A Review of Shoulder Impingement Syndrome

JoDee Backhaus

University of North Dakota

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A REVIEW OF SHOULDER IMPINGEMENT SYNDROME

by

JoDee Backhaus
Bachelor of Science in Physical Therapy
University of North Dakota, 1995

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
May
1996
This Independent Study, submitted by JoDee Backhaus in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Signatures)

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title A Review of Shoulder Impingement Syndrome

Department Physical Therapy

Degree Master of Physical Therapy

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Shoulder impingement syndrome (IS) is one of the most common shoulder problems seen today in the orthopaedic clinical setting. Patients exhibit symptoms of pain and discomfort due to pathomechanics of increasing pressure under the acromion. Factors related to IS include degeneration of the rotator cuff, vascular insufficiency of the supraspinatus, glenohumeral instability, muscle imbalances, bursitis, and bony impingement.

Impingement syndrome is most often classified as an overuse syndrome, although it can occur from a traumatic episode such as a blow to the shoulder or a fall. The population most affected are those in occupations that require a high number of repetitive movements of the shoulder and also athletes who perform overhead activities for an extended period of time.

Because of the many possible causes of shoulder impingement, it is important for physical therapists to know the anatomy of structures involved in the shoulder complex and the contribution of those structures to the biomechanics of upper extremity movement.

This paper focuses on the common causes of impingement syndrome and the presentation of signs and symptoms. A shoulder rehabilitation program for the general population as well as the athletic population will also be described.
CHAPTER 1

INTRODUCTION TO IMPINGEMENT SYNDROME

Impingement syndrome (IS) is a common cause of chronic shoulder pain and disability that has increasingly become a focus of attention within the past few decades.\(^1,2\) The term "impingement syndrome" is widely used to describe the pathomechanics of increasing pressure under the acromion.

Most impingement problems can be considered a type of overuse syndrome; the progression is commonly slow and persistent.\(^3\) A traumatic episode, such as a fall, can be a contributing factor. However, a more common onset of IS is from repetitive use of the arm above the horizontal plane over a prolonged period of time, such as in swimming, tennis, and baseball pitching.\(^4\)

Shoulder disability of this type is not limited to athletes. The general population may be prone to IS depending on their daily physical movements. Occupations susceptible to impingement include nursing, carpentry, millwork, painting, fruit picking, tree pruning,\(^5\) and any other job that requires a lot of overhead or repetitive movements. Activities of daily living, including dressing, washing, combing and curling hair, or putting groceries and dishes away, may also initiate or aggravate the symptoms of IS.
General symptoms of IS include:  

1) pain, located in the superolateral aspect of the shoulder in the area just lateral and anterior to the acromion process and 2) a snapping feeling or catching sensation may occur if the arm is moved from an externally rotated to an internally rotated position when the arm is abducted between 70° and 120°.

DePalma noted the most frequent age of onset of IS is 50 to 59, but it can occur at almost any age. Through his research, DePalma concludes that men are affected more than women with a ratio of 3:2, and the right shoulder is involved two times as often as the left.

Impingement syndrome varies in presentation related to the structure involved and the severity of the involvement. Present in all variations of impingement is the basic problem of inadequate space for the subacromial bursa and rotator cuff in the subacromial space. Loss of space can result from bony encroachment into the subacromial space or from an increase in the size of the structures within the joint space or a combination of both.

Conditions that contribute to IS are many. They include rotator cuff weakness, glenohumeral instability, tightness of the posterior glenohumeral capsule, imbalance of the internal and external rotator musculature of the shoulder, vascular insufficiency of the supraspinatus, and postural malalignment. The coracoacromial ligament, acromion, coracoid, biceps tendon, and subacromial bursa can all be involved to varying degrees.
Neer has brought much order and insight to the problem of IS.\textsuperscript{9-11} He has demonstrated the potentially progressive nature of IS, with the end point being bony change and tear of the rotator cuff. Neer has developed a classification system of impingement syndrome.\textsuperscript{9,10} Stage 1 is the least severe. It involves edema, hemorrhage, and inflammation and is reversible with conservative treatment. The patient population commonly seen in this category is athletes under age 25. Symptoms in stage 1 include 1) a painful arc between 60° and 120° of elevation, 2) positive Neer's impingement sign which is pain with overpressure into abduction, 3) positive Hawkin's impingement sign: pain elicited with 90° forward flexion and overpressure to internal rotation, and 4) pain with resisted supraspinatus testing.

Most patients in stage 2 are 25 to 40 years of age. There are fixed fibrotic changes along with tendinitis. This stage is a progression of stage 1 and includes the symptoms of the first stage, but may also include pain at night, pain limiting activity, crepitus, and a catching sensation at approximately 100° of abduction. In this stage, conservative treatment measures can be effective but are not always successful, and surgical intervention may be needed.

Neer's third stage of impingement involves bony changes and rotator cuff rupture with a history of chronic pain and tendinitis. The average age in this stage of disability is 60 years. A common complaint is night pain. Most types of athletic activities are limited by pain and loss of motion. Conservative treatment in this stage is ineffective and surgical intervention is most often required.
The purpose of this paper is to take a comprehensive look at the different causes of impingement syndrome, differentiate the presentation of symptoms, and identify proper treatment techniques for the specific pathology identified.

A complete and thorough understanding of the anatomical relationships of the shoulder complex is essential for proper identification of pathology and development of appropriate treatment techniques. The next chapter will focus on components of the shoulder complex.
CHAPTER II
ANATOMY OF THE SHOULDER COMPLEX

To better understand exactly what is occurring during impingement syndrome, it is important to take an in-depth look at the anatomical structures involved. This chapter consists of a detailed description of the five components of the shoulder complex beginning with the sternoclavicular joint and moving on to the acromioclavicular, suprhumeral, glenohumeral and, finally, the scapulothoracic joint (see Fig 1).

Sternoclavicular Joint

The shoulder complex is made up of three bones: the scapula, clavicle, and humerus. Of these three, the clavicle is the only one to articulate directly with the thorax.\textsuperscript{12} It does this at the manubrium of the sternum forming the sternoclavicular (SC) joint. The bony surfaces of this joint are incongruent,\textsuperscript{13} saddle shaped,\textsuperscript{3,13,14} and separated by an articular disk.\textsuperscript{3,14} Motions take place between both the clavicle and the disk and between the disk and the sternum.\textsuperscript{12} Despite its saddle-shaped surfaces, the SC joint functions much like a ball and socket joint and has three degrees of freedom:\textsuperscript{3,14} elevation, protraction, and rotation.
Because there is little muscular support and no bony prominences to hold the two bones together, the SC joint depends on the articular disk and surrounding ligaments and capsule for stability.\textsuperscript{14} The articular disk is a flat fibrocartilaginous disk which divides the joint space into two compartments.\textsuperscript{3,13,14} This disk plays a role in shock absorption and helps prevent medial displacement of the clavicle.\textsuperscript{13,16}

According to Moore,\textsuperscript{13} the entire SC joint is surrounded by a fibrous capsule and is reinforced by ligaments which include the anterior and posterior SC ligaments, costoclavicular ligament, and the interclavicular ligament. The anterior SC ligament is a broad fibrous band of tissue that extends from the upper inner edge of the clavicle and passes obliquely down and inward to attach to the sternum.\textsuperscript{10} Covering the posterior joint surface is the posterior SC ligament that blends with the synovial membrane of the capsule. These two ligaments reinforce the capsule and limit anterior and posterior movement of the medial end of the clavicle. The flat, short rhomboid-shaped structure passing from the rib to the clavicle, known as the costoclavicular ligament, acts as a check to clavicular elevation and protraction.\textsuperscript{10,14} This ligament helps to stabilize the clavicle against muscle forces and it serves as a fulcrum for all shoulder movements. The last important ligament of the SCI joint is the interclavicular ligament. Its main function is to limit excessive downward movement of the medial end of the clavicle. On its path from the upper inner edge of one clavicle to the inner edge of the other, it binds to the jugular notch of the sternum.\textsuperscript{10,13}
Because of the strong capsule and ligamentous reinforcement, dislocation rarely occurs and the clavicle will usually fracture before the joint dislocates.\textsuperscript{10,12}

**Acromioclavicular Joint**

Moving laterally along the clavicle, the next joint to be encountered is the acromioclavicular (AC) joint. This is a plane synovial joint located between the convex facet on the lateral end of the clavicle and small concave facet on the acromion of the scapula.\textsuperscript{13,14} Fibrocartilage covers both bony surfaces and a disk is present in the joint but does not completely separate it into two compartments.\textsuperscript{3} The AC joint line is oriented in an anterior and medial direction. The surface faces downward and lateral. A fibrous capsule surrounds this joint but is weak and depends on reinforcement from the superior and inferior AC ligaments that run transversely over the joint.\textsuperscript{13,14} Although these ligaments provide stability to counter a pulling apart (tension) of the two bones, there is nothing around this joint to prevent the clavicle from riding superior and moving laterally over the acromion process when the shoulder encountered a blow from the side.\textsuperscript{16}

Another structure that contributes to the lateral stability of the shoulder joint is the coracoclavicular ligament. It is noted to be the strongest of the ligaments that bind the clavicle to the scapula. It is articulated by means of the two main ligaments, the conoid and trapezoid. The trapezoid runs from the anterior surface of the coracoid process and passes upward and laterally to attach to the inferior surface of the clavicle. The primary function of this
ligament is to prevent overriding of the clavicle on the acromion. The conoid portion lies posterior and medial to the trapezoid ligament. It runs slightly backward and upward from the coracoid to attach on the underside of the clavicle, forming one-half of a cone enveloping the trapezoid ligament.

**Suprhumeral Joint**

Moving inferior to the acromion is the subacromial space or suprhumeral "joint." It is referred to as a "pseudo" joint because it is not a joint in the true sense. This "joint" is formed by the coracoacromial ligament, the acromioclavicular ligament, and acromioclavicular joint from above and below by the head of the humerus. The coracoacromial ligament unites the coracoid and acromion process of the scapula to form the coracoacromial arch (Fig 2). This arch is a protective articulation that prevents trauma to the glenohumeral joint or head of the humerus. However, due to its proximity to the humerus, it may be the causative structure of common debilitating impingement syndromes.

Below this arch is the suprhumeral or subacromial space. Many sensitive tissues are enclosed in this space and are vital components to both facilitating and producing shoulder motions. Structures within this space from superior to inferior are the subacromial bursa, the supraspinatus muscle and its tendon, the superior portion of the glenohumeral joint capsule, and the tendon of the long head of the biceps. These components move constantly in relation to one another and are tightly packed; therefore, they are vulnerable to degeneration.
The bursa acts as a sheath by separating the deltoid muscle from the rotator cuff muscles and biceps tendon. It allows smooth gliding and reduction of friction of these structures as they pass under the coracoacromial arch.\textsuperscript{14,18} The bursa does not normally move into the glenohumeral joint cavity, but may do so during rotator cuff tears. Irritation of this structure can lead to bursitis which can be a painful and chronic condition.\textsuperscript{10}

Any abnormality, including bursitis, that decreases the volume of the subacromial space may lead to impingement and tears of the rotator cuff tendons and of the tendon of the long head of the biceps brachii.\textsuperscript{14} Normal depth of the subacromial joint, measured radiographically, has been reported to be from 7 to 14 millimeters.\textsuperscript{14,18} As noted previously, reduction of this distance can lead to pathology.

**Glenohumeral Joint**

Inferior to the suprhumeral structures is the glenohumeral joint which is designed for mobility at the sacrifice of stability. This ball and socket joint consists of a shallow socket (glenoid fossa of the scapula) and the head of the humerus.\textsuperscript{3,14,16} The humeral head forms 1/3 of a sphere and is directed in a medial, upward, and posterior direction.\textsuperscript{3} It is also noted to have a normal angle of retroversion to the transverse axis of between 25° and 35°.\textsuperscript{14} The glenoid fossa is pear shaped, shallow, and directed outward and anteriorly to correspond to the retroverted position of the humeral head.\textsuperscript{3} Not more than ½ of the humerus is in contact with the glenoid socket at any one time; therefore, the
disproportionate size and lack of congruency of the articular surfaces make the joint inherently unstable. To assist in the task of stabilizing, a labrum or a lip of cartilage circles around the periphery of the glenoid fossa. It contributes approximately 50% of the total depth of the glenoid cavity and assists in holding the humeral head in place. The tendon of the long head of the biceps adheres to the superior segment of the labrum.

The labrum is not the lone factor in glenohumeral joint stability. There are also two main ligaments: the coracohumeral and the glenohumeral ligaments which are subdivided into the superior, middle, and inferior parts. Located on the superior aspect of the glenohumeral joint, the coracohumeral ligament originates on the base of the coracoid and runs transversely to insert into the greater and lesser tubercles blending with the adjacent capsule. This ligament acts as a check against upward and lateral displacement of the humeral head. The glenohumeral ligaments reinforce the joint capsule and are not seen from its external surface. Running under and slightly anterior to the coracohumeral ligament, the superior glenohumeral ligament arises from the superior pole of the glenoid and forms a narrow band inserting medial to the bicipital groove and above the lesser tubercle. Its primary function is prevention of inferior displacement of the humeral head in the adducted, dependent arm position.

The middle glenohumeral ligament passes from the anterior superior aspect of the glenoid under the origin of the superior glenohumeral ligament obliquely downward and laterally inserting on the lesser tuberosity, blending with
the subscapularis tendon. This ligament's primary function is to limit external rotation of the humerus between 0° and 90° of elevation. If it is attenuated or absent, it may lead to anterior instability, particularly between 60° and 90° of elevation. Beyond 90° of elevation, the main static restraint to the external rotation of the humerus is the inferior glenohumeral ligament.\(^8\) Arising from the anterior segment of the glenoid, this ligament runs transversely outward and inserts on the inner part of the surgical neck of the humerus. It is believed by most to be the most important and the strongest static structure providing anterior stability in the abducted and externally rotated position.\(^3,19\)

The capsule of the glenohumeral joint is a relatively large structure that has twice the surface area of the humeral head.\(^10,18\) It attaches along the labrum on the outer edge of the glenoid and forms a thin sleeve around the head of the humerus. The capsule is a lax structure with a redundant inferior portion that lies in fold when the arm is adducted. The redundant portion of the capsule can adhere to itself and lead to adhesive capsulitis.

In examination of the glenohumeral joint, some believe that the capsuloligamentous complex is not an effective stabilizer. They believe that the musculotendinous cuff, forming a true cuff posteriorly, superiorly, and anteriorly, is the main static stabilizer. The muscles of this cuff consist of the subscapularis anteriorly, the supraspinatus superiorly, and the infraspinatus and teres minor posteriorly.\(^17\) Their contribution to the mechanics of the shoulder will be discussed in the next chapter.
Scapulothoracic Joint

The last of the shoulder complex joints to be discussed is the scapulothoracic joint. This joint, along with the previously mentioned subacromial joint, does not fit the definition of a true joint, but it is an important physiological joint that adds considerably to the motions of the shoulder girdle. The components of this joint are the concave scapula and the convex rib cage separated by muscles and a bursa. The scapula is a thin, flat, triangular bone that lies on the posterolateral aspect of the thorax over the 2nd through 7th ribs. The plane of the scapula is approximately at right angles to the plane of the glenoid. At rest, it lies obliquely between the frontal and sagittal planes, 30° to 45° anterior to the coronal plane.

The actual location of movement is not directly between the scapula and the thoracic wall, but rather in two fascial planes. The more superficial plane is between the subscapularis and serratus anterior, and the deep plane is between the serratus anterior and posterolateral and lateral aspects of the thoracic wall. The serratus anterior arises from the anterolateral aspect of the upper nine or ten ribs and thus has the ability to move the scapula laterally along the thoracic wall.

Maintenance of scapular position and control of its movements are critical to the posture of the shoulder and the motion of the shoulder complex. The scapula is primarily dependent on muscular activity for stabilization. The chief suspension mechanism for the entire shoulder girdle is the tone in the upper
The axioscapular muscles of primary importance in maintaining scapular position include the levator scapula which supports the superior angle, the trapezius supports the lateral angle and entire point of the shoulder, the serratus anterior holds the medial border of the scapula against the thoracic wall, and the rhomboid major and minor control the medial aspect of the scapula. These muscles, along with ten others, are responsible for scapulothoracic movement and, then combined with glenohumeral motion, are critical to proper shoulder girdle movement.
CHAPTER III

BIOMECHANICS OF THE SHOULDER COMPLEX

Functional shoulder motion requires integrated muscular activity and full motion of the articulations. Each joint moves in a coordinated fashion to provide the smoothest and greatest range of motion (ROM) possible for the upper limb. Dr. E. A. Codman termed the integrated movement of the humerus, scapula, and clavicle "scapulohumeral rhythm."15

The purpose of scapulohumeral rhythm is threefold. First, the motion is distributed among three joints permitting a large ROM with less compromise of stability than would occur if the range occurred in only one joint. Maintenance of the glenoid fossa in an optimal position to receive the head of the humerus is the second purpose. Basically, proper positioning increases joint congruency while shear forces across the joint decrease. Third, scapulohumeral rhythm permits the muscles acting on the humerus to maintain optimal length-tension relationships which minimizes or prevents active insufficiency of the glenohumeral muscles. Active insufficiency is defined as a muscle's inability to exert a normal force and normal movement on the part to which it is attached due to decreased muscle length.9
Motions of the upper extremity are numerous and the integrated joint movement and muscle timing sequences are complex. Impingement commonly occurs while performing overhead activities and reaching. Therefore, a detailed analysis of abduction with focus on scapulohumeral rhythm will follow.

**Initial 30° of Abduction**

During the initial 30° of elevation in the coronal plane, humeral motion exceeds scapular motion considerably. The humeral motion contributes 20° to 25° while the scapula rotates to add another 5° to 10°. The resultant ratio of glenohumeral to scapulothoracic movement is 4:1. During this initial phase, movement of the bony surfaces of the glenohumeral joint, termed arthrokinematics, consists primarily of spinning of the humeral head with slight superior translation. Upward rotation of the scapula occurs around an axis just inferior to the middle of the spine of the scapula. The lateral aspect of the clavicle is elevated due to the superior movement of the lateral angle of the scapula. This scapular rotation maintains mechanical stability at the glenohumeral joint and proper length of the muscles acting on the joint.

Shoulder abduction (elevation) is achieved by the contribution of both extrinsic and intrinsic muscle contraction. Extrinsic muscles are superficial muscles of the back, the majority of which have direct attachment to the scapula. The main extrinsic muscles contributing to superior rotation of the scapula are the trapezius, the serratus anterior, and the levator scapulae. The rhomboids are also active working as eccentric stabilizers. Other muscles listed in Tables 1
### Table 1. Functions of Extrinsic Muscles of the Shoulder

<table>
<thead>
<tr>
<th>Functions</th>
<th>Muscles</th>
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<tbody>
<tr>
<td>Scapular adduction (retraction)</td>
<td>Trapezius (superior, middle and inferior parts)</td>
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<tr>
<td></td>
<td>Rhomboids (major and minor)</td>
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<tr>
<td></td>
<td>Latissimus dorsi</td>
</tr>
<tr>
<td>Scapular abduction (protraction)</td>
<td>Serratus anterior</td>
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<tr>
<td></td>
<td>Pectoralis major</td>
</tr>
<tr>
<td>Superior rotation of scapula</td>
<td>Trapezius (superior and middle parts)</td>
</tr>
<tr>
<td></td>
<td>Serratus anterior</td>
</tr>
<tr>
<td>Inferior rotation of scapula</td>
<td>Rhomboids (major and minor)</td>
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<tr>
<td></td>
<td>Latissimus dorsi</td>
</tr>
<tr>
<td>Elevation of scapula</td>
<td>Levator scapulae</td>
</tr>
<tr>
<td></td>
<td>Trapezius (superior part)</td>
</tr>
<tr>
<td>Depression of scapula</td>
<td>Pectoralis minor</td>
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<tr>
<td>Flexion of humerus</td>
<td>Pectoralis major</td>
</tr>
<tr>
<td>Extension of humerus</td>
<td>Latissimus dorsi</td>
</tr>
<tr>
<td>Internal rotation and adduction</td>
<td>Latissimus dorsi</td>
</tr>
<tr>
<td>of humerus</td>
<td>Pectoralis major</td>
</tr>
</tbody>
</table>

and 2 act together with the four previously mentioned to achieve and maintain the proper scapular position. Working with these extrinsic muscles to perform specific movements are the intrinsic muscles.

The major intrinsic muscles involved in shoulder abduction are the supraspinatus and deltoid. However, the rest of the rotator cuff (infraspinatus, teres minor, and subscapularis) is also active functioning as a joint stabilizer. The deltoid and supraspinatus both contribute to the first 30° of abduction. Due to the combined action of these muscles, total muscular effort is decreased by 35%.

The supraspinatus has two roles: 1) prevents superior rotation of the humeral head (holds it "down") and 2) initiates the rotation or spin of the humeral head in the glenoid. The initial line of pull of the deltoid is parallel to the shaft of the humerus which causes superior translation of the humeral head in the glenoid. However, this movement is counter balanced, mainly by the supraspinatus, which allows the deltoid to provide force for humeral abduction. Force generated by both muscles increases steadily throughout the initial phase of motion, which produces a combination of shearing and compressive forces in the glenohumeral joint. At the initiation of abduction, the dominant direction of the deltoid pull is vertical, producing significant upward shear—89% compared with a compressive value of 45%. The supraspinatus produces a 93% compressive and 4% shearing force. Loss of supraspinatus function, then, unleashes the deltoid's upward shear, impairing shoulder function and leading to
### Table 2. Functions of Intrinsic Muscles of the Shoulder

<table>
<thead>
<tr>
<th>Functions</th>
<th>Muscles</th>
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<tbody>
<tr>
<td>Abduction of the humerus</td>
<td>Deltoid (middle part)</td>
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<td></td>
<td>Supraspinatus (rotator cuff)</td>
</tr>
<tr>
<td>Flexion of the humerus</td>
<td>Deltoid (anterior part)</td>
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<tr>
<td></td>
<td>Coracobrachialis</td>
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<tr>
<td>Extension of the humerus</td>
<td>Deltoid (posterior part)</td>
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<td>Teres minor</td>
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<tr>
<td>Medial rotation of the humerus</td>
<td>Deltoid (anterior part)</td>
</tr>
<tr>
<td></td>
<td>Teres major</td>
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<tr>
<td></td>
<td>Subscapularis (rotator cuff)</td>
</tr>
<tr>
<td>External rotation of the humerus</td>
<td>Infraspinatus (rotator cuff)</td>
</tr>
<tr>
<td></td>
<td>Teres minor (rotator cuff)</td>
</tr>
<tr>
<td>Stabilization of the glenohumeral joint</td>
<td>Rotator cuff</td>
</tr>
</tbody>
</table>

the impingement of the supraspinatus tendon and subacromial bursa against the coracoacromial arch.

30° to 180° Abduction

Inman et al.\textsuperscript{21} investigated scapulohumeral rhythm in subjects abducting their shoulders in a coronal plane. They found that after the first 30° of abduction, a fairly constant ratio of two degrees humeral motion to one degree of scapular motion occurred.

This phase of motion, from 30° to 180°, is a steady continuation of the initial phase. The amount of humeral motion continues to exceed that of the scapula, but the ratio is reduced from 4:1 to 5:4.\textsuperscript{17} For full range of abduction, the overall ratio is 2:1 humeral contribution of 120° and 60° resulting from scapular rotation. This is consistent with Inman’s findings.

Superior rotation of the scapula continues during this second phase as a result of combined trapezius and serratus anterior activity, but the axis of rotation moves laterally towards the acromioclavicular joint (Fig 3). This lateral displacement of the axis of rotation allows the last 30° of scapulothoracic movement to occur.

Muscles responsible for movement in this final phase are essentially the same as those in the early phase, but the roles have changed. The rotator cuff and deltoid act in concert with the deltoid performing the majority of abduction.\textsuperscript{17} The infraspinatus, teres minor, and subscapularis are now in the ideal position for control of the humeral head. Their coordinated activity produces external
rotation which is needed to prevent mechanical impingement of the greater tuberosity against the acromion. If a person is unable to externally rotate, a maximum 60° of humeral abduction is possible. Only in the externally rotated position can the humerus be abducted actively to 90° and passively to 120° (remainder of the motion is contributed by the scapula). Table 3 describes the contribution of the component shoulder joints from 0° to 180° of abduction.

Component joint movements and proper muscle timing and contraction are critical to the successful attainment of functional, pain-free movement. Any dysfunction or improper motor sequencing may lead to pathology of the shoulder joint.
### Table 3. Abduction of the Humerus: 0 - 180 Degrees

<table>
<thead>
<tr>
<th>Joint</th>
<th>0 - 30°</th>
<th>30 - 180°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glenohumeral joint</td>
<td>20-25° of abduction</td>
<td>90-100° of abduction (predominantly spin); external rotation</td>
</tr>
<tr>
<td></td>
<td>Predominantly spin</td>
<td>Approx.1-2 mm superior translation</td>
</tr>
<tr>
<td></td>
<td>Approximately 1-2 mm superior translation of humeral head</td>
<td>Supraspinatus and deltoid active; deltoid providing force,</td>
</tr>
<tr>
<td></td>
<td>Supraspinatus and deltoid active</td>
<td>supraspinatus concerned with position of humeral head</td>
</tr>
<tr>
<td></td>
<td>Supraspinatus -- rotation (spin) and &quot;holds head down&quot;</td>
<td>Subscapularis, infraspinatus and teres minor &quot;hold head down&quot; and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>control external rotation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inferior capsule cradles head and limits inferior translation</td>
</tr>
<tr>
<td>Scapulothoracic joint</td>
<td>5-10° of upward rotation</td>
<td>50-55° of upward rotation; initial axis below center of spine, later</td>
</tr>
<tr>
<td></td>
<td>Predominantly trapezius and serratus anterior</td>
<td>shifts superolaterally towards acromioclavicular joint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Predominantly trapezius and serratus anterior</td>
</tr>
<tr>
<td>Sternoclavicular joint</td>
<td>Elevation of lateral end of clavicle by Upper trapezius and/or follows</td>
<td>Continued elevation of lateral clavicle until limited by conoid</td>
</tr>
<tr>
<td></td>
<td>scapula</td>
<td>ligament</td>
</tr>
<tr>
<td>Acromioclavicular joint</td>
<td>Minimal adjustments (slide/rotation)</td>
<td>Minimal adjustments (slide and rotation)</td>
</tr>
</tbody>
</table>

CHAPTER IV
PATHOLOGICAL FACTORS RELATED TO IMPINGEMENT

There are many etiological factors that contribute to the development of shoulder impingement syndrome. This chapter will address a few of the more common causes of impingement including instability, bony impingement, and bursitis.

Instability

A clinical overlap between impingement syndrome and anterior shoulder instability has been observed. Warner et al\textsuperscript{25} found that 68% of patients with anterior instability had impingement signs in addition to apprehension sign, capsular laxity, and superior glenohumeral translation.

Not all patients who have instability of the shoulder will present with the same history, onset, or symptoms. However, the majority will fit somewhere in the spectrum of the classification commonly used today. TUBS and AMBRI are the acronyms used for the classification of instability.\textsuperscript{23}

The TUBS classification is used to represent patients who have a \textbf{T}raumatic onset of instability, that is \textbf{U} nidirectional in nature, has an accompanying \textbf{B}ankart lesion (which is detachment of the anterior glenoid labrum and capsule from the glenoid rim) and typically responds best to
Surgery. At the other end of the instability spectrum is the AMBRI classification. Patients who fit into this category present with an Atraumatic etiology, their symptoms are Multidirectional in nature (meaning there is glenohumeral instability in more than one direction with any combination of anterior, posterior, or inferior movement), generally involves Bilateral shoulder findings, and most often responds best to Rehabilitation rather than surgery. If surgery is needed as a last resort, Inferior capsular shift is the preferred treatment.

Causes of instability due to a traumatic event are easier for therapists to perceive and manage. Instability due to trauma is usually caused by stress applied to the externally rotated arm levering the humeral head out of the glenoid. It may also be associated with an anterior blow to the posterolateral aspect of the shoulder. The unidirectional instability of the TUBS classification means that instability of the glenohumeral joint occurs in only one direction—either anterior, posterior, or inferior.

AMBRI patients’ symptoms are often more confusing than those of TUBS patients due to the insidious onset of their symptoms. There are instability patients who have hyperlaxity or hypermobility of all joints and others that have instability only in the shoulder. Frequently, after an overuse episode, these AMBRI patients note they have a feeling that the shoulder is “popping out” or “slipping.” However, some patients do not have generalized hypermobility but
still present with an atraumatic cause. Many times, this is also associated with overuse.

When evaluating a patient, it is important to assess for general ligamentous hyperlaxity. To be classified as an individual with hyperlaxity, a person will present with two or more of the following hypermobility signs: 1) abduction of the thumb to touch the forearm, 2) hyperextension of the little finger MCP joint beyond 90°, 3) elbow hyperextension beyond 10°, and 5) dorsiflexion of ankle beyond 45°. If these criteria are met by an individual, they are at higher risk for shoulder impingement than those who do not have general ligamentous instability.

In a study comparing patients with glenohumeral instability to those with shoulder impingement syndrome, it was found that patients with instability demonstrated an increase in active and passive internal rotation and cross arm adduction when compared with the impingement patients. Mean passive external rotation was also increased by a difference of 12° in the instability group.

Patient with anterior instability may appear to have greater range of motion, but some may have tight posterior structures which can limit internal rotation and cross arm adduction. This overlap of clinical findings may make diagnosis difficult. However, the majority of patients with instability demonstrate significantly greater external rotation compared to those with impingement.
Symptoms found during palpation of an instable shoulder may be specific to the direction of instability. Those with anterior subluxation will exhibit tenderness over the posterior capsule. Patients with anterior subluxation and secondary impingement findings often have tenderness over the greater tuberosity or biceps tendon. As for patients who compensate for multidirectional instability with muscle activity, they are tender along the medial angle of the scapula. Trigger points over the levator scapulae, rhomboids, or along the trapezius may occur in those with multidirectional and posterior instability and those with a painful shoulder. Figure 4 shows a chart of classification of instability.

Scapular winging may occur in shoulders with anterior instability as well as those with impingement. A study found 64% of patients with anterior instability and 100% with impingement syndrome demonstrated either asymmetry or frank scapular winging during repetitive forward flexion. If, during an evaluation, abnormalities or variations from normal are noted, it is important to apply special tests to determine the cause of the deviation.

Special tests, such as Neer and Hawkins-Kennedy impingement test, Apprehension test, Fowler's Sign or Relocation test, Load and Shift test, and Sulcus sign, may be helpful in the diagnosis of instability, but they can also be confusing. In patients with instability, Neer and Hawkins-Kennedy impingement tests may be negative; however, in the presence of secondary impingement, these tests will be positive. The Apprehension test looks at apprehension sign
and pain as criteria. The presence of apprehension indicates a positive test for anterior instability. For the apprehension test, a sensation of pain without apprehension may denote either primary impingement or mild anterior instability with secondary impingement.\textsuperscript{26} When performing Fowler's sign or Relocation test, which is a posteriorly directed force on the anterior, proximal humerus, patients with primary impingement will have no change in pain and those with secondary impingement will experience a reduction of pain.\textsuperscript{26} This test was evaluated by Speer et al in a study with 100 patients who underwent shoulder surgery.\textsuperscript{28} They found the relocation test to be unsatisfactory as an indicator of a certain pathology due to a pain response. However, they did find the relocation test to be a positive predictor of instability on the basis of apprehension.

To assess the amount of anterior/posterior translation in the glenohumeral joint, one may choose the Load and Shift test.\textsuperscript{23} Initial reduction of the humeral head into the glenoid fossa is termed loading. Once loaded, directional stress may be applied to assess the amount of translation. Measurement of the humeral head from central alignment is noted in centimeters. To test excessive inferior laxity of the glenohumeral joint, look for a positive Sulcus sign, which is dimpling of the skin in the area adjacent to the acromion when inferior traction is applied to the humerus.

If a patient has increased mobility and laxity of the shoulder joint, he/she is likely to experience some discomfort due to bony impingement.
Bony Impingement

Anatomical variance throughout the shoulder complex may contribute to impingement (Table 4). The very shape of the acromial process may reduce the vertical dimensions of the subacromial space. Other sources of bony impingement include: 1) an enlarged coracoid process which may impinge against the lesser tuberosity of the humeral head, 2) an enlargement of the acromioclavicular joint, and 3) subacromial spurs that may impinge on the rotator cuff.

The shape of the acromion varies in each individual. Bigliani et al described three characteristic shapes of the acromion: Type I has a flat inferior surface, type II has a curved inferior surface, and type III is hooked. In a morphological study in which variation in shape of the acromion was correlated to tears of the rotator cuff, Bigliani and Morrison reported type III “hooked” to be present in a higher frequency of complete tears of the rotator cuff (Fig 5). Neer described a ridge of proliferative spurs and bony projections on the anterior, inferior surface of the acromion at the site of the coracoacromial ligament. He speculated that these bony change were the result of traction of the coracoacromial ligament caused by mechanical impingement of the humeral head and rotator cuff.

Age has also been suggested to be a confounding factor with acromial impingement. A statistically significant association between age and tears of
Table 4. Bony structural variations that may increase subacromial impingement

<table>
<thead>
<tr>
<th>Structure</th>
<th>Abnormal Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acromioclavicular joint</td>
<td>Congenital anomaly</td>
</tr>
<tr>
<td></td>
<td>Degenerative spur formation</td>
</tr>
<tr>
<td>Acromion</td>
<td>Unfused acromion</td>
</tr>
<tr>
<td></td>
<td>Abnormal acromial shape</td>
</tr>
<tr>
<td></td>
<td>Degenerative spurs on the undersurface acromion</td>
</tr>
<tr>
<td></td>
<td>Malunion/nonunion of an acromial fracture</td>
</tr>
<tr>
<td>Coracoid</td>
<td>Congenital anomaly</td>
</tr>
<tr>
<td></td>
<td>Abnormality of shape following surgery/trauma</td>
</tr>
<tr>
<td>Humerus</td>
<td>Increased prominence of the greater tuberosity due to congenital anomalies or fracture malunions</td>
</tr>
</tbody>
</table>

the supraspinatus has been confirmed for those 50 years old and above. This supports the theory that at least some tears of the rotator cuff are secondary to age related degenerative changes.

If bony impingement is to be considered a possible cause of tendinopathy leading to tears, then identifying impingement prior to tendon tear may be of much greater potential significance to patient outcome than noting impingement after the cuff is torn.

Bony impingement is a problem for clinicians. Diagnosis of impingement, however, can be even more confounding with the presence of other factors, such as subacromial bursitis.

Subacromial Bursitis

Bursitis, simply put, is inflammation of the bursae. It rarely occurs as a primary disorder unless there is involvement of rheumatoid arthritis, tuberculosis, or synovial chondromatosis. Frequently, bursitis occurs secondary to trauma such as sprains, strains, and contusions. Subacromial bursitis often coincides with or is superseded by supraspinatus strain or tendinitis. The concomitant inflammatory reaction is due to the supraspinatus tendon and subacromial bursa sharing a synovial wall. They cannot be separated from one another, so when the outer layer of the tendon sheath is inflamed by trauma or repetitive insult, the inner wall of the subacromial bursae also becomes inflamed.
Bursitis can be a chronic or acute condition. Chronic bursitis can result from episodes of repeated microtrauma as the bursa is compressed against the coracoacromial arch. This is thought to occur most often in patients 25 to 40 years of age. Light activity of the shoulder with motions below 90° is not bothersome, but symptoms become significantly aggravated with overhead use in vocational or recreational activities. Symptoms may resemble those of rotator cuff tendinitis which will be discussed in the next chapter. Patients may present with a nagging, aching pain in the area of the deltoid insertion. Severe night pain may be present and frequently refers down the lateral aspect of the humerus. A painful arc with active and passive abduction in the range of 70° to 120° is also common.

Direct trauma to the shoulder can result in acute bursitis. Pain is the initial symptom; it can be extreme and a rapid onset is common. Pain is most often localized at the anterolateral aspect of the glenohumeral joint. Patients will have marked difficulty with active or passive elevation of the arm. The limitation in motion is of a non-capsular nature with internal and external rotation unrestricted and abduction limited. Free rotation with a non-capsular pattern is a key for diagnosis of this disorder.

Another physical observation that is seen with bursitis is the normally smooth scapulohumeral rhythm is replaced by shoulder “shrugging.” Patients may also report a catching, grinding, or snapping sensation during shoulder
movements. Neer and Hawkins-Kennedy impingement test are both positive for this pathology.
CHAPTER VI

ROTATOR CUFF DEGENERATION

The rotator cuff (supraspinatus, infraspinatus, teres minor, and subscapularis) is a vital component in proper shoulder biomechanics and movement sequencing during activities above the horizontal plane. Any alteration of the rotator cuff's structure decreases its effectiveness of proper functioning which can lead to impingement (Fig 6). Afflictions of the rotator cuff are the most common disorders among all patients with shoulder pain.27 This chapter will include a review of conditions of the rotator cuff that can lead to impingement. One factor that can affect the integrity of the cuff is decreased blood supply or avascularity of the supraspinatus.

Supraspinatus Avascularity

One topic that has been the subject of some debate is the presence of an avascular zone of the supraspinatus. In 1931, Codman introduced the concept of the “critical zone” (avascular zone) near the attachment of the supraspinatus tendon into the greater tuberosity.31 He felt that the critical zone is an area where the majority of rotator cuff pathologies are noted. This area is often subject to repeated microtrauma which may result in an inflammatory response with swelling of the tendinous structures.25 With less space available
Fig. 6-- Potential pathogenesis of rotator cuff damage. Adapted from Physical rehabilitation of the injured athlete. Andrews JR, Harrelson GL. W. B. Saunders Company. Philadelphia Pa. 1991.
for rotator cuff under the coracoacromial arch, impingement is more likely to occur.

Rathburn and Macnab felt this area is at risk to further insult by compression of the humeral head while the arm is held at rest or in the adducted position. They also believe friction of the supraspinatus against the edge of the acromion occurs when abduction takes place. This prolonged compression and friction have a detrimental effect on the vascular supply of the tendon. A study by Rathburn and Macnab showed that the avascular zone preceded degenerative cuff changes and that these degenerative changes were always more extensive in the areas of avascularity.

A study found the critical zone to be present in both young adult subjects and in those older than 50 years; though in the older individuals, the critical zone size is increased, suggesting that the zone tends to increase with age. This may explain why ruptures of the supraspinatus tendon occur frequently over the age of 50.

This critical zone can be weakened by decreased blood supply, repeated microtrauma, inflammation, mechanical impingement, and age. Care must be taken to avoid further insult to this area with improper rehabilitation techniques which could lead to tendinitis or cuff rupture.

Supraspinatus Tendinitis

Supraspinatus tendinitis, which is defined as inflammation of the tendinous sheath, has been thought to occur from eccentric overload of the
supraspinatus. Nirschi believes repetitive microtrauma occurs during overhead activities, resulting in small rotator cuff tears that stimulate the inflammation cascade.

Patients report a vague history of pain in the anterior shoulder region without a clear reason as to why, when, or how it began. The pain is described as acute and excruciating at times, but will more often than not be reported as chronic low grade aching pain and fatigue sensation. Patients will often have difficulty sleeping on the involved upper extremity. They also report a catching sensation in flexion or internal rotation. Another observable finding will be a painful arc between $70^\circ$ and $120^\circ$ of elevation. Passive motion is full and painless, but active internal rotation and abduction may be limited and produce pain. Testing procedures that will produce positive results are Neer and Hawkins-Kennedy impingement tests as well as the "empty can" supraspinatus test.

Additional stress applied to shoulders with active tendinitis by overhead activities or direct injury can lead to further trauma including rotator cuff tears.

Rotator Cuff Tears

Rupture of the supraspinatus tendon is a common and important cause of shoulder disability. In severe cases, the tear may be extensive and may involve the entire rotator cuff of the shoulder.

The mechanism of cuff injury is varied. It may be a progression of degeneration of the "critical zone" exposed to repeated impingement or it may
involve a powerful elevation of the arm, a fall, or a direct blow to the side of the shoulder.\textsuperscript{21} Spontaneous tears are seen most often in patients over 50, especially those who have had repeated steroid injections.\textsuperscript{26} Rotator cuff ruptures that occur slowly may not be diagnosed until impingement of the hypertrophic tendon edges and bursae beneath the coracoacromial ligament causes symptoms. The type of rupture that occurs suddenly in a more active person is usually due to a traumatic episode and is characterized by acute pain and weakness in abduction.\textsuperscript{30}

Diagnosis of a rotator cuff tear is aided by knowledge of common symptoms and presentations. Symptoms include pain or discomfort occurring more intensely at night than during the day.\textsuperscript{30} The pain is most often attributed to spasm of the upper trapezius, levator scapulae, and rhomboids which are acting as a protective mechanism. The patient usually has diminished active shoulder range of motion and decreased strength in abduction, flexion, and external rotation. Passive range of motion, however, is maintained in most cases. A painful arc between 70° and 120° will be present unless there is a complete tear. Patients will often describe a slipping/popping sensation when certain movements are repeated. During observation of the patient, the examiner will most likely notice a disturbance in scapulohumeral rhythm. Palpation may reveal tenderness over the greater tuberosity and, if the tear is several weeks old, atrophy may be noted in the supraspinatus and infraspinatus fossae of the scapula.\textsuperscript{21} The presence of pain is not a factor in determining
whether a tear is partial or complete, but active motion is. If a patient is able to initiate abduction and external rotation, the tear is partial not complete. To pinpoint the exact cause of these symptoms, utilization of special tests is indicated.

Stabilization of the glenohumeral joint is extremely compromised in the presence of a rotator cuff tear. Tests which identify rotator cuff pathology include the drop arm test, forearm drop test, Neer and Hawkins-Kennedy impingement test, and "click" test.

In the presence of a rotator cuff tear, the drop arm test will be positive (patient is unable to maintain 90° of abduction passively attained by examiner).26 The forearm drop test is performed similar to that of the drop arm test. After placing the arm in abduction, the arm is flexed 90° at the elbow, placing the hand and forearm in the horizontal position.21 If the cuff is torn, the weight of the arm will cause it to slowly descend. In a partial tear, weakness is elicited by downward pressure on the arm. Neer impingement and Hawkins-Kennedy impingement tests will also be positive with a rotator cuff tear.30 Zohn and Mennell have developed another test to detect rotator cuff tears.26 In this test, the affected arm is taken to the extreme of painless abduction and moved gently through external and internal rotation by the examiner. If the patient experiences sharp pain and a "click" at the same point of internal and external rotation, the diagnosis of rotator cuff tear is established.
The factors related to rotator cuff tears are numerous. They include decreased vascularity of supraspinatus, degeneration due to aging, muscle weakness, direct trauma, and microtears. In 1931, Meyer was the first to propose that the majority of rotator cuff tears are the end result of impingement of the supraspinatus tendon against the under surface of the acromion.²²

The question of which came first, the impingement or the cuff lesion, has been discussed. As therapists, we have to deal with the end result, which is usually cuff damage with impingement, and design a proper treatment plan to return the patient to activity.
CHAPTER VI

SHOULDER REHABILITATION

Once the diagnosis of shoulder impingement is made, whether primary (impingement of the cuff beneath the coracoacromial arch) or secondary (due to glenohumeral instability or functional scapulothoracic instability), implementation of a proper rehabilitation program must be initiated to regain functional use of the extremity and avoid further disability.\textsuperscript{27}

When designing a treatment program for impingement, there are four key points to keep in mind.\textsuperscript{9} First, to allow the humeral head to glide caudally (inferiorly) during elevation, there must be sufficient laxity in the inferior capsule. Joint mobilization is indicated if there is insufficient mobility. Second, when exercising, the impingement zone should be avoided. Any abduction past 90° should be done with external rotation; flexion past horizontal should be done in neutral or external rotation, and "empty can" or supraspinatus strengthening should be done below 90° of elevation. Third, treatment of instability, if present, must be done simultaneously to avoid further secondary impingement. And finally, proper positioning for strengthening of the supraspinatus and long head of the biceps to avoid further compromise to the area of avascularity must be
incorporated into the rehabilitation program. To avoid vascular compromise, muscular training should be done in slight abduction.

In acute impingement syndrome, time, rest from noxious stimuli, NSAIDs (non-steroidal anti-inflammatory drugs), modalities such as cold, heat, electrical stimulation, and a program of flexibility and progressive exercise are indicated. 28

**Initial Treatment Phase**

Goals for this stage include establishment of proper activity level, restoration of normal range of motion, and pain control. 9 Modification of a patient's activity level is important in this phase. Patients must decrease their activity level or they may further stress the injured tissue. 27 It is also important to evaluate the patient's technique during all exercises to look for deviations from the optimal position and make appropriate suggestions for correction.

To maintain and restore range of motion, a wide variety of exercises may be incorporated into the rehabilitation program. To prevent soft tissue adhesion, passive rather than active motion must be initiated early. 21 One exercise commonly used is the Codman exercises. These exercises are essentially pendulum exercises in which the patient uses motion of the body to get his/her arm passively moving. Other possibilities to aid in increasing range of motion include self assistive devices such as a pulley system, wand exercises, or wall walking. 29 Self-stretching exercises with the wand (at end range for 10 to 15 seconds or longer, if tolerated) or table slide exercises may also be
implemented. All of these range of motion exercises must be done frequently and with enough force to ensure gradual restoration of full range.\textsuperscript{21}

Heat can be applied before and during the exercise, as can ice. Whether to apply ice or heat will be indicated by the stage (acute, subacute, chronic) or the condition (Table 5), severity of pain, and intent of the exercise.\textsuperscript{21}

Proper blood supply and circulation are important in the early phase of rehabilitation. Utilization of an upper body ergometer or UBE for aerobic exercise is useful to increase circulation in the shoulder and should be incorporated into the rehabilitation program as the patient is able to tolerate the activity.\textsuperscript{9} The UBE can also be used as warm-up activity for prolonged stretching.

If there are areas of muscular tightness in the shoulder, static stretching for two to three minutes applied to each area of tightness is indicated.\textsuperscript{9} Common stretches for the rotator cuff include: 1) external rotation at 90° of abduction, 2) internal rotation at 80° of abduction, 3) 135° of elevation, and 4) external rotation with full overhead elevation. To assure the shoulder girdle muscles are relaxed, stretches should be done in supine with a weighted wand or cuff. Care should be taken to avoid over-stretching hypermobile patients.\textsuperscript{23}

If patients demonstrate decreased joint mobility, it is important to utilize joint mobilization. Implementation of posterior and inferior humeral mobilization is useful in the attainment of proper glenohumeral mechanics; however, one
### Table 5. Characteristics and clinical signs of the stages of inflammation, repair and maturation

<table>
<thead>
<tr>
<th></th>
<th>ACUTE STAGE</th>
<th>SUBACUTE STAGE</th>
<th>CHRONIC STAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characteristics:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vascular changes</td>
<td></td>
<td>Removal of noxious stimuli</td>
<td>Maturation of connective tissue</td>
</tr>
<tr>
<td>Exudation of cells and chemicals</td>
<td></td>
<td>Growth of capillaru beds into area</td>
<td>Contracture of scar tissue</td>
</tr>
<tr>
<td>Clot formation</td>
<td></td>
<td>Collagen formation</td>
<td>Remodeling of scar</td>
</tr>
<tr>
<td>Phagocytosis, neutralization of irritants</td>
<td></td>
<td>Granulation of tissue</td>
<td>Remodeling of scar</td>
</tr>
<tr>
<td>Early fibroblastic activity</td>
<td></td>
<td>Very fragile, easily injured tissue</td>
<td>Collagen aligns to stress</td>
</tr>
<tr>
<td><strong>Clinical Signs:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inflammation</td>
<td></td>
<td>Decreased inflammation</td>
<td>Absence of inflammation</td>
</tr>
<tr>
<td>Pain before tissue resistance</td>
<td></td>
<td>Pain synchronous with tissue resistance</td>
<td>Pain after tissue resistance</td>
</tr>
<tr>
<td><strong>Physical Therapy Treatment Approach:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control effects of inflammation:</td>
<td>Prevent or minimize contracture and adhesion formation:</td>
<td>Restore function:</td>
<td></td>
</tr>
<tr>
<td>Modalities</td>
<td>Gentle active movement, gradually increasing in intensity and range</td>
<td>Progressive stretching, strengthening, and functional exercises</td>
<td></td>
</tr>
<tr>
<td>Immobilization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cautious gentle movement</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from *Therapeutic Exercise, foundations and techniques. 2nd ed.* Kissner C, Colby LA. F. A. Davis Company: 1990.
must not overlook scapulothoracic mobility as it is critical to proper scapulohumeral motion. If the patient has been using compensatory movement patterns, such as shoulder shrugging instead of smooth shoulder elevation, biomechanical re-education may be incorporated into the treatment plan. This may be done by practicing activities in front of a mirror for visual feedback or implementation of proprioceptive neuromuscular facilitation (PNF) techniques to re-educate the muscles. In addition to full range of motion, strength and endurance of the rotator cuff and other shoulder girdle muscles must be regained to ensure normal restoration of scapulohumeral rhythm.

Because the supraspinatus plays a critical role in impingement, strengthening this muscle is central to the shoulder rehabilitation program. Exercises that have been shown to produce increased activity of the supraspinatus include: 1) humeral flexion, 2) humeral elevation in the plane of the scapula with external rotation, 3) humeral elevation in the plane of the scapula with internal rotation, and 4) military press. These exercises may be included for selective strengthening of the supraspinatus. However, the remainder of the rotator cuff muscles and external rotators must not be neglected. These muscles may be strengthened by performing submaximal isometrics listed in Figure 7 and also external rotation in sidelying, external rotation in prone and 90° of abduction, and lying prone, abduct horizontally with external rotation. These exercises may be done with or without a weight of one
I. Submaximal Isometrics
1. Abduction at 30° and 60°
2. Supraspinatus at 30° and 60°
3. IR at 0° abduction
4. ER at 0° abduction
5. Biceps isometrics

II. Short-arc isotonics
1. Abduction 30° to 90°
2. Supraspinatus at 30° to 90°
3. ER at 30° with towel roll with tubing
4. IR at 30° with towel roll with tubing
5. Flexion 30° to 90°
6. Biceps isotonics at 40° shoulder flexion
7. D2 flexion RS at 30°, 60°, 90° and 120°

III. Rotator cuff dynamic stabilization
Sets (initially no weight, progress to 1 lb. and gradually increase)
1. Arm elevation from 0° to 60° isometric hold 2 seconds
2. Arm elevation from 60° to 120° isometric hold 2 seconds
3. Supraspinatus from 0° to 60° isometric hold
4. Supraspinatus from 0° to 90° isometric hold
5. D2 flex UE, RS and SRH at 0°, 60°, 120°, and 160°
6. Tubing D2 flexion with isometric holds

Fig. 7—Stabilizing exercises of the humeral head. Adapted from Orthopedic therapy of the shoulder. Kelly MJ, Clark WA. J. B. Lippencott Company; 1995.
to two pounds, depending on the patient's tolerance. Scapulothoracic muscles must also be strengthened to avoid muscle imbalance and fatigue (Table 6).

Again, ice can be applied throughout the day for periods of 20 minutes to control pain and inflammation.

Before a patient can progress to the next phase of rehabilitation, it is important that he/she meet certain requirements. These requirements are: 1) full painless range of motion, 2) good strength (grade 4/5 of shoulder internal/external rotators), and 3) minimal tenderness and pain with analysis of the shoulder.

Intermediate Phase

Continuation of strengthening, range of motion, and aerobic activity are essential to this stage. All previous exercises may be continued with increased resistance and repetition. Implementation of free weight and use of resistive bands or tubing is now indicated to increase strength of the cuff muscles and the scapulothoracic stabilizers. Submaximal isometrics can now be progressed to short-arc isotonics and rotator cuff dynamic stabilization listed in Figure 7. The direction of the exercises should be increased from single plane to multiplane or sport specific positions to further challenge the patient.

Throughout this intermediate phase of rehabilitation, the therapist should watch for proper technique during exercise, monitor complaints of impingement and look for signs of inflammation. If inflammation persists, phonophoresis or iontophoresis may be indicated.
Table 6. Suggested exercises for strengthening the scapulothoracic muscles

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Suggested Exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serratus anterior</td>
<td>Scapular plan abduction, push ups, end range shoulder flexion prone, serratus anterior punch</td>
</tr>
<tr>
<td>Upper trapezius</td>
<td>Shoulder shrugs, scapular plan abduction</td>
</tr>
<tr>
<td>Middle trapezius</td>
<td>Rowing, shoulder elevation and hyperextension in standing, shoulder abduction and flexion in prone, scapular retraction with horizontal abduction of the externally rotated shoulder in prone</td>
</tr>
<tr>
<td>Lower trapezius</td>
<td>Scapular plane abduction and rowing, shoulder depression and retraction in sitting, elevation of the externally rotated arm which is positioned diagonally between flexion and abduction</td>
</tr>
<tr>
<td>Levator scapulae</td>
<td>Shoulder elevation, abduction, flexion and rowing</td>
</tr>
<tr>
<td>Rhomboids</td>
<td>Rowing, shoulder retraction, elevation, and abduction, scapular retraction with horizontal abduction of the internally rotated shoulder in prone</td>
</tr>
<tr>
<td>Latissimus dorsi</td>
<td>Press ups, lat pull down</td>
</tr>
<tr>
<td>Pectoralis major</td>
<td>Press ups</td>
</tr>
<tr>
<td>Pectoralis minor</td>
<td>Press ups</td>
</tr>
</tbody>
</table>

To progress from this phase to the advanced phase, the patient must display 1) full pain free range of motion, 2) no tenderness or pain upon examination of the shoulder, and 3) strength that is 70% of the uninvolved shoulder for internal/external rotators and the abductors/adductors.  

Athletes and those individuals who may want to return to strenuous activity will progress to the advanced phase. However, the general population of patients and sedentary individuals should now be able to adequately perform activities of daily living and will not require further progression.

**Advanced Phase**

In this phase of shoulder rehabilitation, exercise should be modified to prepare the patient for full return to activity. Strength gained in the intermediate phase can now be converted into task specific or sports specific activity. For instance, a tennis player can practice her back-hand in a controlled environment with the increased strength and control she attained from resistive band exercises and free weights. Core principles of stretching and strengthening from the previous phases should still be continued.

If the patient is an athlete, intensity and duration of sports specific activities should be increased to improve the patient's endurance. One way of improving a patient's strength, endurance, and power of the shoulder is to incorporate isokinetic exercise. Utilization of isokinetics prepares the upper extremity for high-velocity, high-energy training during this phase of rehabilitation. It has also been recommended that training be done in the plane
of the scapula, when possible, to avoid impingement.\textsuperscript{1} Plyometrics may also be introduced during this phase. Plyometric drills refer to quick, powerful movements involving a prestretch of the muscle thereby triggering the stretch-shorten cycle of the muscle.\textsuperscript{10} Plyometric drills are often employed to enhance the amount of neuromuscular coordination in the unstable shoulder joint. 

Plyometric drills for the upper extremity are listed in Figure 8. These dynamic activities prepare the shoulder musculature for stresses that will be encountered during sport specific or vocational activities.

Criteria for progression to the functional phase are full, pain free range of motion; no pain or tenderness upon examination; satisfactory muscle strength, power, and endurance based on functional demands; and an acceptable clinical examination.\textsuperscript{10}

Functional Phase

This phase is more specific for athletes who want to return to their sport or those patients who have specific work demands at which they need to be proficient. Practicing the exact skill that they are going to be performing prepares patients physically as well as psychologically.\textsuperscript{9} A combination of coordination exercises, strength and endurance training helps to stress the healing tissue to ready the patient for functional activities.

To ensure the patient/athlete is ready for a full return to previous activity levels, it is recommended that he/she complete a functional program developed by the therapist which may consist of specific drills and activities as well as
1. **Warm-up Exercises**
   - medicine ball rotation
   - medicine ball side bends
   - medicine ball wood chops
   - tubing external rotation
   - tubing diagonal pattern-D2
   - tubing biceps
   - push-ups

2. **Throwing Movement**
   - med ball soccer throw
   - med ball chest pass
   - med ball step and pass
   - med ball side throw
   - tubing plyos IR/ER
   - tubing plyos diagonals
   - tubing plyos biceps
   - plyos push-ups (boxes)
   - plyos (clappers)

3. **Medicine Ball Wall Exercises**
   - soccer throw
   - chest pass
   - side-to-side throw
   - backward side-to-side throw
   - forward two-hand through legs
   - one hand baseball throw

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Fig. 8—Plyometric drills for the upper extremity. Adapted from Orthopedic therapy of the shoulder. Kelly MJ, Clark WA. J. B. Lippencott Company: 1995.
variation of intensity and duration.\textsuperscript{9} Once the patient has completed the functional phase of rehabilitation, he/she should be ready to return to previous activity level. However, the patient should continue the core exercises of rotator cuff and scapulothoracic strengthening, range of motion, and gentle stretching as maintenance care of the shoulder.
CHAPTER VII

CONCLUSION

The shoulder complex is composed of five joints that act together to allow a large amount of mobility of the upper extremities. This mobility, however, sacrifices the stability of the shoulder. When stress variables such as trauma, overuse, and age related degeneration affect the components of the shoulder joint, impingement can occur.

Shoulder impingement syndrome is believed to be one of the most common causes of shoulder pain in adults today. Impingement occurs when there is decrease in the space below the acromion which causes "pinching" of the sensitive structures including the biceps tendon, subacromial bursa, and the rotator cuff.

Changes in the integrity of the rotator cuff function are often the focus of rehabilitation. If the function of the cuff musculature is altered, so is the synchronicity with the scapulothoracic joint which ultimately disturbs scapulohumeral rhythm. This integrated motion is needed for full, smooth range of motion, shoulder joint congruency, and maintenance of proper muscle lengths during overhead movements.
Clinical features of impingement may include pain in the anterior shoulder with activity, a painful arc with arm elevation between 60° and 120°, reports of "clicking," "popping," or "catching"; pain frequently occurring at night; and increased pain with resisted internal/external rotation and abduction.

Impingement syndrome is commonly classified in stages. Stage I and II are most often successfully treated by conservative treatment including rest, NSAIDs, modalities, and physical therapy intervention. Conservative treatment of stages III and IV of impingement is most often fruitless and surgical intervention is indicated.

There are many factors related to impingement, some of which may occur concurrently, further complicating diagnosis and treatment. These factors include instability, bony impingement, bursitis, muscular weakness, and rotator cuff degeneration.

Once diagnosis of the exact etiological factor has been made by proper utilization of evaluation skills and special tests, a shoulder rehabilitation program should be implemented. This program should focus on: 1) decreasing shoulder pain, 2) maintaining or increasing shoulder range of motion and joint play, 3) increasing strength of the rotator cuff and scapulothoracic musculature, 4) increased endurance, and 4) preparation of the athlete/patient to return to sport or previous activity level. The patient should progress through the phases of rehabilitation as the goals of each phase are met. Once the patient reaches a rehabilitation level that is sufficient to his/her premorbid activity level, the patient
has completed the in-house shoulder rehabilitation program. However, this is not the end of shoulder rehabilitation. It is essential that the patient continue stretching and strengthening the shoulder on a home program basis to assure proper function and avoid return of impingement symptoms.

The role of the physical therapist throughout the entire process of assessment, treatment, and reassessment is very important. The therapist must continually make adjustments in the treatment program and watch for proper execution of the program. If the patient does not respond to conservative treatment after a considerable period of rehabilitation, the therapist must consider referral to the appropriate medical source for surgical intervention.

Shoulder impingement syndrome is a complex subject with numerous related pathologies. This paper covers some of the more common factors of impingement syndrome, but it is beyond the scope of this paper to discuss every contributing factor and related pathology.
October 9, 1995

Neal E. Pratt PhD  
Program Director  
Orthopedic Physical Therapy  
Hahnemann University  
Philadelphia, Pennsylvania

Dear Sir:

My name is JoDee Backhaus and I am a graduate student in physical therapy at the University of North Dakota in Grand Forks, ND. I am doing my masters paper on shoulder impingement syndrome and while doing my literature review I came across your article- Anatomy and Biomechanics of the Shoulder. Your article was very well done and there were a lot of figures and tables which I found to be a helpful resource. I would like to know if I could get permission to submit some of your figures in my paper and sight your article as the source. I would greatly appreciate a reply as soon as possible. Please feel free to call me collect if you have any questions.

Sincerely,

JoDee Backhaus

Verbal permission given on 9-12-95.
DATE: 11/14/95
MESSAGE FROM: Jodie Backhaus
UND - PT Grad Student
Grand Forks, ND 58203

MESSAGE TO: Jean-Francois Villain
F.A. Davis Company
Philadelphia, PA

FAX NUMBER 215-568-5272

NORMAL DELIVERY

SPECIAL INSTRUCTION/COMMENTS:

2) you give full acknowledgment

Best wishes

 signature
November 3, 1995

Jean-Francios Villian
F.A. Davis Company
1915 Arch Street
Philadelphia, PA 19103

Dear Sir:

I am a graduate student in physical therapy at the University of North Dakota in Grand Forks. I am inquiring for permission to copy some figures from the book Joint Structure and Function, second edition, by Cynthia Norkin and Pamela Lavangie. I am working on my independent study for my master's degree and would like to include shoulder anatomy figures from this book. Each figure will be cited in proper format. My paper on shoulder impingement syndrome, as well as the figures included, will be used strictly for educational purposes. If you have any questions or need any further information, please contact me at (701)- 772-8736.

Sincerely,

JoDee Backhaus, B.S., P.T.
REFERENCES


