP, Burkhart SS. Arthroscopic humeral avulsion of the glenohumeral ligament (HAGL) repair. *Arthroscopy.* 2004;20-Suppl 2:134-141.
22. Spang JT, Karas SG. The HAGL lesion: An arthroscopic technique for repair of humeral avulsion of the glenohumeral ligaments. *Arthroscopy.* 2005;21:498-502.
23. Wolf EM, Cheng JC, Dickson K. Humeral avulsion of glenohumeral ligaments as a cause of anterior shoulder instability. *Arthroscopy.* 1995;11:600-607.
24. Blaiser RB, Burkus K. Management of posterior fracture-dislocations of the shoulder. *Clin Orthop.* 1998;232:197-204.
25. Schwartz E, Warren RF, O'Brien SJ, et al. Posterior shoulder instability. *Orthop Clin North Am.* 1987;18:409-19.
26. Mair SD, Zarzour R, Speer KP. Posterior labral injury in contact athletes. *Am J Sports Med.* 1998;26:753-758.
27. Kaplan LD, Flanigan DC, Norwig J, et al. Prevalence and variance of shoulder injuries in elite collegiate football players. *Am J Sports Med.* 2005;33:1142-1146.
28. Rodeo SA, Suzuki K, Yamauchi M, et al. Analysis of collagen fibers in shoulder capsule in patients with shoulder instability. *Am J Sports Med.* 1998;26:634-643.
29. Morris AD, Kemp GJ, Frostick SP. Shoulder electromyography in multidirectional instability. *J Shoulder Elbow Surg.* 2004;13:24-29.
30. Caspari RB, Geissler WB. Arthroscopic manifestations of shoulder subluxation and dislocation. *Clin Orthop* 1993;291:54-66.
31. O'Brien SJ, Warren RF, Schwartz E. Anterior shoulder instability. *Orthop Clin North Am.* 1987;18:395-408.

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Appendix 1. Traumatic dislocation protocol

NON-OPERATIVE REHABILITATION
TRAUMATIC DISLOCATION OF THE SHOULDER

The program will vary in length for each individual depending on several factors:

- Severity and onset of symptoms
- Degree of instability symptoms
- Direction of instability
- Concomitant pathologies
- Age and activity level of patient
- Arm dominance
- Desired goals and activities

I. PHASE I - ACUTE MOTION PHASE

Goals:
- Protect healing capsular structures
- Re-establish non-painful range of motion
- Decrease pain, inflammation, and muscular spasms
- Retard muscular atrophy / Establish voluntary muscle activity
- Re-establish dynamic stability
- Improve proprioception

Note: During the early rehabilitation program, caution must be applied in placing the capsule under stress until dynamic joint stability is restored. It is important to refrain from activities in extreme ranges of motion early in the rehabilitation process.

Decrease Pain/Inflammation:
- Sling or ER brace for comfort and depending on age of patient (MD preference)
- Therapeutic modalities (ice, TENS, etc.)
- NSAIDs
- Gentle joint mobilizations (grade I-II) for pain neuromodulation
  * Do not stretch injured capsule

Range of Motion Exercises:
- Gentle ROM only, no stretching
- Pendulums
- Rope & Pulley
  - Elevation in scapular plane to tolerance
- Active-assisted ROM L-Bar to tolerance
  - Flexion
  - Internal Rotation with arm in scapular plane at 30 degrees abduction
  - External Rotation with arm in scapular plane at 30 degrees abduction
  - Motion is performed in Non-Painful arc of motion only *

★ DO NOT PUSH INTO ER OR HORIZONTAL ABDUCTION with anterior instability
★ Avoid excessive IR or horizontal adduction with posterior instability

Strengthening/Proprioception Exercises:
Isometrics (performed with arm at side)
- Flexion
- Abduction
- Extension
- Biceps
- Internal Rotation (multi-angles)
- External Rotation (multi-angles)
- Electrical muscle stimulation may be used to ER during isometrics
- Scapular retract/protract elevate/depress (seated manual resist.)

Rhythmic Stabilization
- ER/IR in scapular plane (pain-free multi-angles)
- Flex/Ext in scapular plane(pain-free angles, multi-angles)
- Weight Shifts – standing hands on table (CKC Exercises) – (ant. instability only)
- Proprioception training drills - Active joint reproduction proprioceptive drills (ER,IR,Flex)

II. Phase II - Intermediate Phase

Goals:
- Regain and improve muscular strength
- Normalize arthrokinematics
- Enhance proprioception and kinesthesia
- Enhance dynamic stabilization
- Improve neuromuscular control of shoulder complex

Criteria to Progress to Phase II:
- Nearly full to full passive ROM (ER may be still limited)
- Minimal pain or tenderness
- "Good" MMT of IR, ER, flexion, and abduction
- Baseline proprioception and dynamic stability

Progress range of motion activities at 90 degrees abduction to tolerance (painfree)

Initiate isotonic strengthening

Emphasis on external rotation and scapular strengthening
- ER/IR Tubing
- Scaption raises (full can)
- Abduction to 90 degrees
- Sidelying external rotation to 45 degrees
- Standing ER with tubing with manual resistance
- Hand on ball against wall resistance stabilization
- Prone extension to neutral
- Prone horizontal adduction
- Prone rowing
- Lower and middle trapezius
- Sidelying neuromuscular exercise drills
- Push-ups onto table
- Seated manual scapular resistance
- Biceps curls
- Triceps pushdowns
- Electrical muscle stimulation may be used to ER during exercises

Improve Neuromuscular control of Shoulder Complex
- Initiation of proprioceptive neuromuscular facilitation
- Rhythmic stabilization drills
- ER/IR at 90 degrees abduction (limit degree of ER)

Appendix 1 (cont'd). Traumatic dislocation protocol

- Flexion/Extension/Horizontal at 100 degrees flexion, 10 degrees horizontal abduction
- Progress to mid and end range of motion
- Progress OKC program
- PNF
- Manual resistance ER (supine ‡ sidelying Æ eccentrics), prone row
- ER/IR tubing with stabilization
- Progress CKC exercises with rhythmic stabilizations
- Wall stabilization on ball
- Hand on wall – wall circles for rotator cuff endurance
- Hand on wall – side to side motion for scapular muscles and deltoid
- Static holds in push-up position on ball
- Push-ups on tilt board
- Core
- Abdominal strengthening
- Trunk strengthening / Low back
- Gluteal strengthening

Continue Use of Modalities (as needed)
- Ice, electrotherapy modalities

III. Phase III - ADVANCED Strengthening Phase

Goals:
- Improve strength/power/endurance
- Improve neuromuscular control
- Enhance dynamic stabilizations
- Prepare patient/athlete for activity

Criteria to Progress to Phase III:
- Full non-painful range of motion
- No palpable tenderness
- Continued progression of resistive exercises
- Good – normal muscle strength, dynamic stability, neuromuscular control

Continue use of modalities (as needed)

Continue isotonic strengthening (progress resistance)
- Continue Thrower's Ten
- Progress to end range stabilization drills
- Progress to full ROM strengthening
- Progress to bench press in restricted ROM (restrict horizontal abduction ROM)
- Progress to flat & incline chest press (weighted) restrict motion
- Program to seated rowing and lat pull down (in front) in restricted ROM

Emphasize PNF
Manual D2 with RS at 45, 90, & 145 degrees

Advanced neuromuscular control drills (for athletes)
- Ball flips on table
- ER tubing at 90 deg abduction with manual resistance & RS at end range
- Push-ups on ball/rocker board with rhythmic stabilizations
- Manual scapular neuromuscular control drills
- Initiate perturbation activities (ER with exercise tubing with end range rhythmic stab)

Endurance training
- Timed bouts of exercises – 30-60 seconds
- Increase number of repetitions (sets of 15/20 reps)
- Multiple bouts throughout day (3x)

Initiate plyometric training
- 2-hand drills:
  - Chest pass throw
  - Side to side throw
  - Overhead soccer throw
- Progress to 1-hand drills:
  - 90/90 baseball throws
  - Wall dribbles
  - 90/90 baseball throws against wall

★ Continue to avoid excessive stress on joint capsule

IV. Phase IV - RETURN TO ACTIVITY PHASE

Goals:
- Maintain optimal level of strength/power/endurance
- Progressively increase activity level to prepare patient/athlete for full functional return to activity/sport

Criteria to Progress to Phase IV:
- Full ROM
- No pain or palpable tenderness
- Satisfactory isokinetic test
- Satisfactory clinical exam

Continue all exercises as in Phase III

Progress isotonic strengthening exercises

Resume normal lifting program (Physician will determine)

Initiate interval sport program (as appropriate)

Continue modalities- ice, e-stim, etc. (as needed)

Consider GH joint stabilizing brace for contact sports

FOLLOW-UP
- Isokinetic test (ER/IR & Abd/Add)
- Progress interval program
- Maintenance of exercise program

Appendix 2. Atraumatic Instability protocol

Non-operative Rehabilitation for Atraumatic Instability

This multi-phased program is designed to allow the patient/athlete to return to their previous functional level as quickly and safely as possible. Each phase will vary in length for each individual depending upon the severity of injury, ROM/strength deficits, and the required activity demands of the patient.

PHASE I – ACUTE PHASE

Goals:

- Decrease pain/inflammation
- Re-establish functional range of motion
- Establish voluntary muscular activation
- Re-establish muscular balance
- Improve proprioception
- Decrease Pain/Inflammation
  - Therapeutic modalities (ice, electrotherapy, etc.)
  - NSAIDs
  - Gentle joint mobilizations (Grade 1 and II) for neuromodulation of pain

Range of Motion Exercises

- Gentle ROM exercises – no stretching
- Pendulum exercises
- Rope and pulley
- Elevation to 90 degrees, progressing to 145/150 degrees flexion
- L-Bar
- Flexion to 90 degrees, progressing to full ROM
- Internal rotation with arm in scapular plane at 45 degrees abduction
- External rotation with arm in scapular plane at 45 degrees abduction
- Progressing arm to 90 degrees abduction

Strengthening Exercises

- Isometrics (performed with arm at side)
- Flexion
- Abduction
- Extension
- External rotation at 0 degrees abduction
- Internal rotation at 0 degrees abduction
- Scapular isometrics
- Biceps
- Retraction/protraction
- Elevation/depression
- Weight shifts with arm in scapular plane (closed chain exercises)
- Rhythmic stabilizations (supine position)
- External/internal rotation at 30 degrees abduction
- Flexion/extension at 45 and 90 degrees flexion

★ *Note: It is important to refrain from activities and motion in extreme ranges of motion early in the rehabilitation process in order to minimize stress on joint capsule.*

Proprioception/Kinesthesia

Active joint reposition drills for ER/IR

PHASE II – INTERMEDIATE PHASE

Goals:

- Normalize arthrokinematics of shoulder complex
- Regain and improve muscular strength of glenohumeral and scapular muscle
- Improve neuromuscular control of shoulder complex
- Enhance proprioception and kinesthesia

Criteria to Progress to Phase II:

- Full functional ROM
- Minimal pain or tenderness
- "Good" MMT

Initiate Isotonic Strengthening

- Internal rotation (sidelying dumbbell)
- External rotation (sidelying dumbbell)
- Scaption to 90 degrees
- Abduction to 90 degrees
- Prone horizontal abduction
- Prone rows
- Prone extensions
- Biceps
- Lower trapezius strengthening

Initiate Eccentric (surgical tubing) Exercises at Zero Degrees Abduction

- Internal rotation
- External rotation

Improve Neuromuscular Control of Shoulder Complex

- Rhythmic stabilization drills at inner, mid, and outer ranges of motion (ER/IR, and Flex/Ext)
- Initiate proprioceptive neuromuscular facilitation
- Scapulothoracic musculature
- Glenohumeral musculature
- Open kinetic chain at beginning and mid ranges of motion
- PNF
- Manual resistance
- External rotation
- Begin in supine position progress to sidelying
- Prone rows
- ER/IR tubing with rhythmic stabilization
- Closed kinetic chain
- Wall stabilization drills
  - Initiated in scapular plane
  - Progress to stabilization onto ball
- Weight shifts had on ball

Appendix 2.(cont'd) Atraumatic Instability protocol

- Initiate core stabilization drills
  - Abdominal
  - Erect spine
- Gluteal strengthening

Continue Use of Modalities (as needed)
- Ice, electrotherapy

PHASE III – ADVANCED STRENGTHENING PHASE

Goals:
- Enhance dynamic stabilization
- Improve strength/endurance
- Improve neuromuscular control
- Prepare patient for activity

Criteria to Progress to Phase III:
- Full non-painful ROM
- No pain or tenderness
- Continued progression of resistive exercises
- Good to normal muscle strength

Continue Use of Modalities (as needed)

Continue Isotonic Strengthening (PRE's)
- Fundamental shoulder exercises II

Continue Eccentric Strengthening

Emphasize PNF Exercises (D2 pattern) With Rhythmic Stabilization Hold

Continue to Progress Neuromuscular Control Drills
- Open kinetic chain
- PNF and manual resistance exercises at outer ranges of motion
- Closed kinetic chain
- Push-ups with rhythmic stabilization
- Progress to unsteady surface
- Medicine ball
- Rocker board
- Push-ups with stabilization onto ball
- Wall stabilization drills onto ball

Program Scapular Neuromuscular Control Training
- Sidelying manual drills
- Progress to rhythmic stabilization and movements (quadrant)

Emphasize Endurance Training
- Time bouts of exercise 30-60 sec
- Increase number of reps
- Multiple boots bouts during day

PHASE IV – RETURN TO ACTIVITY PHASE

Goals:
- Maintain level of strength/power/endurance
- Progress activity level to prepare patient/athlete for full functional return to
  activity/sport

Criteria to Progress to Phase IV:
- Full non-painful ROM
- No pain or tenderness
- Satisfactory isokinetic test
- Satisfactory clinical exam

Continue all exercises as in Phase III

Initiate Interval Sport Program (if appropriate)

Patient Education

32. Warner JJ, Flatbow EL. Anatomy and biomechanics. In: Bigliani LU, ed. *The Unstable Shoulder.* Rosemont, IL: American Academy of Orthopaedic Surgeons; 1996.

33. Beltran J, Rosenberg ZS, Chandnani VP, et al. Glenohumeral instability: Evaluation with MR arthrography. *Radiographics* 1997;17:657-673.

34. Goubier JN, Duranthon LD, Vandenbussche E, et al. Anterior dislocation of the shoulder with rotator cuff injury and brachial plexus palsy: a case report. *J Shoulder Elbow Surg.* 2004;13:362-363.

35. Maffet MW, Gartsman GM, Moseley B. Superior labrum-biceps tendon complex lesions of the shoulder. *Am J Sports Med.* 1995;23:93-98.

36. Smith RL, Brunoli J. Shoulder kinesthesia after anterior glenohumeral joint dislocation. *Phys Ther.* 1989;69:106-112.

37. Blasier RB, Carpenter JE, Huston LJ. Shoulder proprioception. Effect of joint laxity, joint position, and direction of motion. *Orthop Rev.* 1994;23:45-50.

38. Zuckerman JD, Gallagher MA, Lehman C, et al. Normal shoulder proprioception and the effect of lidocaine injection. *J Shoulder Elbow Surg.* 1999;8:11-6.

39. Rockwood CA, Burkhead WZ: Treatment of instability of the shoulder with an exercise program. *J Bone Joint Surg.* 1992;74A:890-896.

40. Arciero RA, Wheeler JH, Ryan JB, et al. Arthroscopic Bankart repair versus nonoperative treatment for acute, initial anterior shoulder dislocations. *Am J Sports Med.* 1994;22:589-594.

41. Larrain MV, Botto GJ, Montenegro HJ, et al. Arthroscopic repair of acute traumatic anterior shoulder dislocation in young athletes. *Arthroscopy*. 2001;17:373-377.

42. Wheeler JH, Ryan JB, Arciero RA, et al. Arthroscopic versus nonoperative treatment of acute shoulder dislocations in young athletes. *Arthroscopy*. 1989;5:213-217.

43. Kiviluoto O, Pasila M, Jaromea H, Sundholm A. Immobilization after primary dislocation of the shoulder. *Acta Orthop Scand*. 1980;51:915-919.

44. Itoi E, Sashi R, Minigawa H, et al. Position of immobilization after dislocation of the glenohumeral joint. A study with use of magnetic resonance imaging. *J Bone Joint Surg*. 2002;84A:873-8744.

45. Itoi E, Hatakeyama Y, Kido T. A new method of immobilization after traumatic anterior dislocation of the shoulder: a preliminary study. *J Shoulder Elbow Surg*. 2003;12:413-415.

46. Dehre E, Tory R. Treatment of joint injuries by immediate mobilization based upon the spinal adaption concept. *Clin Orthop*. 1971;77:218-232.

47. Haggmark T, Eriksson E, Jansson E. Muscle fiber type changes in human muscles after injuries and immobilization. *Orthopaedics*. 1986;9:181-189.

48. Salter RB, Hamilton HW, Wedge JH. Clinical application of basic science research on continuous passive motion for disorders of injuries and synovial joints. *J Orthop Res*. 1984:1:325-333.

49. Reinold MM, Wilk KE, Macrina LC, et al. The effect of electrical stimulation of the infraspinatus on shoulder external rotation force production following rotator cuff repair surgery. Presented at American Physical Therapy Association Combined Sections Meeting, February, 2005.

50. Carpenter JE, Blaiser RB, Pellizon GG. The effects of muscle fatigue on shoulder joint position sense. *Am J Sports Med* 1998:26:262-265.

51. Ellenbecker TS, Mattalino AJ. The elbow in sport. Champaign, IL: Human Kinetics 1997;171-177.

52. Reinold MM, Wilk KE, Reed J, et al. Interval sport programs: Guidelines for baseball, tennis and golf. *J Orthop Sports Phys Ther*. 2002;32:293-298.

53. Wilk KE, Reinold MM, Andrews JR. Postoperative treatment principles in the throwing athlete. *Sports Med Arthrosc Rev*. 2001;9:69-95.

54. Wilk KE, Andrews JR, Arrigo CA, et al. The strength characteristics of internal and external rotator muscles in professional baseball pitchers. *Am J Sports Med*. 1993;21:61-66.

55. Wilk KE, Andrews JR, Arrigo CA: The abductor and adductor strength characteristics of professional baseball pitchers. *Am J Sports Med*. 1995;23:307-311.

56. Barden JM, Balyk R, Raso VJ, et al. Atypical shoulder muscle activation in multidirectional instability. *Clin Neurophysiol*. 2005;116:1846-1857.

57. Kronberg M, Brostrom LA, Nemeth G. Differences in shoulder muscle activity between patients with generalized joint laxity and normal controls. *Clin Orthop Relat Res*. 1991;269:181-192.

58. Myers JB, Ju YY, Hwang JH, et al. Reflexive muscle activation alterations in shoulders with anterior glenohumeral instability. *Am J Sports Med*. 2004;32:1013-1021.

59. von Eisenhart-rothe R, Jager A, Enlmeier KH, et al. Relevance of arm position and muscle activity on three-dimensional glenohumeral translation in patients with traumatic and atraumatic shoulder instability. *Am J Sports Med*. 2002;30:514 - 522.

60. Misamore GW, Sallay PI, Didelot W. A longitudinal study of patients with multidirectional instability of the shoulder with seven- to ten-year follow-up. *J Shoulder Elbow Surg*. 2005;14:466-470.

61. Wilk KE, Arrigo CA. Current concepts in the rehabilitation of the athletic shoulder. *J Orthop Sports Phys Ther*. 1993;18:365-378.

62. Wilk KE, Voight ML, Keirns MA, et al. Stretch-shortening drills for the upper extremities: Theory and clinical application. *J Orthop Sports Phys Ther*. 1993;17:225-239.

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CASE REPORT

RETURNING TO SPORTS AFTER PERIACETABULAR OSTEOTOMY FOR DEVELOPMENTAL DYSPLASIA OF THE HIP

Steven R. Tippett PT, PhD, SCS, ATC[a]

ABSTRACT

Background: A periacetabular osteotomy,indicated for adults or adolescents requiring correction of congruency and containment of the femoral head, is a common surgical procedure to address developmental dysplasia of the hip.

Objectives: To describe developmental hip dysplasia, a surgical procedure performed to address the condition, as well as therapeutic exercise and functional progression principles utilized to return a patient to tennis following periacetabular osteotomy.

Case Description: The patient was a 14 year-old female who underwent a Ganz periacetabular osteotomy of the right pelvis due to developmental dysplasia of the hip. Post-operative outpatient physical therapy consisted of strengthening of the hip, thigh, and core musculature, as well as activities to increase muscular and cardiovascular endurance, anaerobic conditioning, lower extremity proprioception, and soft tissue length. A functional progression program to return to tennis was also provided.

Outcomes: The patient was seen in outpatient physical therapy for a total of 34 visits over the course of 42 weeks. Results of a Lower Extremity Functional Scale (LEFS) indicated that heavy activities of daily living, as well as recreational and sporting activities, were improved following the post-operative rehabilitation program.

Discussion: The role of the physical therapist is vital in prescribing and progressing activity levels to facilitate return of function following this periacetabular osteotomy. Surgery that is technically well performed followed by a comprehensive rehabilitation program can allow for resumption of pre-morbid activities, enhancement of the quality of life, and return to sports activities.

Key Words: functional progression, tennis, congenital hip dysplasia.

INTRODUCTION

Hip problems in the developing youngster can be congenital or acquired and are frequently encountered by the physical therapist. Sports physical therapists may be comfortable in dealing with acquired hip conditions in active youth, but not as familiar with treating congenital hip dysfunction. On the other hand, pediatric physical therapists may be at ease addressing congenital hip issues but not as well versed in caring for acquired macro or microtrauma of the hip in active, normally developing youngsters. The generalist physical therapist may be somewhere in between these two extremes. The purpose of this case report is to describe developmental hip dysplasia, a surgical procedure performed to address this condition, as well as therapeutic exercise and functional progression principles utilized to return a patient to tennis following periacetabular osteotomy.

Developmental Dysplasia of the Hip

Conditions involving the hip joint in the skeletally immature youngster range from joint dysplasia to joint subluxation and dislocation. Traditionally, all of these conditions have been collectively referred to as congenital dysplasia of the hip; however, the term developmental dysplasia of the hip (DDH) has become more acceptable.[1] Developmental dysplasia of the hip more accurately describes situations when hip problems that may not be noticed at birth, become apparent as a child matures and begins to bear weight in a standing position.

The epidemiology, etiology, examination and treatment of DDH are well documented.[1-4] In addition to the clinical physical examination, standard anterior-posterior plain film radiographs of the

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pelvis are helpful in the diagnosis of DDH. Abnormal findings on plain film radiographs suggestive of DDH include the delayed appearance of ossification centers of the hip and pelvis beyond six months, as well as an abnormal relationship between the developing femoral neck and pelvis. As the youngster matures, in addition to the traditional anterior-posterior view of the pelvis, a weight bearing view with the pelvis rotated 25° toward the x-ray beam (faux profile view) may also be helpful in quantifying the relationship between the developing femoral head and the acetabulum.[3,5-9]

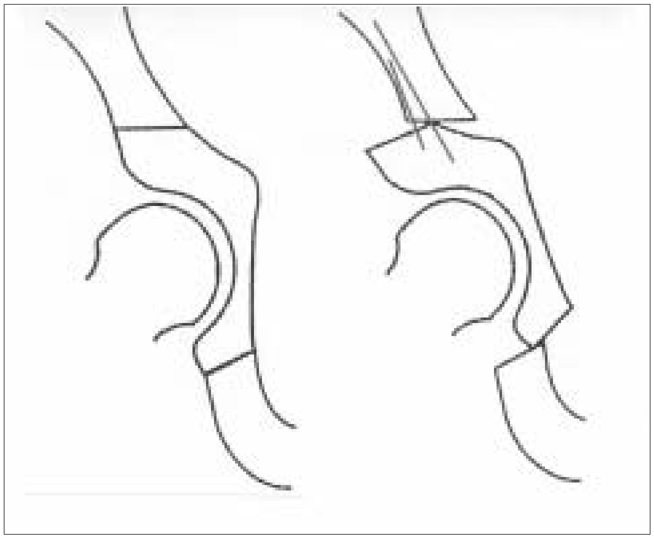

Figure 1
Two-dimensional view of acetabular re-positioning before (A) and after (B) Ganz osteotomy. Note: the roof of the acetabulum has moved more horizontally to cover the femoral head.

Surgical Intervention for DDH
Many individuals with DDH develop through childhood and adolescence without symptoms. Hip pain when present is typically due to high stresses on the acetabular rim resulting in articular cartilage damage with subsequent increased stresses on underlying subchondral bone. When infants with DDH are not diagnosed until late, or when previous treatment attempts in diagnosed infants are not successful, surgical intervention is indicated. Untreated acetabular dysplasia is the second most common cause of secondary osteoarthrosis with degenerative joint disease from pathological joint-loading forces becoming symptomatic before the age of 50 in 25% to 50% of patients with DDH.[10] Surgical options entail capsulorrhaphy, femoral derotation and varisation osteotomy, periacetabular osteotomy, or shelf arthroplasty, of the pelvis. The primary goal of the various procedures is to provide coverage of the developing femoral head.[11-18]

The Ganz triple osteotomy, also known as the Bernese osteotomy, is a common surgical procedure to address DDH. The Ganz procedure provides for the large bony corrections required to cover the femoral head in all needed directions including lateral rotation, anterior rotation, and medialization of the hip center.[13] Ganz first performed his periacetabular osteotomy in 1983.[16] The Ganz osteotomy is indicated in adults or adolescents with closed physes who have dysplastic hips requiring correction of congruency and containment of the femoral head. In most cases, the opening of the acetabulum lies in excessive anteversion from the sagittal plane.

The purpose of the Ganz procedure is to reorient the position of the acetabulum anteriorly and laterally to gain greater coverage of the femoral head and bring the roof of the acetabulum from an oblique position to a more horizontal position through a series of cuts in the innominate bones *(Figure 1)*. Advantages of this periacetabaular osteotomy include using only one approach, the potential for significant correction in all directions (including medial and lateral planes), the posterior column of the hemipelvis remains mechanically intact which allows immediate crutch walking with minimal internal fixation, the shape of the true pelvis is unaltered permitting a normal child delivery later in life, and retaining the hip's center of rotation. Complications of the Ganz procedure include interarticular extension of the osteotomy, temporary femoral nerve palsy, insufficient or excessive overcorrection, secondary subluxation of the femoral head, osteonecrosis, nonunion, heterotopic ossification, vascular compromise or loss of fixation.[6,15,18]

CASE DESCRIPTION
History
At the time of the initial physical therapy visit the patient was 15 years old, 68 inches tall, and weighed 129 pounds. The patient was an incoming freshman at a local high school and had previously been involved in recreational and competitive tennis, participating in both singles and doubles.

At the age of five months, the patient was diagnosed with bilateral DDH with no occurrence of hip dislocation. Initial treatment for the DDH was via a hip spica cast which was removed at one year of age. Due to complaints of persistently painful clicking in the right hip during childhood the patient underwent a surgical release of the psoas at age ten. The patient was followed by her family physician and local orthopedists but her condition worsened. She was subsequently referred to a regional orthopaedic specialist due to complaints of constant lateral hip pain. Upon reviewing her condition and past history, the surgeon recommended and performed a Ganz periacetabular osteotomy for the right hip. *Figures 2 and 3* demonstrate pre- and post-operative radiographs.

Post-Operative Intervention

The patient had an uneventful hospital stay and after five days was discharged partial weight bearing (PWB) with axillary crutches and a home exercise program of active hip range of motion and gentle isometric hamstring and quadriceps muscle sets. Serial radiographs taken between surgery and the initial physical therapy visit demonstrated normal post-operative findings.

Post-Operative - Week Four Four weeks following the osteotomy the surgeon referred the patient for outpatient physical therapy for three visits per week for six weeks. Physician orders were to advance weight bearing up to 40 pounds on the involved right lower extremity, strengthening, and range of motion work.

At the initial physical therapy visit, the patient had subjective complaints of minimal hip pain at rest and did note numbness in the thigh. The patient was ambulating PWB with an appropriate gait pattern using axillary crutches. In the sitting position she lacked full knee extension by five degrees due to quadriceps weakness. During the exam, the patient could not transfer from sitting to a supine position on the treatment table without manually assisting the involved leg. Observation of the patient in the supine position revealed quadriceps atrophy and an inability to initiate a straight leg raise. The patient was also unable to initiate gravity resisted abduction in the side-lying position. In the standing position hip abduction was with immediate substitution palpated in the quadratus lumborum. Active range of motion of the hips was measured and these values are found in *Table 1*. In addition, the patient filled out the Lower Extremity Functional Scale. This scale and the results are reported in the Outcomes Section of this case study.

Figure 2
Pre-operative anterior-posterior view (Faux profile) of pelvis and hips demonstrating an increased acetabular index (angle formed by a horizontal line drawn through the inferior part of the ilia and a line drawn across the acetabular roof).

Figure 3
Post-operative oblique x-ray (Faux profile) of the pelvis and hip demonstrating adequate coverage of the femoral head.

Treatment in the outpatient clinic included hip flexor strengthening, open kinetic chain and closed kinetic chain quadriceps strengthening, and functional electrical stimulation for the quadriceps. Open kinetic chain quadriceps work was performed at terminal extension to address her extension lag. Closed kinetic chain strengthening was performed on the Shuttle (Contemporary Design Company, Glacier, WA). The Shuttle is a horizontal sliding carriage that allows the patient to perform perform closed chain activities in a gravity eliminated position. Added resistance from 25 to 200 pounds can be applied to the Shuttle by a series of elastic cords. Added resistance to strengthening activities on the Shuttle for the current patient did not exceed 50 pounds. Efforts to strengthen the gluteus medius were increased with manual resistance and resisted isotonic exercise in the supine position.

Post- Operative - Week Eight After four weeks of rehabilitation (eight weeks after surgery), the patient returned to the physician. At that time the patient's active standing hip flexion had increased to 90°. Hip extensor strength had increased and the patient was able to perform single leg bridging activities. Quadriceps atrophy persisted (one and one-quarter inch difference eight inches proximal to the knee joint line). However, the patient could actively extend the knee completely, and open chain terminal knee extensions were up to seven pounds of resistance. The patient could inconsistently initiate a straight leg raise but did so with a knee extension lag of greater than 30°. Gait was still PWB with axillary crutches.

After the visit to the surgeon, orders were received to continue outpatient treatment twice a week for six weeks with an emphasis on strengthening (especially with hip extension and abduction) and to increase weight bearing to 60 pounds. Crutch use was to be discontinued before the next scheduled visit with the surgeon in approximately twelve weeks.

TABLE 1. Active range of motion (in degrees) at initial evaluation

Motion	Uninvolved Left Hip	Involved Right Hip
Supine abduction	0-46	0-11
Supine adduction	0-20	0
Seated external rotation	0-26	0-4
Seated internal rotation	0-48	0-12
Supine flexion	0-111	0-55
Standing flexion	0-115	0-40
Prone extension	0-28	0-15

Rehabilitation now focused on longer lever arm strengthening of the hip musculature with assisted and substitution free straight leg raises (SLR) and gravity resisted gluteus medius strengthening. Hip flexor stretching was initiated. Core strengthening of the abdominals and paravertebral muscles consisting of crunches, assisted leg lowering, diagonal crunches, and prone body weight resisted extension were instituted and progressed. Lower extremity strengthening and gait activities were begun in waist deep water.

The patient was instructed to progress to full weight bearing (FWB) ambulation with crutches at nine weeks following surgery. The patient admitted she was non-compliant with appropriate weight bearing status and had started to ambulate occasionally at home without crutches. During this time, the patient went on a family vacation and did some swimming and more walking than she had done since surgery. At this time the patient noted an inconsistent non-painful popping in the anterior hip, especially after prolonged weight bearing. It was also during this time that the patient noted increased pain at rest and an inability to lie comfortably on the affected side. The patient denied night pain. Decreased weight bearing restrictions were implemented and enforcement of consistent use of crutches. Strengthening efforts in the clinic and at home were de-emphasized. With these restrictions in activity and consistent use of the crutches, the pain at rest was eliminated. No imaging was performed at this time.

During the course of the next two weeks the patient was able to ambulate FWB with two crutches and was gradually weaned from the crutches to begin full weight bearing gait without an assistive device. The patient demonstrated a slight gluteus maximus lurch with slight trunk extension at heel strike. Gait training along with weight bearing strengthening and balance were instituted. Aerobic and anaerobic conditioning efforts were instituted on the recumbent bike.

Post-Operative - Week Eighteen

At the time of the surgeon's follow-up visit three and a half months post-operatively, despite the increased quadriceps strength, the patient still could not consistently initiate a SLR. No extension lag was present with the eccentric SLR from 90° to 60°, but a lag of five degrees was present from 60° to 0°. The surgeon suggested another month of strengthening prior to allowing a return to tennis and scheduled the patient for a return visit in three months. Clinic visits focused on core and lower extremity strengthening, early functional progression activities, and progressing the functional progression program. *Table 2* summarizes the rehabilitation program.

Functional Progression

Functional progression is a series of sport-specific, basic movement patterns graduated according to difficulty of the skill and the athlete's tolerance.[19] The end goal of functional progression is an athlete's timely and safe return to competition. From post-operative week 24 to week 42, the patient was progressed along a continuum of increasingly more difficult activities culminating in her playing tennis.

At week 24, lower extremity efforts began with bilateral non-support activities, jumping side-to-side and front-to-back. Transition to unilateral non-support activities (hopping) was initially performed at a single point until the contralateral hip did not drop indicating adequate dynamic gluteus medius muscle strength. Jumping was followed by alternating single leg hopping on the involved extremity and uninvolved extremity upon command and in place. Again, once this activity was performed without substitution, progression was allowed to hopping side-to-side and front-to-back

Since no healing time concerns existed for the patient's upper extremities, upper extremity tennis drills (forehand and backhand ground, over head returns, serves) could be progressed quickly. Effective power generation for all of these upper extremity movements, however, require force generation and force coupling from the lower extremities and the trunk. The patient was right hand dominant, so forehand ground strokes involving a neutral pelvis transitioning to hip extension and internal rotation were instituted. Backhand ground strokes involving more hip internal rotation followed by right trunk rotation over the fixed pelvis followed. Both of these strokes began with gentle volleys from mid court and were progressed to the baseline. Overhand returns and serves to incorporate more hip extension were also stressed. Emphasis was placed on a neutral spine while minimizing excessive trunk flexion due to concerns of gluteus maximus weakness and fatigue.

From post-operative weeks 26 to 32, figure-of-eights were progressed from full court to half court beginning with a jog and progressing to full speed. Acceleration and deceleration activities in the half court forwards, backwards, and side shuffling were then stressed from weeks 32 to 40 *(Figure 4)*. Once the patient progressed through the acceleration and deceleration drills, she was then instructed to incorporate either a forehand or backhand stroke into the dynamic drills. After the patient was fluid in the acceleration/deceleration activities with twisting strokes, she began to play teammates, first doubles and then singles. When the coach and athlete were comfortable with her level of performance, the patient was allowed to compete. The functional progression program is summarized in *Table 3*.

Table 2: Rehabilitation Summary

Immediate Post-Op **Post-Op: Week 4-8**	**Pre-Full Weight Bearing** **Post-Op: Week 8-12**	**Post-Full Weight Bearing** **Post-Op: Week 12**
Strengthening • Gluteus maximus isometrics • Quadriceps isometrics • Supine bilateral hip bridging • Standing hip abduction **Range of Motion** • Heel slides **Gait** • PWB with crutches	**Strengthening** • Functional SLR's • Open chain terminal terminal knee extension • Shuttle closed chain bilateral support • Abdominals • Gravity resisted hip adduction • Standing hip abductor • Standing hip flexion • Unilateral bridging • Bilateral bridging with hip adduction **Gait** • Progress to FWB **Aquatics** • Pre-gait activities • Hip strengthening **Conditioning** • Aerobic recumbent bike • Anaerobic recumbent bike	**Strengthening** • Closed chain unilateral support • Abdominals • Paravertebrals • Gravity assisted abduction • Gravity assisted extension • Gravity resisted rotation **Gait** • Correction of gluteus maximus gait **Functional Progression**

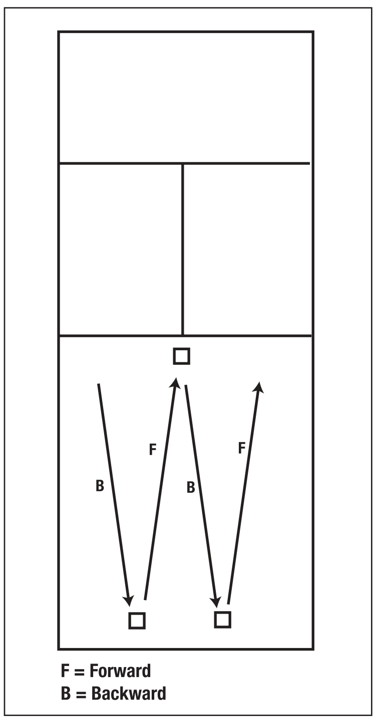

Figure 4
Forward and backward acceleration/deceleration drills on the tennis court. Diagonal sprinting to the net and backpedaling to the backcourt.

OUTCOME

Forty-two weeks transpired from the time of surgery to completion of the functional progression and a return to tennis competition. During this time the patient was seen a total of 34 physical therapy visits. At the time of discharge the patient was performing at a level that allowed her to play number two doubles on her high school tennis team. The patient was also participating in singles tennis at a level the coach rated subjectively superior to before the surgery.

Prior to surgery and at the end of the physical therapy intervention, the patient completed the Lower Extremity Functional Scale (LEFS).[20] The LEFS is used to qualitatively assess individual's functional status during 20 specific functional tasks on a scale from 0 (unable to perform actively) to 4 (no difficulty). The maximum score of the assessment test is 80. Binkley et al[20] have reported the LEFS to be reliable, valid, and sensitive to change.

The LEFS was administered to the patient to document perceived function prior to surgery with a resultant score of 63% (50 out of 80 points). The LEFS was also administered to the patient to document perceived function at the termination of post-operative rehabilitation with a resultant score of 83% (66 out of 80 points) *(See Table 4)*.

All parameters of the LEFS to assess simple activities of daily living did not present

Table 3: Function Progression Summary

Activity	Dosage	Onset
Bilateral non-support		
Single plane front-to-back	3 sets – 2 minutes	Week 24
Single plane side-to-side	3 sets – 2 minutes	
Serving		
Baseline ground strokes		
Unilateral non-support		
Stationary	3 sets – 1 minute	Week 25
Stationary alternating legs	3 sets – 1 minute	
Single plane front-to-back	3 sets – 1 minute	
Single plane side-to-side	3 sets – 1 minute	
Serving		
Baseline ground strokes		
Figure-eights		
Full court jog	10 repetitions	Week 26
Full court half-sprint	10 repetitions	Week 27
Full court sprint	10 repetitions	Week 28
Half court jog	10 repetitions	Week 29
Half court half-sprint	10 repetitions	Week 30
Half court sprint	10 repetitions	Week 31
Light volleys		
Acceleration/deceleration (sagittal)		
Jog, no racquet	10 repetitions	Week 32
Half-sprint, no racquet	10 repetitions	Week 34
Full sprint, no racquet	10 repetitions	Week 36
Jog, racquet, swing	10 repetitions	Week 38
Half-sprint, racquet, swing	10 repetitions	Week 39
Full sprint, racquet, swing	10 repetitions	Week 40
Volleys		
Acceleration/deceleration (lateral)		
As above	10 repetitions	Week 40
Doubles tennis		Week 40
Singles tennis		Week 42

problems for the patient prior to surgery or following rehabilitation after surgery. Heavy activities around the house presented moderate difficulty prior to surgery and following the post-operative course these activities no longer presented any difficulty. Prolonged activities such as walking two blocks and standing for an hour, negotiating stairs, and sitting for an hour presented only a little bit of difficulty after post-operative rehabilitation. At a more strenuous level, walking a mile, recreational activities, sporting events, and squatting also caused the patient a little bit of difficulty following post-operative rehabilitation. Running on even and uneven ground, along with making sharp turns while running still presented moderate difficulty after post-operative rehabilitation.

DISCUSSION

The rehabilitation of the patient after periacetabular osteotomy for DDH is much like that of a stable fracture following open reduction and internal fixation with similar healing time constraints and weight bearing restrictions. Range of motion in this case returned quickly as there were no significant intra-articular concerns of the hip joint. Specific strengthening of the affected hip musculature along with strengthening of the core for proximal stability was paramount. Restricted weight bearing until bony healing had occurred can limit closed kinetic chain strengthening. However, weight bearing strengthening activities on a device like the Shuttle provides safe and functional loading. Since core strength is vital in the translation of lower extremity power to the upper body and shoulder, core strengthening can and should commence early. Cardiovascular endurance activities also must progress according to weight bearing restrictions.

Long lever arm function of the hip is limited in activities of daily living and in many sports including tennis. It is vital, however, to assure that function of the rectus femoris, a primary muscle responsible for long lever arm function is recovered. Isolated function and control of the rectus femoris was delayed after the periacetabular oteotomy. In this patient, potential contributing factors to the temporary rectus femoris weakness may be due to involvement of the femoral nerve and a change of the length tension relationship from detachment and re-attachment of the muscle during surgery. Although the patient did demonstrate transient sensory changes following surgery, transient motor involvement cannot be ruled out.

Transient gait deviations, specifically a slight gluteus maximus lurch at heel strike, was also a concern. It is difficult to ascertain how much of this problem with gait was due to the patient's gait prior to surgery. Even though gluteal strength gains occurred quickly and gains were subsequently sufficient enough to approximate the contralateral side, slight deviations occurred and were more pronounced at faster gait speeds. Walking backwards (retro-walking) in the clinic with and without external resistance from rubber cords and retro-walking in the pool were helpful in correcting gait deviations.

Exercise dosage and activity modification can be difficult to prescribe. In a young and otherwise healthy individual, the tendency is for the patient to be overzealous. As the patient began to move about better, she did not feel the

TABLE 4. Lower Extremity Function Scale (LEFS) before surgery and at the completion of physical therapy

	Extreme Difficulty or Unable to Perform		Quite a Bit of Difficulty		Moderate Difficulty		A Little Bit of Difficulty		No Difficulty	
Activities	**0 Points**		**1 Point**		**2 Points**		**3 Points**		**4 Points**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Usual work, housework or school activities									▲	★
Usual hobbies, recreational, sporting activities			▲					★		
Getting into or out of bath									▲	★
Walking between rooms									▲	★
Putting on shoes or socks									▲	★
Squatting							▲	★		
Lifting objects from the floor									▲	★
Light activities around the house									▲	★
Heavy activities around the house					▲					★
Getting in or out of the car									▲	★
Walking two blocks					▲			★		
Walking a mile			▲					★		
Ascending/descending a flight of stairs					▲			★		
Standing for an hour			▲					★		
Sitting for an hour					▲			★		
Running on even ground			▲			★				
Running on uneven ground			▲			★				
Making sharp turns while running fast			▲			★				
Hopping			▲					★		
Rolling over in bed									▲	★

▲ Score prior to surgery

★ Score at physical therapy discharge

need to utilize crutches as instructed. This increased weight bearing with concomitant advancement of a therapeutic exercise regime may result in excessive stress on the healing tissue. This was the case in managing this patient. Muscle discomfort immediately following workouts were common and to be expected. As the patient was allowed to do more in one area (weight bearing, exercise) another area was de-emphasized. When the patient became more aggressive in performing the prescribed exercises, when she increased her overall level of activity and disregarded the consistent use of crutches, she became symptomatic at rest. Symptoms at rest are when activities needed to be significantly restricted to allow the healing areas to accommodate to the added stress.

CONCLUSION

This case study describes the rehabilitation program employed following periacetabular osteotomy in a 14 year-old female tennis player. The role of the physical therapist is vital in prescribing and progressing activity levels to facilitate return of function following this surgical procedure. Goals of the periacetabular osteotomy were to allow resumption of pre-morbid activities and enhance the patient's quality of life and prevent early osteoarthtic changes in the hip. Surgery that is technically well performed followed by a comprehensive rehabilitation program allowed for a return to sports activities following periacetabular osteotomy.

REFERENCES

1. Salter RB. Textbook of Disorders and Injuries of the Musculoskeletal System. 3rd Edition. Philadelphia: Lippincott, Williams & Wilkins; 1999.
2. Leach J. Orthopedic Conditions. In: Campbell SK, ed. Physical Therapy for Children. Philadelphia: W.B. Saunders Company; 2000:398-428.
3. Greenspan A. Orthopedic Radiology: A Practical Approach 3rd Edition. Philadelphia: Lippincott, Williams & Wilkins; 2000.
4. Weinstein SL, Mubarak SJ, Wenger DR. Developmental hip dysplasia and dislocation: Part One. *J Bone Joint Surg*. 2003;85A:1824-1832.
5. Garbuz DS, Masri BA, Haddad F, Duncan CP. Clinical and radiographic assessment of the young adult with symptomatic hip dysplasia. *Clin Orthop*. 2004; 418:18-22.
6. Gillingham BL, Sanchez AA, Wenger DR. Pelvic osteotomies for the treatment of hip dysplasia in children and young adults. *J Am Acad Orthop Surg*. 1999;7:325-337.
7. McKinnis LN. Fundamentals of Orthopedic Radiology. Philadelphia: FA Davis Company; 1997:240.
8. Troum OM, Crues JV. The young adult with hip pain: Diagnosis and medical treatment circa 2004. *Clin Orthop*. 2004;418:9-17.
9. Magee DJ. Orthopedic Physical Assessment. 4th Ed. Philadelphia: Saunders; 2002:626.
10. Leunig M, Podeszwa D, Beck M, Werlan S, and Ganz R. Magnetic resonance arthrograpy of labral dysplasia and impingement. *Clin Orthop*. 2004;418:74-80.
11. Leunig M, Siebenrock KA, Ganz R. Rationale of periacetabular osteotomy and background work. *Instructional Course Lectures, American Academy of Orthopaedic Surgeons*; 2001:229-238.
12. Salter RB. Innominate osteotomy in the treatment of congenital dislocation of the hip. *J Bone Joint Surg*. 1961;43-B:518-539.
13. Sutherland HD, Greenfield R. Double innominate osteotomy. *J Bone Joint Surg*. 1977;59-A:1082-1091.
14. Trousdale RT. Acetabular osteotomy: Indications and results. *Clin Orthop*. 2004;429:182-187.
15. Canale ST, ed. Campbell's Operative Orthopaedics. Tenth Edition. Philadelphia: Mosby; 2003:939-942.
16. Ganz R, Klaue K, Vinh TS, Mast JW. A new periacetabular osteotomy for the treatment of hip dysplasias: Technique and preliminary results. *Clin Orthop*. 1988; 232:357-369.
17. Lazennec JY, Valladares NM, Laudet CG, et al. Anatomical bases of a new technique of juxta-acetabluar osteotomy: technical principles and performance. *Surg Radiol Anat*. 1998;20:153-159.
18. Hussell JG, Mast JW, Mayo KA, et al. A comparison of different surgical approaches for the periacetabular osteotomy. *Clin Orthop*. 1999;363:64-72.
19. Tippett SR, Voight ML. Functional Progressions for Sport Rehabilitation. Champaign, IL: Human Kinetics: 1995.
20. Binkley JM, Stratford PW, Lott SA, Riddle DL. The lower extremity functional scale (LEFS): Scale development, measurement, properties, and clinical application. *Phys Ther*. 1999;79:371-383.

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