

T.C.

YEDİTEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

MASTER'S PROGRAM IN PHYSIOTHERAPY AND
REHABILITATION

**COMPARISON OF THE EFFECTS OF MULLIGAN
CONCEPT AND PNF (PROPRIOCEPTIVE
NEUROMUSCULAR FACILITATION)
TECHNIQUES APPLIED IN ADDITION TO
CONVENTIONAL TREATMENT IN CASES WITH
ADHESIVE CAPSULITIS**

MASTER THESIS

PELİN AKDOĞAN, PT.

İSTANBUL - 2021

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İSTANBUL-2021

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APPROVAL

This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated and numbered

Prof. Dr. Bayram YILMAZ
Director of Institute of Health Sciences

DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgement has been made in the text.

03.08.2021

PELIN AKDOĞAN

DEDICATION

I would like to dedicate my husband Can Florian KARAKAYA and also I thank to my loving parents Ayşe Nur AKDOĞAN and Cemil AKDOĞAN and my sister Sinem AKDOĞAN for their support.



03.08.2021

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LIST OF SYMBOLS AND ABBREVIATIONS

AC	Adhesive Capsulitis
ACJ	Acromioclavicular Joint
BMI	Body Mass Index
DASH	Disability of Arm, Shoulder and Hand Questionnaire
FS	Frozen Shoulder
GH	Glenohumeral Joint
PLG	Posterolateral Gliding
PNF	Proprioceptive Neuromuscular Facilitation
QoL	Quality of Life
ROM	Range of Motion
SC	Sternoclavicular Joint
SHT	Scapulohumeral Rhythm
ST	Scapulothoracic Joint
SPADI	Shoulder Pain and Disability Index
SPSS	Statistical Package of Social Science
TENS	Transcutaneous Electrical Nerve Stimulation
US	Ultrasound
WHO	World Health Organization

ABSTRACT

Akdoğan, P. (2021). Comparison of the Effects of Mulligan Concept and PNF (Proprioceptive Neuromuscular Facilitation) Technique Applied to the Conventional Treatment in Cases with Adhesive Capsulitis. Yeditepe University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, Master Thesis. Istanbul.

The aim of this study is to examine the effects of Mulligan Concept and PNF Technique applied in addition to conventional treatment on joint range of motion, pain and sleep quality in individuals diagnosed with adhesive capsulitis. The study included 42 (28F, 14E; $62.33 \pm$ years) volunteers who were treated under the direction of a physician in Sportomed Suadiye Clinic between June 2019 and August 2020. The characteristics of the participants were evaluated with the sociodemographic questionnaire prepared by us. Shoulder range of motions were measured using a goniometer. The pectoralis muscles, teres major, latissimus dorsi and rhomboid muscles were evaluated for shortness with the help of a tape measure. Using the Shoulder Pain and Disability index, the pain intensity and disability of the patients were evaluated in a way that each question was scored between 0-10. Upper extremity pain and function were evaluated by applying the Arm, Shoulder and Hand Questionnaire. Abnormal scapular motion was evaluated with the Lateral Scapular Slip test. Sleep problems were evaluated with the Pittsburgh Sleep Quality Index. Individuals were randomly divided into two groups as Mulligan Group (n=21) and PNF Group (n=21). Individuals in both groups had the conventional treatment, which included a 20-minute hotpack and 100Hz, 0.05-0.07 MS TENS. A home exercise programme was given to the patients. The duration of treatment was 5 days a week for 3 weeks. At the end of the treatment, there were significant differences in terms of ROM, muscle shortness, pain, QoL and sleep quality in both groups compared to pre-treatment ($p<0.05$). However, none of the applications found to be superior to each other ($p>0.05$). In the line of our hypothesis, Mulligan concept and PNF technique applied in addition to conventional treatment in patients with adhesive capsulitis have a positive effect on joint range of motion, pain, quality of life and sleep quality.

Keywords: adhesive capsulitis, range of motion, quality of life, sleep quality, pain, Mulligan Concept, PNF Techniques.

ABSTRACT (Turkish)

Akdoğan, P. (2021). Adeziv Kapsülitli Olgularda Konvansiyonel Tedaviye Ek Olarak Uygulanan Mulligan Konsepti ve PNF (Proprioseptif Nöromusküler Fasilitasyon) Tekniğinin Etkilerinin Karşılaştırılması. Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon ABD., Yüksek Lisans Tezi. İstanbul.

Bu çalışmanın amacı adeziv kapsülit tanısı alan bireylerde konvansiyonel tedaviye ek olarak uygulanan Mulligan Concept ve PNF Tekniğinin eklem hareket açıklığı, ağrı ve uyku kalitesi üzerine etkilerini incelemektir. Çalışmaya Haziran 2019-Ağustos 2020 tarihleri arasında Sportomed Suadiye Kliniği'nde hekim kontrolünde tedavi gören 42 (28K, 14E; 62,33 $\pm$ yıl) gönüllü dahil edildi. Katılımcıların özellikleri tarafımızca hazırlanan sosyodemografik anket ile değerlendirildi. Omuz hareket açıklığı bir gonyometre kullanılarak ölçüldü. Pektoralis kasları, teres major, latissimus dorsi ve rhomboid kasları mezura yardımıyla kısalık açısından değerlendirildi. Omuz Ağrısı ve Özürlülük indeksi kullanılarak hastaların ağrı şiddeti ve özürlülüğü her soru 0-10 arasında puanlanacak şekilde değerlendirildi. Kol, Omuz ve El Anketi uygulanarak üst ekstremité ağrı ve fonksiyonu değerlendirildi. Anormal skapular hareket Lateral Skapular Kayma testi ile değerlendirildi. Uyku sorunları Pittsburgh Uyku Kalitesi İndeksi ile değerlendirildi. Bireyler rastgele Mulligan Grubu (n=21) ve PNF Grubu (n=21) olmak üzere iki gruba ayrıldı. Her iki gruptaki bireylere de , 20 dakikalık bir sıcak paket ve 100Hz, 0.05-0.07 MS TENS içeren geleneksel tedavi uygulandı. Hastalara ek olarak evde egzersiz programı verildi. Tedavi süresi 3 hafta boyunca haftada 5 gün olarak belirlendi. Tedavi sonunda her iki grupta EHA, kas kısalığı, ağrı, yaşam kalitesi ve uyku kalitesi açısından tedavi öncesine göre anlamlı farklılıklar vardı ($p<0.05$). Ancak uygulamaların hiçbiri birbirine üstün bulunmadı ($p>0.05$). Hipotezimiz doğrultusunda adeziv kapsülitli hastalarda konvansiyonel tedaviye ek olarak uygulanan Mulligan konsepti ve PNF tekniği eklem hareket açıklığı, ağrı, yaşam kalitesi ve uyku kalitesi üzerinde olumlu etkiye sahiptir.

Anahtar Kelimeler : adeziv kapsülit, eklem hareket açıklığı, yaşam kalitesi, uyku kalitesi, ağrı, Mulligan Konsepti, PNF Teknikleri.

1.INTRODUCTION AND PURPOSE

Adhesive capsulitis, also known as frozen shoulder, is a condition characterized by restriction and pain in the shoulder joint that develops due to fibrosis and contracture of the glenohumeral joint capsule (1,2). Its incidence is 3% in the general population and 10-20% in the diabetic population (3). It is frequently seen between the ages of 40-70 and more in women than in men. (1)

Adhesive capsulitis is divided into two subgroups, primary and secondary: idiopathic, progressive, and painful, active and passive loss of movement, and primary adhesive capsulitis with similar histopathological appearance but as a result of intrinsic and extrinsic factors - trauma, immobilization, rotator cuff injuries, diabetes, etc. secondary adhesive capsulitis. (1, 4). The sudden onset of pain in primary adhesive capsulitis limits the patient's gradual use of the arm. (4)

Pain in the deltoid insertion is associated with inability to sleep on the affected side, painful and incomplete elevation and external rotation, and a normal radiological appearance. Capsular skates are listed as the most affected external rotation, abduction, and internal rotation, respectively. The nondominant side is frequently affected (5). Frozen shoulder is usually seen bilaterally. A few years after symptoms begin, they often appear in the contralateral shoulder, but do not affect the same shoulder twice. (6)

Adhesive capsulitis develops in three stages: Freezing Phase, Frozen Phase and Thawing Phase. Freezing Phase, in which the symptoms of increasing pain and limitation in active and passive joint movements last up to 9 months, the Frozen Phase of 4-20 months with minimal pain and significant imitation other than the last point of joint movement, and the Thawing Phase with progressive improvement in joint movements that can last up to 26 months. (3). Although some patients have complaints of long-term pain and restricted shoulder movements for more than 3 years, most patients recover within 3 years. (5,7)

A condition that negatively affects patients with adhesive capsulitis as well as activity limitations is night pain. These pains are generally chronic and adversely affect the patient's quality of life and daily routine. Such musculoskeletal pain causes motor control problems, leading to muscle weakness (8).

The treatment of adhesive capsulitis is examined in two groups as conservative and surgical. Conservative therapy includes NSAID use, intra-articular injection, exercise program, and physical therapy modalities. Joint mobilization techniques provide joint and soft tissue mobility. In addition, exercise, massage and physiotherapy modalities are used in pain management in the literature. Hot and cold applications, ultrasound, interferential therapy, transcutaneous electrical nerve stimulation and laser therapy are some of the electrotherapy agents that are used. (9,10). Stretching exercises play an important role in musculoskeletal problems. Especially deep warming agents are more effective in tissue extensibility than superficial ones. The effectiveness of using the two applications together has been shown in studies. (11).

In the treatment, besides electrotherapy agents, the exercise modality PNF (1), which facilitates the neuromuscular mechanism by stimulating the proprioceptors to reduce pain and limitation, and the Mulligan technique, which is based on positional error due to misalignment of the joint and aims painless movement by repositioning the bone. In the Mulligan technique, while gliding force is applied to the joint manually by the therapist or passively by the patient, simultaneous osteokinematic joint movement is combined to reposition (10). Mulligan technique provides a hypoalgesic effect during and after the application and changes the sympathetic nervous system. (12).

The PNF concept includes a theoretical mechanism that increases range of motion and muscle activation: autogenic inhibition, reciprocal inhibition, stress relaxation and gate control theory. (9) The mechanisms of PNF techniques application include stimulating postural reflexes by facilitating muscles with the force of gravity, providing muscle activation using eccentric contractions, and utilizing diagonal movement patterns for activation of biarticular muscles. (1)

The aims of the treatment program, which includes range of motion, strengthening and stretching exercises, PNF and mobilization techniques, are to reduce pain due to capsular contracture and to improve glenohumeral mobility. (9)

When the literature is reviewed, it is seen that the Mulligan and PNF techniques applied in addition to conventional therapy in these patients have a positive effect on range of motion, pain status and sleep quality (5,9,10,13). However, the superiority of all these treatment methods to each other is unknown. With the findings obtained as a result of the study, it is planned to present the treatment options that can be applied in addition to conventional treatment and their effects. In this postgraduate thesis, it is aimed to determine a treatment protocol by comparing the effects of Mulligan Concept and Proprioceptive Neuromuscular Facilitation on range of motion, pain and sleep quality in patients with adhesive capsulitis.

The hypotheses of the study can be listed as follows:

- H0: PNF has no advantage over Mulligan.
- H1: Mulligan Concept is effective in the development of joint range of motion, pain and sleep quality in patients diagnosed with adhesive capsulitis.
- H2: Proprioceptive Neuromuscular Facilitation is effective in the development of range of motion, pain and sleep quality in patients diagnosed with adhesive capsulitis.

2.THEORETICAL FRAMEWORK AND LITERATURE

2.1 Structure of the Shoulder Complex

The most complex and most active joint in the human body is the glenohumeral joint (14). The clavicle, scapula, humerus, the scapulothoracic, sternoclavicular and acromioclavicular joints (15) connecting them and the muscles that provide their mobility combine to form the shoulder complex. (14). The cervicothoracic junction, the first six costa and thoracic vertebrae are included in this group, and each joint plays an active role in the shoulder joint movements with its own anatomical, functional activity and loading characteristics. (16). There is a need for coordination between the glenohumeral, sternoclavicular, acromioclavicular and scapulotoracic joints. (14, 17, 18). Although each joint can work in isolation and produce minor movements, obvious actions such as raising and lowering our arm can only be created when all four joints work together and synchronously. (19, 20)

2.1.1. Bone Structure of the Shoulder Complex

It consists of three bones: clavicle, scapula, and humerus. This complex structure is connected to the skeleton with the sternum and the thorax, which affect the function of the structure with its shape. (15)

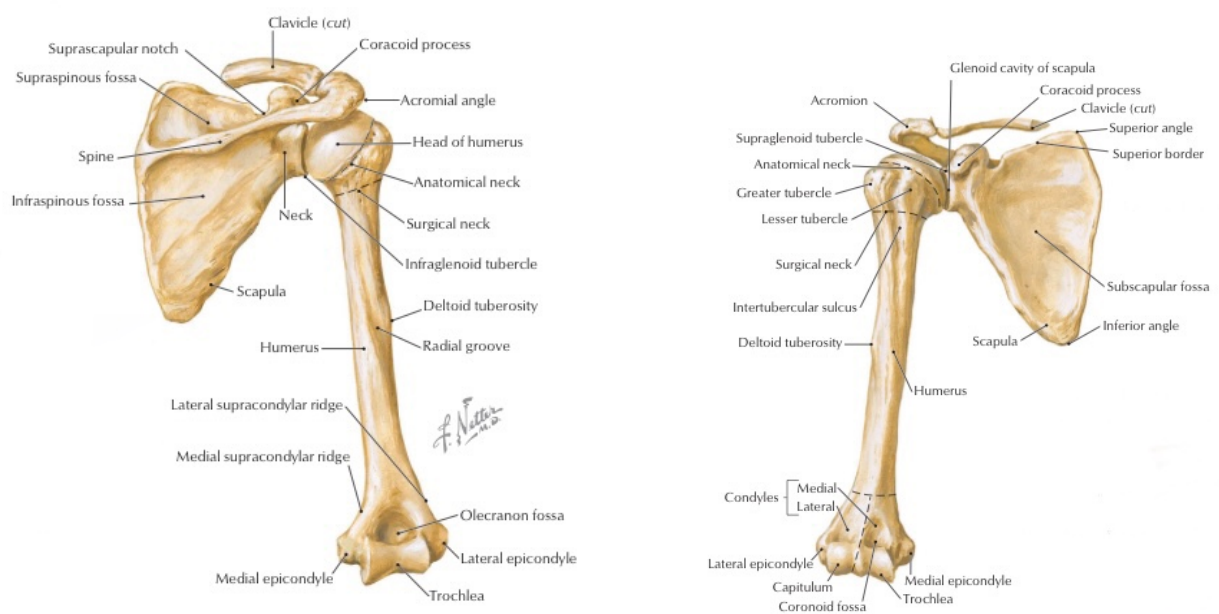


Figure 2.1. Anterior and Posterior View of Shoulder Complex Bones [21]

2.1.1.1. Clavicle

The middle 1/3 of the clavicle, which is cylindrical and S-shaped, is the weakest and thinnest part mechanically and is the bone with the most frequent fracture (18,21). It acts as a support to keep the shoulder complex attached to the skeleton. (15, 22) In addition, it has functions such as providing a place for attachment to the muscles, protecting the nerves and vessels, contributing to increasing the range of motion of the shoulder, and transferring muscle strength to the scapula. . (15,18)

The medial 2/3 part of this bone lying in the transverse plane is convex anteriorly; the lateral 1/3 part makes it convex posteriorly. With this shape, it is important in shoulder movements. Its superior surface is smooth and can be palpated under the skin. Anteriorly, its surface is used medially by the pectoralis major and laterally by the deltoid as the attachment site. Inferiorly, the costoclavicular ligament and the subclavius muscle, the surface of which is medial; laterally it is the attachment point for the coracoclavicular ligament.

Its medial and lateral ends form the articular surface for the sternum and acromion, respectively. It widens medially to form the head of the clavicle and articulates with the sternum. 1/3 of the lateral is flatter and combine with the acromion to form the acromioclavicular joint. It is covered with fibrocartilage instead of hyaline cartilage. Medial and lateral angles can be easily palpated. (15).

2.1.1.2. Scapula

The scapula takes many tasks for optimal shoulder function. It is connected to the axial skeleton by the clavicle, acromioclavicular and sternoclavicular joint. It connects to the posterior part of the thorax with the help of Trapez, Rhomboid and Serratus. With the connection of the clavicle, it allows up-down translation of the thoracic wall and protraction-retraction. Mobility and stability depend on muscle activity. (23). It is a flat, triangular bone whose primary task is to create a total of 17 muscle attachment points for the shoulder. (18,21,22,24, 25).

The scapula has 5 main functions:

1. Creates a stable area for the glenohumeral joint by increasing the socket compatibility of the glenoid fossa with synchronized medial and lateral rotations (23).

2. Protraction-retraction makes.
3. It prevents the risk of impingement by elevating the acromion with its rotation.
4. Provides attachment point to muscles.
5. Creates a proximal-distal link for the kinetic chain. (14, 22).

Three groups of muscles adhere to the scapula. The first group is the trapezoidal, rhomboid that provides rotation and stabilization of the scapula. It consists of levator scapula and serratur anterior. The second group is the extrinsic muscles consisting of the deltoid, biceps and triceps. These muscles are located on the lateral surface and perform gross motor movements in the glenohumeral joint. The third group consists of the rotator cuff muscles, which are intrinsic muscles (22).

Its fracture is rarely seen (21). With its width in the mediolateral, it provides connection points to three of the rotator cuff muscles. (15,20). It has two surfaces as anterior (costal) and posterior (Dorsal). The slightly concave anterior surface forms the supscapularis fossa and provides origin to the subscapularis muscle. (26). Serratus anterior passes through the medial border of the anterior surface. The dorsal surface is divided by the spina scapula into two regions: supraspinous fossa superiorly, infraspinous fossa inferior. Spina scapula, which is diagonal, forms the acromion process by extending laterally and superiorly to the scapula. (26) The acromion forms a roof for the humeral head and is mostly defined as flat. Unlike in the study of Bigliani and Morrison it is suggested that it can be found in three different forms: flat, round, and hook-shaped, which also causes impingement syndrome. (15, 24) Trapezoid and levator scapula muscles are located on the superior side of the medial edge. Lateral to the anterior surface is the coracoid ridge below which the suprascapular nerve passes.

Teres major, teres minor and latissimus dorsi muscles are attached to its lateral edge. The lateral edge continues superior to the glenoid fossa, which is the superficial pit where the scapula and the GH joint join. (15, 26). The glenoid fossa forms the socket of the glenohumeral joint, often referred to as the shoulder joint, and provides a stable articular surface coordinated with the movement of the scapula humerus. (22,26)

It makes an angle of approximately 30-45 with the frontal plane. (15,25,27). The glenoid surface makes 4-12 degrees of retroversion in the scapular plane. (18). Rotation of the scapula in the frontal plane is called medial or lateral rotation according to the position of the glenoid fossa. (15,28). When viewed from the sagittal plane, the scapula makes a 10-20 degree tilt forward with respect to the frontal plane. (14,25). This forward tilt develops depending on the position of the scapula on the thorax. (15). In healthy women over the age of 50, the scapula was more retracted. It has been concluded that increased retraction is a compensatory mechanism to balance the flexion posture that develops with aging. (25).

2.1.1.3. Proximal Humerus

The humerus is the longest bone of the upper extremity, consisting of head, neck and shaft parts. The surface of the humeral head that articulates with the glenoid cavity of the scapula resembles a hemisphere. (15,18,21,29). The humeral head ends at the anatomical neck, indicating that the articular surface ends. The tuberculum majus, which is easily palpable laterally form a surface for supraspinatus, infraspinatus and teres minor. Anteriorly, the tubercle minor forms a surface to the subscapularis. On the anterolateral surface of the humeral shaft there is deltoid tuberositas, the disqualifying attachment point of the deltoid muscle. In the posterior and proximal half of the humerus, there is a spiral groove through which the radial nerve passes. (15).

The humeral head angulates 130-150 degrees with its shaft and 26-31 degrees retroversion is seen. (18).

Surgical neck fractures, which are risky for the axillary nerve, are common. (21). In addition, the surgical neck is responsible for glenohumeral dislocation. Proximal humeral fracture risk increases over the age of 40 and is associated with osteoporosis. (18)

2.1.1.4. Sternum and Thorax

Although not part of the shoulder complex, the superior part of the sternum forms the articular surface proximal to the manubrium clavicle. This joint surface is called the

clavicular notch. The two clavicular notches are separated by a sternal or jugular notch. This notch is used to locate the sternoclavicular joint as it is quite prominent.

The ligaments connecting the clavicle to the sternum and the 1st rib: the anterior and posterior sternoclavicular ligament is the interclavicular ligament, the costoclavicular ligament. (30)

Scapular movements are restricted due to the shape of the thorax. (15). Both scapulae start from the superior thorax and rise upward between the 1st and 8th ribs and T2-T7-8. The medial to the spina scapula is at the T2 spinous process level. The inferior angle of the scapula is usually at the T7 spinous process level.

Dorsal surface of thorax is convex shaped. Therefore, when the scapula moves superiorly, it also goes anteriorly. (15).

The main connections between the scapula and ribs are the scapulothoracic Bursa, serratus anterior and subscapularis muscles (30).

2.1.2. Joint Structure of the Shoulder Complex

2.1.2.1. Glenohumeral Joint

The glenohumeral joint is the center of motion in the shoulder and expands the acromioclavicular and sternoclavicular range of motion. (31). This joint, which is spheroid type, is located between the humeral head and the glenoid fossa. (24) The articular surface of the humeral head retroverses 30 degrees, and the glenoid cavity between 4-8 degrees. It is possible to perform a wide variety of movements in this joint. However, the shoulder joint is not a stable joint and the joint surfaces are often incompatible with each other during movement (18,24). The only movements in which maximum stabilization and full compliance are achieved is abduction and external rotation. (33,34). This position also has the greatest risk of dislocation, subluxation and Strain. (33)

The glenohumeral joint, which has a wide range of motion, has a high risk of dislocation and ligaments cannot prevent subluxation without muscles. (24)

The ligaments in the shoulder girdle extend at different angles to limit various movements in many directions. The coracoacromial ligament extends in the vertical direction between the acromion and the coracoid process, supporting the humeral head from the top and preventing it from going up. The acromioclavicular ligament extending in the horizontal direction prevents the separation of the acromion process and the lateral clavicle. (26). The protrusion of the humeral head in the inferior direction is blocked by the Deltoid, the long head of the Triceps, the short head of the Biceps and the Coracobrachialis.

Coracoacromial arc is formed with the coracoid process, the acromion and the coracoacromial ligaments connecting them. The area between the humeral head and the coracoacromial arch is called the subacromial space. The subacromial area is covered by rotator cuff tendons and subacromial bursa. The distance between the inferior surface of the acromion and the humeral head was 9-10mm by radiological measurement in normal shoulders. The decrease in this distance can be attributed to tears of the rotator cuff tendon and long biceps head. The compression in these structures occurs mostly under 1/3 anterior of the acromion. The decrease in the volume of the subacromial area causes impingement syndrome. (25)

Glenoid Labrum: Glenoid cavity - providing 30% contact with the humeral head (18). The articular surface of the glenoid fossa is less than 1/3 of the humeral head. (14,33,35). Glenoid labrum attaches to the glenoid cavity and the fibrocartilagenous feature of the structure contributes to joint stability by increasing the depth and surface area (14, 21, 33). Howell Galinat determined the depth of the labrum as 9 mm in the superior-inferior direction and 5 mm in the anteroposterior direction as a result of his study on cadavers. (14, 25,30). It constitutes 50% of the total socket depth. (25, 31)

When there is no glenoid labrum, the mentioned ratio is about 1/4. (16). When the integrity of the labrum is broken, the resistance to humeral translation decreases by 20%.

(18). In the elevation movement, the humeral head initially moves in the superior direction between 1-3 mm. It is then centered with the glenoid fossa. (33). Matsen et al. Found that the centering of the humerus head in the glenoid fossa optimizes the mechanical advantages of rotators. (30).

Table 2.1. Stability of Glenohumeral Joint

Position	Structure
Dependent	Coracohumeral ligament Superior glenohumeral ligament Supraspinatus muscle
Elevation (degrees)	
Lower range (0-45)	Anterior capsule Superior glenohumeral ligament Coracohumeral ligament Middle glenohumeral ligament Subscapularis, infraspinatus, and teres minor muscles
Middle range (45-75)	Middle glenohumeral ligament (MGHL) Subscapularis muscle (decreasing importance) Infraspinatus and teres minor muscles Inferior glenohumeral ligament (superior band)
Upper range (≥ 75)	Inferior glenohumeral ligament (anterior band, axillary pouch)
Throughout elevation	Dynamic activity of rotator cuff

Wilk, E., et al. The athletes shoulder. 2009 : Churchill Livingstone, p:9
Glenohumeral Joint Ligaments:

1. Glenohumeral Ligament

1.a.Superior glenohumeral ligament : extends from the superior of the glenoid labrum, the tuberculum supraglenoid and the base of the coracoid process to the superior of the

tuberculum minus. Basmajian et al found that the superior glenohumeral ligament passively inhibits the inferior subluxation or dislocation of the humerus. (14, 16, 25). It also limits external rotation between 0-60 degrees with the coracohumeral ligament and supraspinatus. (31).

1.b. Middle glenohumeral ligament: The tuberculum extends obliquely in the inferior and lateral directions starting from the supraglenoid and the tuberculum attaches to the minus. It works in abduction and external rotation of the shoulder. (15, 16). Together with the subscapularis tendon, it is one of the important anterior stabilizers. It limits lateral rotation in 0-90o elevation. (25, 31).

1.c. Inferior glenohumeral ligament: This ligament, which is thicker (14) and longer than other ligaments, starts from the glenoid labrum and ends at the inferior and medial surfaces of the humeral neck and prevents excessive anterior translation of the humeral head during abduction and external rotation movement. (14,33). It is the most important glenohumeral stabilizer ligament. (14).

2. Coracohumeral Ligament

Looking at histological sections, it is seen as a thickening of the upper part of the glenohumeral joint capsule, but biomechanically it is considered as a ligament. It creates tension and stability when the arm is at the side. (26). The coracohumeral ligament provides joint stability in adduction and external rotation movement. (16). Also it controls the lateral rotation in the 0-60 degrees elevation of the humerus. (25). The fibers of this ligament adhere to the tuberculum majus and minus and form a bridge in the bicipital groove (14). By this position, it provides an important stabilization mechanism for the biceps tendon. (16)

3. Transverse Humeral Ligament

The tubercle extends between the majus and the minus, making the intertubercular groove a channel through which the long head of the biceps can pass the tendon. Thus, the tendon and synovial sheath become stable during glenohumeral joint movements. (16, 21).

Rotator Cuff Interval: It is a triangular capsular area between the supraspinatus and subscapularis tendons. The coracohumeral ligament and the superior glenohumeral ligament, the coracoglenoid ligament, the medius glenohumeral ligament and the anterior of the supraspinatus tendon come together in this area to stabilize the intraarticular portion of the tendon of the long head of the biceps. (16, 33,36,37,38).

Bursas related to the glenohumeral joint

- Subacromial bursa
- Subdeltoid bursa, *which is the largest bursae in human body*
- Bursa subtendinea musculi subscapularis
- Bursa subtendinea musculi infraspinati
- Bursa subtendinea musculi teretis majoris
- Bursa subtendinea musculi latissimi dorsi
- Bursa subtendinea musculi tricipitis brachii
- Bursa subtendinea musculi coracobrachialis (16)

2.1.2.2. Sternoclavicular Joint

It is a fibrocartilagenous saddle type joint formed between the medial clavicle, sternum manubrium and the superior cartilaginous rib. (16, 26, 30). Although it is a saddle type joint in terms of joint surfaces, it is similar to a ball-socket joint in terms of function. (25). The sternoclavicular is the only true joint between the upper limb and the trunk (14,18,24) and is easily palpable. Since the bone stability in this joint is low, ligamentous structures provide the stability of the joint. (16). 30-35 degrees elevation between the disc and the medial end of the clavicle, 35 degrees anteroposterior movement between the disc and sternum, and 45-50 degrees rotational movements of the clavicle around the long axis are observed. (18,25). The most important relation of the sternoclavicular joint is with the parietal pleura of the lung and the trachea. These structures can be damaged in dislocations of the clavicle posteriorly from the sternum. (16)

Sternoclavicular Joint Ligaments

1. Anterior sternoclavicular ligament: It lies between the sternal end of the clavicle and the anterosuperior of the manubrium and the first cartilage Costa. (30)

2. Posterior sternoclavicular ligament: It is the most important stabilizer in the depression movement of the lateral end of the clavicle. Together with the anterior sternoclavicular ligament it inhibits the anteroposterior movement of the clavicle. (14) It causes anterior subluxation of the joint by weakening with aging. (16,30).

3. Interclavicular ligament: Connecting the sternal ends of both clavicles contributes to the stability of the sternoclavicular joint in the superior direction. (14,16,30).

4. Costoclavicular ligament: It is the most important structure limiting the movement of the sternoclavicular joint by preventing the mediolateral movement of the clavicle over the sternum. (16,30). It becomes tense in shoulder elevation and protraction movements. (14)

2.1.2.3. Acromioclavicular Joint

It is a planar joint that forms between the acromion process of the scapula and the lateral clavicle. (14, 16, 26). During elevation, it ensures the continuation of the lateral rotation of the scapula from 100 degrees of abduction (14). Its stabilization is provided by the acromioclavicular ligament and the coracoclavicular ligament. Deltoid and trapezius muscles also constitute the dynamic balance element of the joint. These muscles gain importance as dynamic stabilizers in any problem that occurs in their ligaments. (16).

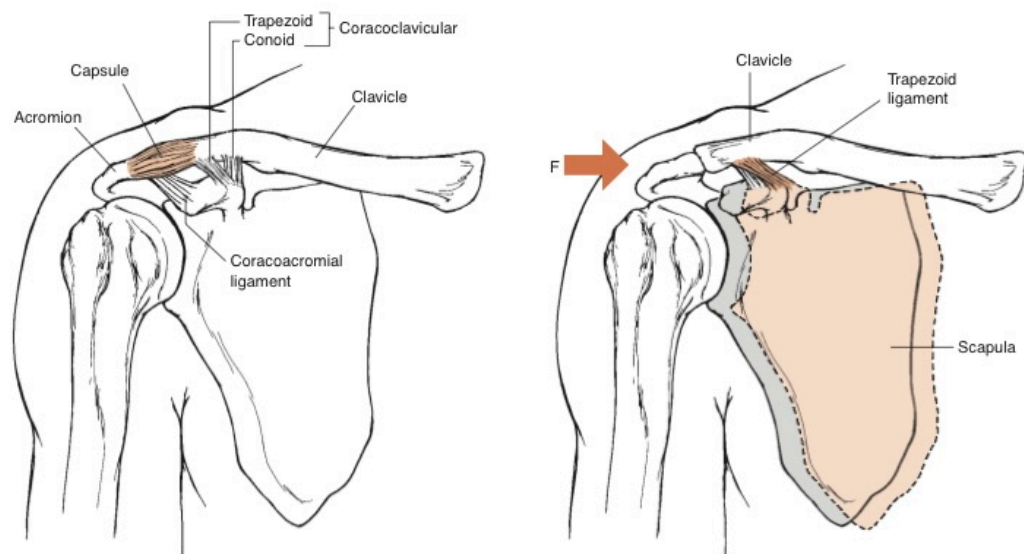


Figure 2.2. Acromioclavicular Joint [15]

Acromioclavicular Joint Ligaments

1. Acromioclavicular ligament: It is a fibrous band starting from the acromion to the clavicle, providing the antero-posterior stability of the joint. (16,18).

2. Coracoclavicular Ligament: Although its location is far from the joint, it is the most effective bond that connects the acromion and the clavicle (14). Its primary task is to prevent vertical displacement. (18). It provides the stability of the acromioclavicular joint and also supports scapulohumeral adaptation. It consists of two parts, the conoid ligament and the trapezoid ligament. (25). The external rotation of the scapula is increased by the fact that the two parts have different adhesion points (14). In shoulder elevation, the scapula rotates so that the coracoid process moves in the inferior direction. As a result, the stress that occurs in the coracoclavicular ligaments causes the clavicle to rotate around its long axis and the amount of elevation increases. (14,16,21,25). At full elevation, the clavicle rotates 50 degrees. If the clavicle did not rotate, the abduction would be 120 degrees. (14)

2.1.2.4. Scapulothoracic Joint

The position of the scapula on the thorax is provided by the shape of the thorax and the tonus of the levator scapula, pectoralis minor, rhomboids, serratur anterior and trapezius muscles at the rest position. Although the scapulotoracic joint is not considered as a true joint since there is no connection between the scapula and thorax, it is considered as a functional joint due to the sliding surface of the subscapularis and serratur anterior fascia (18,24, 26, 30). The scapula is connected to the thorax by acromioclavicular and sternoclavicular joints. (26)

The ST joint supports arm elevation by upward rotation of the scapula and upward rotation of the glenoid fossa.

Scapulothoracic Joint ligaments:

1. Coracoacromial ligament: Combining with the acromion and coracoid process, it forms the coracoacromil arc and prevents the extreme superior movement of the humeral head. (14,24,). It limits the displacement of the humeral head in the glenoid fossa in overhead activities (16,26)

2. Superior Transverse Scapular Ligament: It provides passage for the scapular artery and structures by turning the scapular into a drawn hole. (16)

3. Inferior Transverse Scapular Ligament: Also called the spinaglenoid ligament. It creates an arc for the passage of scapular vessels and nerves. (40)

2.1.3. Muscle Structure of the Shoulder Complex

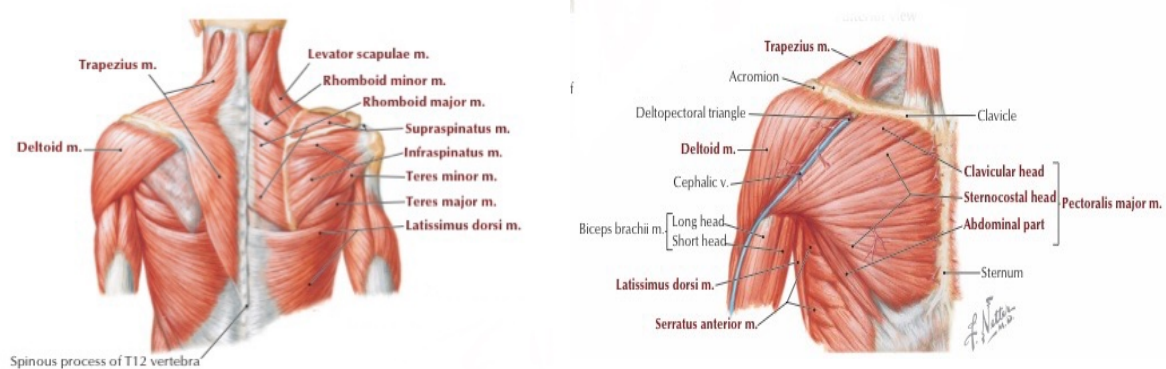


Figure 2.3. Anterior and Posterior View of Shoulder Complex Muscles [21]

2.1.3.1. Deltoid

It starts from the 1/3 lateral of the clavicle, the acromion and spina scapula and extends to the deltoid tubercle. It consists of anterior, middle and posterior fibers. While the anterior fibers are responsible for flexion, adduction and internal rotation movement in the sagittal plane; the movements of extension, external rotation and horizontal abduction are performed by the posterior fibers. Middle fibers cause abduction movement. (21, 33) Innervation is provided by the axillary nerve C5-C6. (15,20,39).

It acts primarily in almost all movements of the shoulder. It acts as an important lever for the glenohumeral joint. Strong abduction occurs when all fibers work at the same time. While performing the deltoid abduction movement, the supraspinatus stabilizes the humeral head and prevents compression. This function is important in overhead activities. (39). While it performs its strongest activity at 90-180 degrees of elevation, it draws a plateau between those who will turn over. (20).

2.1.3.2. Pectoralis Major

Pectoralis Major, the origin of which is the costal cartilage of the medial clavicle, sternum and 1-7 Costa, terminates in the intertubercular groove. Clavicular fibers are responsible for flexion, costal fibers for extension, and all fibers are together for horizontal adduction. In addition, all fibers provide internal rotation, especially in the

neutral position, and abduction and adduction at different levels. It is innervated by medial and lateral pectoral nerves, C5-T1. (21, 41).

Pectoralis Major, which is a strong muscle with multiple and different fiber arrangement, performs the movements of the shoulder in front of the body such as pushing, reaching out and throwing. It makes a rotation near the adhering point and with this feature, it provides leverage arm to the fibers in different positions. In the full flexion position, this rotation becomes straight and allows arm to perform extension and internal rotation. This feature is important in vigorous overhead activities. (39)

The clavicular part of the Pectoralis Major, which is not active in the abduction movement, is the most active in the forward flexion movement. This activity peaks at 75 and 115 degrees. Again, the clavicular part works synchronously with the anterior fibers of the deltoid and performs anterior flexion function. (20).

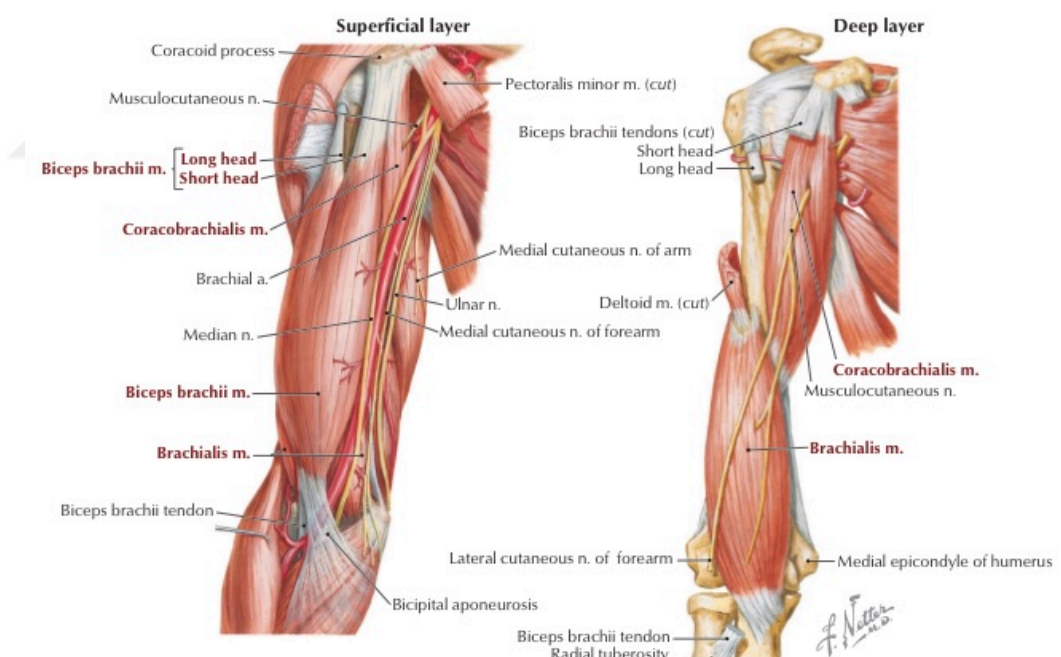


Figure 2.4. Anterior Compartment of Shoulder Muscles and Nerves [21]

2.1.3.3. Coracobrachialis

It extends between the coracoid process and 1/3 of the humerus and the medial shaft. Coracobrachialis, whose primary task is glenohumeral elevation, is also involved in

flexion and adduction movements (42). N. Musculocutaneus, C5-C7 is responsible for innervation (43).

They are like the 3rd Head of the Biceps and work in coordination with the Biceps to reveal the flexion and adduction movement. Coracobrachialis is a powerful stabilizer and is responsible for arm swing in walking. (39)

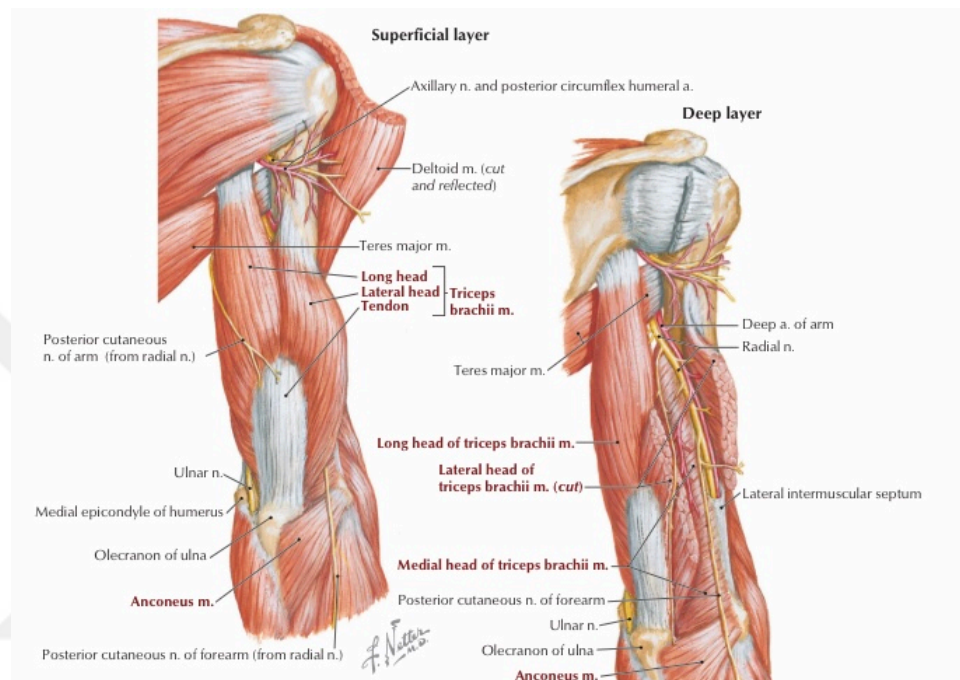


Figure 2.5. Posterior Compartment of Shoulder Muscles and Nerves [21]

2.1.3.4. Biceps Brachii

The long head starts from the supraglenoid tubercle and the short head starts from the coracoid process and extends to the radial tuberositas and bicipital apenurosis. The long head causes joint flexion and adduction, and the short head adducts. N. Musculocutaneus provides C5-C6 innervation. In the flexion movement, the long and short head of the Biceps work in a coordinated manner, helping stabilization. The short head of the biceps combines with the Coracobrachialis and provides the forward movement of the arm in adduction and walking. (39). Also, the short head of the Biceps initiates elevation and pulls the humerus in the supine position to the side of the trunk. (42).

2.1.3.5. Pectoralis Minor

It starts from 3-5 costas and extends to the coracoid process. Scapular protraction with the serratus anterior is involved in the lower rotation of the scapula with the Levator scapula (44). Its innervation is provided by the medial and lateral pectoral nerves, C5-T1 (43). It provides a connection between the rib cage and the scapula. When contracted in isolation, the coracoid process pulls the scapula anteriorly and provides elevation. (43). When body weight is transferred onto the arms, it aids in anterior stabilization of the scapula. This muscle also functions as a secondary respiratory muscle by expanding the thorax and increasing the space in the thorax. (39, 42)

2.1.3.6. Subclavius

It is between the 1st rib and the inferior 1/3 middle part of the clavicle. It helps the inferior stabilization of the clavicle, protraction of the scapula and anterior-inferior movements of the shoulder. Subclavius muscle is innervated by the subclavian branch of the brachial plexus, C5-C6 (21,39,43).

2.1.3.7. Trapezius

It consists of upper, middle and lower fibers. The upper fibers starting from external occipital protuberance, 1/3 medial to superior nuchal line, nuchal ligament, the spinous process of C7; the middle fibers starting from the T1-T5 spinous processes and the lower fibers starting from the T6-T12 spinous processes extend to the 1/3 lateral of the clavicle, the acromion and the spine scapula (43).

It is responsible for elevation, retraction, and rotation of the scapula. Specifically, upper fibers produce elevation, middle fibers produce retraction and lower fibers produce scapular depression. The upper and lower fibers work together with the Serratus anterior (33) to increase the glenohumeral joint movement by providing the optimal position of the glenoid fossa with the upward rotation of the scapula in overhead activities. The middle and lower fibers work in coordination to stabilize the scapula and thorax (33). It is innervated by N. Accessorius, C3-C4. (21,39)

2.1.3.8. Serratus Anterior

It lies between the upper and outer surface of the eight and ninth costa and the medial surface of the scapula. It is involved in the upward rotation, protraction and depression movements of the scapula. The innervation of Serratus Anterior is provided by N. Long thoracic, C5-C8 (43,44). Together with the pectoralis minor, it is responsible for the stabilization of the scapula on the thorax while transferring weight on the arm. With the trapezius, it provides the glenohumeral rhythm by directing the glenoid fossa in order to reach the maximum range of motion in overhead activities. (39). One of its most important tasks is to provide the upper rotation of the scapula by contracting synchronously with the upper and lower fibers of Deltoid. (33)

The contribution of Trapezius upper-lower fibers and Serratus anterior muscles is important in scapular stabilization and mobility. Synchronization of these two muscles primarily initiates upward rotation and posterior tilt of the scapula (25). In addition, the activation of the lower fibers of the trapezius provides stabilization in the overhead activities of the arm and return from maximum elevation. (23).

The middle part of the trapezius starts at C7, T1 level and reaches the acromion and spina scapula. According to the connection and orientation patterns of the trapezius, a connection can be made regarding the upward rotation of the scapula. C7 and T1 fibers lie close to the axis of rotation of the scapula. With the Serratus Anterior initiating the upward rotation, the rotation efficiency of the Trapezius also increases. Rotation of the scapula lifts the acromion and the two muscles create a force pair together to increase the upward rotation and prevent the downward rotation.

The trapezius muscle alone cannot create a force pair on the scapula. Because the upper and lower fibers cannot move in the opposite direction and cannot reset the net force. In order for the force to be reset, another force like Serratus working in the opposite direction is needed. When Serratus works synchronously with Trapeze, its upper and lower fibers work differently. When the serratus is activated, it wants to pull the scapula laterally and is opposed by the lower fibers of the trapezius. The upper fibers, on the other hand, create an upward rotation of the scapula, creating a complementary effect on the Serratus.

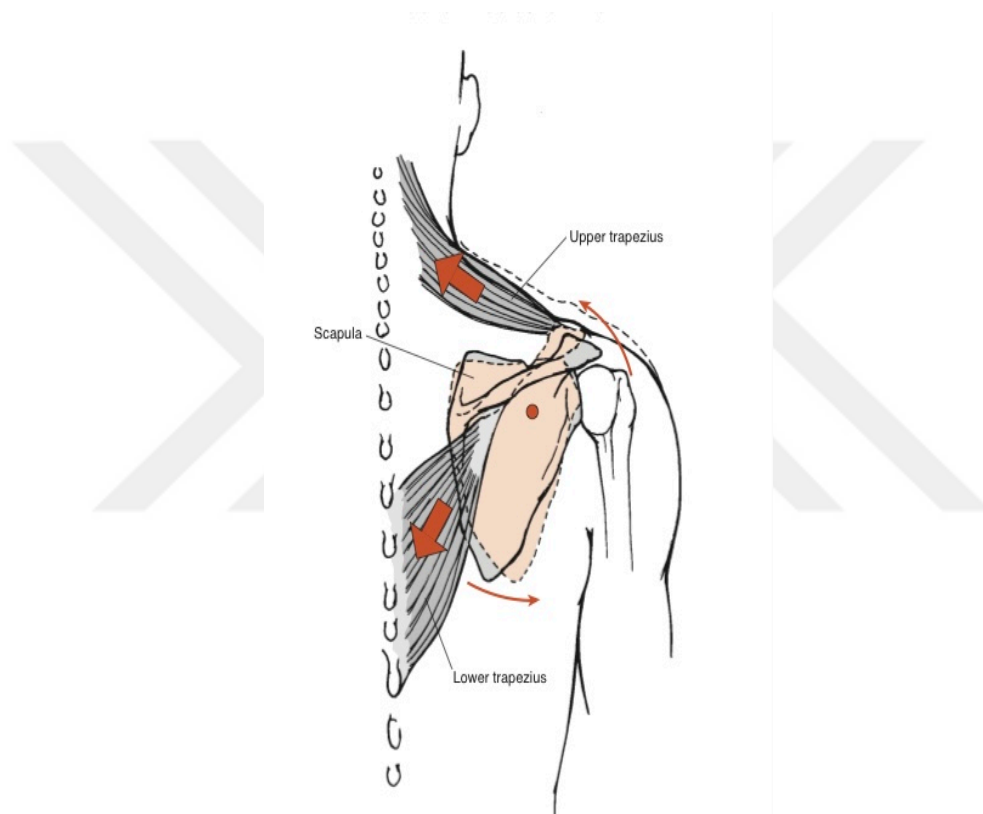


Figure 2.6. Force Couples of Upper and Lower Trapezius [15]

In the resting position, the clavicle is directed upward and laterally. The trapezius nuchal fibers reveal a medial directional movement in the clavicle, due to the direction it extends. Thus, the lateral end of the clavicle is moved medially and upwards. Therefore, the upward movement of the clavicle and scapula is provided not only by elevation but also by rotation of the clavicle (45).

2.1.3.9. Levator Scapula

Starting from the C1-C4 transverse process, it ends in the superior part of the scapula. Its innervation is provided by N. Scapulo dorsalis, C3-C5. (43). Levator Scapula is responsible for scapular elevation and down rotation (44). By creating different connections close to the connection points of the transverse processes of the vertebrae in the cervical, it continues to generate force and increase tension throughout the movement in weight transfer exercises such as push-ups. (21,39)

2.1.3.10. Rhomboid Major and Minor

Rhomboid Minor and Major are connected to the inferior angle of the scapula, the major one starting from the spinous processes T2-T5, and the minor one from C7-T1 spinous processes. With levator scapula and pectoralis minor, they are involved in the movements of downward rotation, elevation and retraction of the scapula. (44) With the rotation of the scapula, the glenoid fossa is depressed and the scapula is fixed to the thoracic wall. Trapezius, levator scapula, serratus anterior and rhomboids work in coordination to stabilize the scapula on the thorax in weight transfer. (21,39)

2.1.3.11. Latissimus Dorsi

It extends from the T7-T12 spinous process, the thoracolumbar fascia, the posterior iliac crest and the lower 3-4 ribs to the intertubercular groove. It takes part in shoulder adduction, extension and internal rotation movements (33,43,44). It is innervated by N. Torocodorsalis C6-C8. (43). The Latissimus Dorsi, whose primary task is to provide the movement of the humerus, creates a great force in the glenohumeral joint due to its adhesion. Like the pectoralis major muscle, it rotates near the attachment site on the humerus, and this feature shows the synergistic relationship between the two muscles. (21,39)

2.1.3.12. Teres Major

It takes its origin from the inferior of the lateral edge of the scapula and ends medial to the intertubercular groove. It is responsible for the adduction, internal rotation and extension functions of the shoulder (33, 39, 43). It performs its maximum activity in 90

degrees of the elevation. It is important in maintaining static posture. (20) The innervation of Teres major is provided by N.Subscapularis, C5-C7. (39, 43).

Supraspinatus, Infraspinatus, Teres minor and Subscapularis muscles are grouped together as rotator sheath muscles. Rotator sheath muscles center the humeral head in the glenoid fossa and thus provide glenohumeral stabilization. These muscles balance the superior force created by the deltoid in the humerus in elevation and follow the translations of the humeral head in various movements. (42).

Deltoid cannot perform flexion or abduction movements without rotator cuff's stabilizing the humeral head. Rotator cuff muscles can create 50% of the force to be released in flexion or abduction. When the glenohumeral joint is in neutral position, it has a smaller force arm than the deltoid supraspinatus. In this position, when the middle part of the deltoid, which is the primary abductor, contracts, it causes superior translation of the humeral head in the glenoid fossa instead of abduction. Supraspinatus is advantageous with its larger force arm and actively initiates abduction. However, supraspinatus alone cannot create sufficient abduction force. Therefore, they have to contract simultaneously. When the superior translation of the humeral head is not prevented, pressure occurs in the structures in the subacromial space. When the deltoid contraction begins in elevation, all rotator cuff muscles are activated to keep the humeral head in the glenoid fossa. When the abduction angle is halved, that is, above 90°, the rotator cuff muscles lose their effectiveness except for the supraspinatus and gain advantage due to the Deltoid force arm. Nevertheless, the rotator cuff muscles continue to work to maintain stabilization. (24, 43).

2.1.3.13. Supraspinatus

It starts from the supraspinous fossa and reaches the large tubercle. It is responsible for initiating the abduction movement (20,43, 46). Supraspinatus is innervated by N. Suprascapularis with C5-C6 (43). Supraspinatus performs internal or external rotation according to the position of the shoulder. If the abduction angle is low and the shoulder is in internal rotation, its activation is internal rotation; If the humerus is in neutral or

external rotation, external rotation occurs. As the amount of abduction increases, its stimulation produces external rotation. (31,46).

It is one of the muscles that make up the rotator cuff and is a more active muscle than the Infraspinatus. (42) The infraspinatus works in coordination with the teres minor and subscapularis and provides stabilization by increasing the pressure between the humeral head and the glenoid fossa. They work synchronously throughout the span (20). Thus, compression of the humeral head under the acromion and damage to the supraspinatus tendon and subacromial bursa are prevented (39). It is the most active rotator cuff muscle in all movements involving glenohumeral elevation. (42). Its activity peaks at 90 degrees of abduction and 110 degrees of flexion. (20). From a biomechanical perspective, the greater amplitude of the Supraspinatus is at 90 degrees due to the greater gravity torque and the greatest joint pressure force. (43).

2.1.3.14. Infraspinatus

It extends from the infraspinous fossa to the large tubercle. It takes part in shoulder external rotation, adduction, extension and horizontal abduction. Its innervation is provided by N. Supraskapularis C5-C6 (43). It is one of the rotator cuff muscles and works synchronously with the teres minor, depressing the humeral head, providing posterior placement in the glenoid fossa (33) and preventing compression on the coracoid process. Infraspinatus is one of the powerful external rotators and with this feature it is important in reducing speed in movements such as shooting and hitting. (33,39,41). It prevents posterior subluxation in internal rotation position and anterior subluxation in external rotation and abduction position. (31).

2.1.3.15. Teres Minor

It starts from the superior lateral of the scapula and attaches to the large tubercle. It performs external rotation, adduction, extension and horizontal abduction movements. Its innervation is provided by N. Axilllaris with C5-C6 (43). Being one of the rotator cuff muscles, works synchronously with Infraspinatus for depressing the humeral head in activities such as shooting, holding it at the posterior of the glenoid fossa (33) and

preventing impingement. (39). It also performs external rotation with the infraspinatus. 45% of this exposed external rotation force is provided by teres minor (31).

2.1.3.16. Subscapularis

It extends between the subscapular fossa and the small tubercle. It is responsible for the internal rotation of the shoulder joint and innervated by N. Subscapularis, C5-C6. (43). It is the largest muscle in the rotator cuff muscles and is the only one which is responsible for internal rotation (43, 44). It acts as a passive stabilizer by preventing the anterior translation of the humeral head as a barrier. (31,47,). Also it performs internal rotation while the arm is in anatomical position. (42). While the arm is at the side of the body over the head, it provides the stabilization of the humeral head with strong forces exerted by the teres minor, latissimus dorsi and pectoralis major muscles. (39). When the posterior capsule is stretched, it creates a mechanism that prevents compression by preventing further translation of the humeral head in the anterior and superior directions. (31,48) It is a major dynamic stabilizer that restricts the posterior instability of the glenohumeral joint. (42).

2.1.3.17. Triceps Brachii

The long head starting from the infraglenoid tubercle of the scapula, the medial head from the distal 1/2 of the humerus posterior shaft, and the lateral head from the 1/2 proximal of the humerus posterior shaft, all reach to the olecranon process. Innervation is provided by the radial nerve, C5-T1. Just like biceps, it crosses multiple joints and they are antagonist to each other. (39)

Its primary task is the extension movement in which all fibrils work together. It provides shoulder extension, especially in pulling movements. The long head is involved in extension and bringing the arm from anterior to posterior. (39) It also minimizes the inferior translation of the humeral head in the glenoid fossa, contracting and pulling the humerus superiorly. (33).

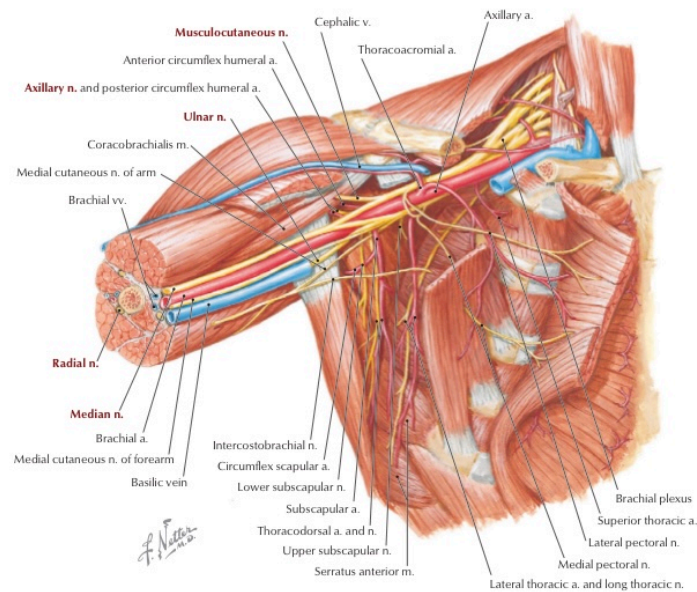


Figure 2.7. Brachial Plexus and Axillary Artery [21]

2.1.4. The Biomechanics of Joints Forming the Shoulder Structure

It is interesting with its functional anatomy of the upper extremity in terms of the interaction between the joints and structures required for the correct and effective movement (49,50). Shoulder elevation occurs depending on the function of the shoulder complex formed by the total mobility of the glenohumeral, sternoclavicular, acromioclavicular and scapulotorasic joints. (16) Shoulder movements require static and dynamic stabilizers to work together. (17,18). With this strong structure, complex movements such as overhead activities, pushing and pulling movements, supporting and throwing one's own body weight can be achieved. Coordinated working of all four joints is essential for painless function. (14). An important reason of the pain and dysfunction complaints of the patients is the disruption of the normal coordination of these independent structures. Therefore, in order to understand shoulder function and dysfunction, it is necessary to first understand the coordinated work between components in the shoulder complex. (15, 26)

2.1.5. Arthrokinematics and Osteokinematics in the Joints of the Shoulder Complex

2.1.5.1. Glenohumeral Joint

According to the studies of Poppen and Walker, and Johnson, the shoulder joint performs the most accurate movement in the scapular plane, not in the plane with the coronal. The scapular plane is provided anterior to the frontal plane with elevation between 30-45 ° (28,30). Kondo et al found that the medial tilt of the scapula remained constant at 40 ° during 150 degrees of elevation. The length-tension relationship is at the optimum level in the abductors and rotators in the scapular plane. At 90% of the muscle length, the tension reaches its maximum. As the muscle gets shorter, the tension decreases. (30).

The arthrokinematics of the glenohumeral joint occurs as a result of the movements of the rotator cuff and subscapularis, latissimus dorsi, teres major and teres minor, that is, the humeral head depressors. Wuelker et al. Reported that the translation of the humerus in glenohumeral elevation was 9 mm superior, 4 mm anterior and 20-90 degrees; it was revealed that this translation could also be reduced by rotator cuff activation. (30). Likewise, Harryman et al found more than 10 mm glenohumeral translation in non-lesioned shoulders. (51). Deutsch et al in their study with healthy individuals stated that the humeral head is centered in isometric activities. (52).

In the frontal plane, the humeral head and neck axis make an angle of 135-140° with its shaft. As a result of this angulation, the center of the humeral head falls 1 cm medial to the long axis. It also has a 30-40 ° retroversion angle. (53).

It has the largest joint capability in the body and allows movement in all three axes. The movements take place in an infinite number of axes that intersect in the center of the humeral head. Flexion-extension, abduction-adduction, medial-lateral rotation and circumduction (25) movements are all seen. While the widest range of motion is seen in flexion and abduction, extension has the least range. (16, 53).

Flexion and extension occur perpendicular to the plane of the glenoid fossa. Thus, at 45 degrees of flexion in the sagittal plane, the arm moves forward and medially. In

extension, it moves backward and laterally. Range of motion is 110 degrees in flexion and 70 degrees in extension. With the participation of the shoulder girdle, flexion reaches 180 and extension only reaches 90 degrees. The reason for the limited extension is the contact between the large tubercle and the coracoacromial arch. (53). Again, due to the large tubercle and acromion, while the humerus is in internal rotation in the coronal plane, the glenohumeral joint abducts 60-90°. If external rotation of the humerus is achieved, abduction occurs between 90-120 degrees. (25).

Saha et al. Examined the alignment of abduction in the occipital plane with the glenoid fossa and the humeral head; He found that the contact surface of the humeral head moves up and forward while the region in the glenoid fossa remains constant. Poppen and Walker observed in their study that they investigated the rotation center in abduction, the humeral head moved 3 mm superiorly between the first 30 ° and 30-60 °. On the other hand, it only found rotation above 60 degrees. (30).

In a normal upper limb function, the scapula creates a stable area for glenohumeral mobility to be exposed. (54,55,56). In the humeral movement, the scapula moves in 3 axes: anterior-posterior, superior-inferior and medial-lateral (57,58,59,60). Elevation requires upward rotation of the scapula for flexion or abduction, elevation of the clavicle and upward rotation. The scapula goes towards or away from the spine between the first 30 degrees of abduction or 45-60 degrees in flexion. (24). After stabilization is achieved, it performs upward rotation, protraction and elevation. Clavicle, on the other hand, performs posterior rotation, elevation and protraction.

In abduction that occurs in the same plane with the glenoid fossa and in the oblique-horizontal axis, the arm moves away from the body in anterolateral direction. Total joint range of motion is 120 degrees. However, only 25 degrees of that movement can be done without scapular rotation. Scapular rotation between 30 and 180 degrees of movement increases shoulder abduction by 1: 2. Movement in the terminal part of abduction is accompanied by lateral rotation of the humerus (30,53). The amount of this rotation in healthy people varies between 30-35° (61, 62, 63). In order to prevent the tuberculum majus from coming into contact with the coracoacromial arch, the scapula must translate

upwards and outwards in abduction above 90 °, and this rotation is provided by the serratus anterior and trapezius. In this way, it increases the articular surface for the humeral head in the glenoid fossa. When the humerus is in medial rotation, abduction is limited by the tension of the posterior capsule and lateral rotators. (16,24,53). As abduction progresses, the glenoid surface moves medially and tilts upward. The lower half of the 0-30° scapula goes into rotation, from 60 degrees the center of rotation shifts towards the glenoid fossa and the inferior end of the scapula is displaced laterally. (28)

Saha et al. Emphasized that lateral rotation of the humerus is important to eliminate the risk of impingement. Similarly, Rajendran emphasizes the importance of lateral rotation that automatically arises for the abduction movement. An et al. Examined the humerus-scapula relationship in 3 dimensions and concluded that lateral rotation is needed for maximum elevation. Again, Browne et al. Found in their 3D study that 35° lateral rotation is required for maximum elevation. Brem et al. stated in their studies that the most function allowed by the shoulder is lateral rotation and functional disability can be seen in the loss of lateral rotation. Ponatelli also found a correlation between passive lateral rotation and active abduction in the scapular plane. (30).

Supraspinatus initiates abduction with the arm in anatomical position and in the first 20 degrees it is required (46,53). The supraspinatus is the muscle with the earliest activation, and its activation peaks early in abduction (64,65,66). However, it is not only the muscle that initiates abduction, but also functions in all phases of elevation. (46). The middle fibers of deltoid also start to work and abduction is continued. When the deltoid does not work, Supraspinatus is not strong enough to perform its abduction function. (53). Linge et al and Howell et al found that abduction strength decreased when the suprascapular nerve was blocked. (46) If supraspinatus is not functional, Deltoid cannot initiate abduction. A 20 degrees of passive abduction allows Deltoid to continue the movement. As the abduction angle increases, the rotator cuff muscles join the movement to balance the upward force exerted by the deltoid. (53).

80 degrees of lateral rotation of the joint occurs by the posterior fibers of the infraspinatus, teres minor and deltoid. The 90 degrees of medial rotation is performed by

the subscapular, pectoralis major, latissimus dorsi, teres major and deltoid anterior fibers. Rotations are the movements in which shoulder pathology is seen the most. (53).

For the flexion movement, as in abduction, outward and upward rotation of the scapula is required from 90 degrees of movement. In addition, medial rotation is important in completing the movement in both flexion and abduction movements. In this way, the scapular rotation and medial rotation of the humerus in order to complete the flexion and abduction movements to 180 degrees is called Codman's paradox. (16)

In adduction, a little forward or backward movement of the arm is required to prevent it from hitting the body, which is achieved by flexion or extension. However, the adduction angle made by flexion is 45 degrees, and it creates a greater movement than extension. (16). Adduction after neutral position is blocked by the trunk. (53).

Throughout the movements of the glenohumeral joint, the harmony of the humeral head and the glenoid fossa constantly changes, but in most of the humeral head, 25-30% of the humeral head adapts to the glenoid fossa. During 60-120° elevation, glenohumeral contact is of maximum functionality and this ensures joint stability. In abduction, the harmony between the humeral head and the glenoid fossa is greater than in other movements. (67). In the first 30° of abduction, the humeral head shifts superiorly in the glenoid fossa, but translates anteriorly and inferiorly throughout the movement. (16)

Ludewig and Phadke found that glenohumeral movement was less exposed in abduction compared to flexion in their study in which they compared flexion and abduction in elevation and compared the glenohumeral joint motion in the arcs of 30 degrees. Accordingly, glenohumeral movement is less in abduction of 30-60 degrees than flexion; While 30-60 ° glenohumeral lateral rotation is more in abduction, it is less in 90 ° flexion. At 120°, glenohumeral lateral rotation is more in flexion. He also found that in flexion, the retraction of the clavicle was less, the internal rotation of the scapula was more, and the humerus had less lateral rotation at the beginning. In addition, he stated that there was very little clavicular elevation in healthy subjects when raising the arm, and that clavicular elevation increased in cases with shoulder pain. (63).

2.1.5.2. Sternoclavicular Joint

Since almost every movement in the upper extremity is transmitted to the sternoclavicular joint, it is the joint that moves most frequently (20). Movements in the sternoclavicular joint due to the direct connection of the clavicle to the scapula; It occurs as a result of scapular movement on the thorax or opposite movements in the acromioclavicular joint. (68) The source of the movements in this joint is the protraction, retraction, elevation and depression movements of the clavicle. (20). The superior and inferior movement of the clavicle in the sternoclavicular joint produces 30 degrees of elevation and 40 degrees of depression, respectively. Anterior and posterior movements reveal 30 degrees of protraction and 35 degrees of retraction (18,24). The lateral and medial ends of the clavicle move in opposite directions due to their shape. Elevation of the lateral end of the clavicle causes downward and lateral movement of the medial end. While the lateral end has 10 cm elevation and 3 cm depression range of motion, it is mobilized in a total of 60 degrees of motion. In protraction and retraction in the vertical plane, the lateral end of the clavicle moves along 5 cm protraction and 2 cm retraction. One of the movements in the sternoclavicular joint is axial rotation, a passive movement that occurs through the coracoclavicular ligament as a result of rotation of the scapula. It varies between 20-40° depending on the position of the clavicle. If the clavicle is in the frontal plane, the angle of motion is smaller. (53).

In addition, Inman found in his study that at an elevation above 90°, approximately 40° of upward rotation begins and continues increasingly. (14). Also during elevation, elevation of the clavicle is needed in the sternoclavicular joint. This elevation is completed in the first 90 degrees. At every 10° elevation, 4° clavicular elevation occurs. From the 90°, elevation of the clavicle becomes insignificant. (20)

30-35 ° elevation between the clavicle and intraarticular disc, an anteroposterior 35 ° movement between the sternum and the disc, and rotation movements around the long axis between 44-50 ° are seen.(18,20,53). According to The study of Inman et al., maximum sternoclavicular elevation is seen between 30-99° of elevation and between 70-80 degrees ,maximum rotation is seen. (20).

Elevation movement is limited with the costoclavicular ligament while depression is limited by the interclavicular ligament. (14). These two mechanisms are important for the mobility between the clavicle and the 1st rib. The anterior sternoclavicular and costoclavicular ligament limit anterior movement, while the posterior sternoclavicular and costoclavicular ligament limit posterior movement. (53).

2.1.5.3. Acromioclavicular Joint

The acromioclavicular joint has a higher laxity joint than the sternoclavicular joint does. So it allows more movement, but the dislocation rate is higher. (30).

Steindler examines AK joint rotation in 3 axes: axial rotation in the longitudinal axis, protraction-retraction in the vertical axis, and elevation-depression in the horizontal axis. All this is controlled by the Conoid, Trapezoid, and AK ligament. (30).

Since there is no muscle-bone connection, all of the movements in this joint occur passively. Except for axial rotation, all functions in the joint occur by the sliding movements of the coracoclavicular ligament. (53). The major movement is the rotation of the clavicle. (30).

In this joint, medial and lateral rotations and anteroposterior shifts occur primarily that allow the scapula to adapt to the thorax.

While the clavicle moves upwards, it also tilts the scapula and the glenoid fossa upwards. With the clavicular elevation made with the trapezius and the serratus anterior, 30° upward rotation occurs in the glenoid fossa. The costoclavicular ligament is also stretched and the elevation movement is completed. In order for the elevation to be fully performed, a further 30° of upward rotation is required, and this is due to the rotation of the clavicle around its own axis. Due to the S shape of the clavicle, it pulls the scapula and glenoid fossa up with its rotation and the remaining 30° is completed. (16,53).

Inman concluded in his study that there was acromioclavicular mobility in the first 30° and last 45° of flexion and 10° of abduction. (14). After the first 30° abduction and 135° elevation in the acromioclavicular joint, 20 degrees of movements occur. Acromioclavicular mobility is not seen between these two degrees.

Below 15 ° elevation movement is limited by the coracoclavicular ligament; depression is controlled by the coracoid process that contacts the lower surface of the clavicle (53). The elongation of the coracoclavicular ligament is related to the rotation around its axis, which it can do due to the shape of the clavicle. (20).

2.1.5.4. Scapulothoracic Joint

The scapulohumeral joint mainly provides arm-trunk movement and glenohumeral stabilization. (14).

The joint kinematics depend on the sternoclavicular and acromioclavicular joint movements, and the sum of the movements of these joints are equal to the range of motion of the scapula. (20,30). 4° sternoclavicular motion is revealed in every 10° abduction. The acromioclavicular joint is mostly mobile before 30° and after 135°. (30). Teece et al. Observed scapulothoracic translation in elevation-depression, abduction-adduction movements and demonstrated that the scapula simultaneously performs upward rotation, internal rotation, and posterior tilt. He found that all these movements are the result of the clavicular movement of the sternoclavicular joint. Scapulothoracic elevation occurs as a result of sternoclavicular elevation and abduction-adduction occurs as a result of protraction-retraction movements in the sternoclavicular joint. (30).

The scapulothoracic joint is responsible for the upward rotation of the scapula and the upward rotation of the glenoid fossa in the elevation movement. (16). This 60° upward rotation of the scapula is the widest movement in the ST joint. (15). In addition to rotation, the scapula performs lateral rotation up to 90 ° elevation and also makes posterior tilt during the first 90°. (15,56,69). Scapular lateral rotation changes linearly with the angle of the humerus. Increasing lateral rotation in elevation is a compensatory strategy used when there is a limitation in the glenohumeral joint. (54,70).

Various muscles work together as a force pair for scapular stabilization. The most important pair of forces is Trapezius - Serratus anterior (22). While the Serratus Anterior provides upward rotation of the scapula, the upper and lower fibers of the Trapezius also act as synergists (54). In order to provide acromial elevation, lower fibers of trapezius - Serratus Anterior and upper fibers of trapezius- Rhomboid is another force pair that works synchronously. (22). Trapezoidal upper fibers also cause the upward rotation of the scapula in elevation. The lower fibers, on the other hand, activate the horizontal-vertical balance of the scapula. One of the roles of the lower fibers is to provide posterior tipping of the scapula with its activation and prevent contact of the acromion and rotator cuff tendons. In this way, it prevents impingement. (54).

Scapulohumeral movement accompanies the movement of the glenohumeral joint in shoulder elevation, flexion and abduction. This increases the harmony of the muscles involved in the movement. (20)

Scapulohumeral and glenohumeral joints work simultaneously to provide scapulohumeral rhythm. (26). This definition was first used by Codman to describe the synchronization of 2 movements in upper extremity elevation (25). The coordination of the humerus and scapula during elevation limits the arthrokinematics between the two bones. Thus, the harmony between the glenoid fossa and the humeral head is achieved and the risk of impingement is prevented (16). This harmony is important to ensure the compliance of the length-tension relationship of the muscles affecting the scapula and humerus. Scapulohumeral rhythm rates are very high in the early stages of elevation. This ratio starts to decrease as the humerus angle increases. A higher ratio indicates that the scapula contributes less to movement. (57). The ratio between glenohumeral elevation and scapulohumeral rotation was found to be 2: 1 by measuring with the 2D radiographic method by Inman et al. (20). For every 2° glenohumeral elevation, 1° scapulohumeral elevation occurs. (15). At every 15° movement, the glenohumeral joint reveals 10° of movement, while the scapula rotates 5° on the thorax. (20). In other words, 180° movement is provided with a total of 120° GH and 60° scapular movement. (15,24).

From 30° abduction and 60° flexion, the GH / ST ratio remains constant. (15,20). Scapulohumeral rhythm during shoulder elevation is seen as 3 different phases.

❖ The ratio is 6: 1-7: in the first phase between 0-60°. In the first 30° abduction and 60° flexion, the scapula looks for the most stable position together with the humerus. In this first phase, called the setting phase, the scapula either stays fixed or moves in the medial-lateral direction until it finds a stable position; However, although the scapula moves, the main movement takes place in the glenohumeral joint. (20,25).

❖ 60-130° is the phase in which the ratio is 1: 1 and in this phase, the glenoid fossa and the humeral head are in perfect harmony. Bagg and Forrest define this phase between 80-140° as the most challenging phase in elevation and indicates that the scapular rotation is seen most in this phase where the Trapeze-Serratus anterior force pair is activated. (25)

❖ Between 130-180°, the ratio becomes 5: 1. In the final phase, the scapular muscles continue to rotate upwards and the excessive movements are limited by the ligaments and joint stabilization is provided. (25)

Table 2.2. Reported Average Ratios of Glenohumeral to Scapulothoracic Motion during active arm-trunk elevation in the plane of the scapula

Authors	Ratio
Freedman and Munro	1.58:1
Poppen and Walker	1.25:1
Bagg and Forrest	1.25:1 to 1.33:1
Graichen et al.	1.5:1 to 2.4:1
McClure	1.7:1

When movement is limited only in the glenohumeral joint, only 90-120° elevation can occur in the arm. If the glenohumeral joint is immobile allows a 60 ° elevation by performing only a 60 ° upward rotation of the scapula. (16)

Saha, Sharkley and Marder investigated the relationship between humerus and glenoid in abduction. (30). The contact zone is centered at 30 degrees. And at 120 degrees,

it slides up to 1.5mm superior. Poppen and Walker observed that between the first 30 ° and 30-60 ° of abduction, the humeral head goes 3 mm superior to the glenoid fossa. (14,30). Superoinferior translation of the humeral head is less than 1.5 mm in every 30 degrees arc of movement in healthy people. (28). Graichen found the inferior translation to be 1.2mm between 30-150°. Again, according to the same study, it was found that the humerus was located 1mm superior to the glenoid in 60° abduction; It was observed to be more centered between 90-120°. Graichen et al. evaluated the reason for superior translation in 60°, and found that it is because of the domination of force direction of deltoid muscle. They stated that between 90-120°, the centering effect of the rotator cuff muscles become more active. Howell et al found in their study that the humeral head is almost in the center position in full extension. (71)

Deltoid shows EMG activity in the first phase of elevation. Also, the activation of Subscapularis, Infraspinatus and Teres minor is important in order to stabilize the humeral head at the first level of elevation (30). Yamaguchi, in his study, stated that the humeral head progressively translates in the glenoid fossa during elevation. (14). In many studies carried out in different years, it has been found that there is the translation of the humeral head in active elevation of the arm and this translation can cause impingement syndrome by reducing the subacromial area up to 100-110°. It was emphasized that activation of the rotator cuff muscles is important to prevent soft tissue from contacting the lower surface of the acromion before 90 °. (72).

McClure defines the GH / ST ratio as 1.7: 1 in the scapular examination performed in healthy volunteers using 3D techniques. He found that in the scapular plane elevation, 50° upward rotation, 24° external rotation, 30° posterior tilt and 10° elevation and 21° retraction in the clavicle were revealed. (14, 56). After 50°, the upward rotation of the scapula and the clavicular rotation occur linearly. Posterior tilt and lateral rotation are nonlinear and usually not seen until after 90°. During elevation, retraction of the clavicle reveals the posterior movement of the scapula. This movement peaks between 130-150°. 10 degrees of elevation of the clavicle also provides superior movement of the scapula. While the arm is rolling back, the opposite of the same movements occurs in different patterns (56). On the other hand, Ebaugh observed that the scapula goes to anterior tilt at

elevation above 90°. (14). Differently, Inman observed 30 degrees of clavicular elevation and found that the majority of movement occurred at 90°. These different results can be attributed to the different measurement methods in the studies and the variability of the measurement locations.

Inman found a GH / ST ratio of 2: 1 in the 30-170 ° range of motion. (14, 20). Between 0-135°, Saha found the same ratio 2.3: 1, Freedman and Munro found 3: 2. (14). Again, Doody et al examined the abduction movement and found a 3: 2 ratio. Similarly, Borsa et al. Found the lowest GH / ST ratio in the middle of elevation and observed that the scapula contributed the most to movement in this phase. (57). Poppen and Walker 4.3: 1 between 0-30°; Between 30-180°, he defined it as 5: 4. In other words, while the humerus moves 5° in the glenoid fossa, the scapula moves 4° on the thorax. (28). Recently, the scapulohumeral rhythm was found to be 2.1: 1 for abduction and 2.2: 1 for flexion as it can be seen from Table 2.3 below. (63)

Table 2.3. Comparison of Ratios of Active GH to ST Rhythm in the Plane of Scapula

Study, Year	Ratio (Average)
Inman et al, 1944	2:1
Saha, 1961	2.3:1
Freedman and Munro, 1966	3:2
Doody et al, 1970	1.74:1
Poppen and Walker, 1976	1.25:1 or 5:4
McClure et al, 2001	1.7:1
Graichen et al, 2000	1.5:1 to 2.4:1
McQuade and Smidt, 1998	7.9:1 to 2.1:1 (passive ROM) 1.9:1 to 4.5:1 (with load)

Wilk, K., et al. The athlete's shoulder. 2009 : Churchill

In the first phase of elevation, the deltoid exerts an upward force on the head of the humerus. When this force reaches its highest value in 60° abduction, it encounters the

opposite force of the rotator cuff muscles. The subscapularis depresses the humeral head by opposing the deltoid. (30). The sternoclavicular joint makes the largest movement in this phase. (20).

In the second phase of elevation, the widest movements are seen in the acromioclavicular joint (20). In this phase, the GH / ST ratio shifts towards ST. The forces stabilizing the joint are maximum at 90° elevation. Here the opposite forces are equalized. At the end of the critical phase, the forces on the deltoid are zeroed and thus dynamic stabilization is achieved. (30). During this phase, the deltoid reaches its maximum activity at 110 ° and then plateaus. Supraspinatus provides maximum activation at 100 degrees and then disappears. (20). Subscapularis activation starts to decrease from 130°. Scapular rotation starts between 60-90°. The clavicular elevation completed between 120-150° allows maximum scapular rotation in the AC joint. (30). The humeral head translates 1.5 mm inferior-superior in the glenoid.

In the last phase, GH superiority is observed proportionally. GH joint movement becomes dominant again.

Unlike the study results of Inman, Borsa et al observed a 5° downward rotation during 0-30° humeral elevation in 2003. This rotation has not been encountered in previous studies. Downward rotation is related to the weight of the arm and the muscle forces acting on the scapula. (57).

Ludewig, Behrens et al found results similar to the results of the study of McClure et al and different from the findings in Inman's study in their 3D radiographic clavicular examination performed on 39 healthy and asymptomatic people. The different results may be due to Inman doing his study in 2 dimensions. Although the severities are found to be different, there is a general belief in the direction or pattern of clavicular movement in elevation in many studies. In arm elevation, the clavicle goes into elevation, retraction, and posterior rotation, and this can vary per person; The intensity of movement can be different. (68).

2.1.6. Shoulder Static and Dynamic Stability

2.1.6.1. Shoulder static stabilizers

- ✓ Coracohumeral ligament
- ✓ Glenohumeral ligament
- ✓ Glenoid labrum
- ✓ Articular capsule
- ✓ Joint contact
- ✓ Negative intraarticular pressure

Dynamic stabilizers serve for light displacements and static stabilizers serve for large displacements (16,73). Position, motion and tension are sensed by the capsuloligamentous structures and reach from static stabilizers to dynamic stabilizers, and this process is called proprioception. The optimal orientation of the shoulder joint is achieved by the function of the scapulothoracic muscles and the neural Feedback pathway between the rotator cuff muscles and the ligaments of the glenohumeral joint. (16). Often the glenohumeral ligaments prevent excessive translation of the humeral head through the wide range of motion of the shoulder. (16)

Inferior translation of the humeral head in the anatomical position is blocked by the superior glenohumeral and coracohumeral ligament (16). When coracohumeral ligament stretches in adduction, it restricts the humeral head to the glenoid fossa (18). The humeral head translations in the first 30 degrees of the elevation are also limited by the same ligaments. (16). In addition, the coracohumeral ligament and superior glenohumeral ligament prevent inferior translation of the humeral head in adduction and prevents posterior translation in flexion-adduction-internal rotation (18).

Superior glenohumeral and coracohumeral ligaments limit the anterior translation that occurs when external rotation is performed in the anatomical position. When external rotation is performed in abduction, the anterior band of the inferior glenohumeral ligament functions. (16)

In posterior translations, the anterior angulation of the glenoid fossa, the glenoid labrum and the anterior band of the inferior glenohumeral ligament are important for joint stabilization. (74).

For total anterior stabilization, SGHL and MGHL at 0 degree, MGHL at 45 degrees of abduction and at 90 degrees of abduction IGHL is the primary restrictor. (14,18).

Intra-articular pressure is another static stabilization tool. It is at the minimum level in slight elevation and at the maximum in full elevation. (16,64).

2.1.6.2. Shoulder dynamic stabilizers:

Rotator cuff muscles, deltoid and biceps are important in dynamic stability provided by the muscles in the glenohumeral joint. (31).

✓ Rotator cuff muscles

The rotator cuff is a musculotendinous structure consisting of supraspinatus superiorly, subscapularis anteriorly, teres minor and infraspinatus posteriorly. Ovesen and Nielson in 1986 and Howell and Galinat in 1989 found that when the shoulder muscles were eliminated or muscle tissue was removed, the translations of the humeral head in anteroposterior and inferior-superior directions increased (31). Rotator cuff muscles provide joint stabilization by increasing the harmony of the humeral head with the glenoid fossa, especially in abduction movement (33). They respond to the pulling force exerted by the deltoid at the humeral head in the early phases of elevation. (66) Centering the humeral head in the glenoid fossa prevents anterior-posterior translation. (14). Thus, it prevents the risk of impingement. (75). If the rotator cuff muscles cannot provide sufficient force against the deltoid in the first phase of elevation, dynamic stabilization of the glenohumeral joint cannot be achieved and the humeral head goes superior. (61).

They provide additional abduction torque and support humeral lateral rotation. (75). Without the 10 degrees of movement, the stabilization function of these muscles is not needed in the joint (66).

Infraspinatus, one of the rotator cuff muscles, prevents posterior subluxation in medial rotation. It acts as a stabilizer for anterior subluxation in abduction and external rotation. Teres minor and Subscapularis muscles are also involved in anterior stabilization. (16). Infraspinatus and teres minor work together to control external rotation and reduce anterior-inferior strain. While the strongest stabilizer muscle is Subscapularis, Supraspinatus has the least effect on stabilization. Subscapularis - infraspinatus force pair is responsible for stability between 60-150o. (30).

Payne et al. compared rotator cuff, biceps and deltoid muscle strengths on cadavers, he found that 17% more deltoid strength was needed to initiate abduction without rotator cuff force. (30). A 50% reduction in rotator cuff power means a 50% increase in anterior translation of the humeral head due to external loads on the shoulder joint. (14).

✓ Biceps long head tendon

When the long head of the biceps is activated, it pushes the humeral head towards the glenoid fossa. In addition, with its short head, it stabilizes the shoulder from the anterior by preventing the translation of the humeral head in abduction and external rotation movement. (16,30). It is as effective as supraspinatus, infraspinatus and teres minor in biceps stabilization task (16). Kim et al. In their EMG study, they found that the biceps acts as an anterior stabilizer in joints with anterior instability. (14,16). In another study, the efficiency of biceps and rotator cuff muscles in stable shoulders was investigated and it was concluded that biceps is an effective stabilizer as supraspinatus, infraspinatus and teres minor. When the rotator cuff is damaged, the biceps is activated, preventing the humeral head from translating superiorly and joint kinematics are provided. (16). In their study, Itoi et al. Found that the activity of the biceps long head may be better than the rotator cuff muscles when shoulder stability is low. (30).

✓ Deltoid

Provides anterior stabilization of the glenohumeral joint in abduction and external rotation movements. In cases where there is no shoulder stabilization, the importance of this task increases. (16). Lee and An examined the effect of deltoid on glenohumeral joint stabilization and concluded that deltoid activity reduces stabilization at 60o

abduction. (14). Because the deltoid's traction force reaches its maximum at 60 degrees and starts to decrease from 90 degrees and resets at 135 degrees. (20).

2.1.7. Normal and Abnormal Shoulder Function

It has a major role in optimal shoulder function as it produces the parameters necessary for normal scapular function and position, as well as the normal physiology and biomechanics of the shoulder. (22, 23). Scapular control and position allows the transfer of upper extremity core strength to the hand by providing the humeral-glenoid relationship. (23, 76).

When abnormal biomechanics and physiology occur, the role of the scapula can be altered by many factors such as bone anatomy, posture, or injury. While thoracic kyphosis or cervical lordosis causes increased protraction, impingement occurs in elevation and more muscle strength is needed to provide retraction in the thoracic wall. (22).

Abnormal movements and positions of the scapula relative to the thorax are associated with many different shoulder pathologies such as tendinitis, impingement, rotator cuff tears, and glenohumeral instability (68, 75, 77). It increases the risk of rotator cuff functions being altered and kinematic impingement. The reduction of the subacromial area develops as a result of kinematic anomalies such as abnormal translations of the humeral head and abnormal scapular movements. In cadaver studies, the subacromial area of 5mm decreases up to 100-110° during elevation, but before it reaches 90°, this area is adapted to the surrounding structures so that it does not come into contact with the lower surface of the soft tissue acromion. This adaptation cannot be achieved in patients with impingement due to abnormal scapular movements. (75).

Since scapular movement over the thorax is a result of movements in the sternoclavicular and acromioclavicular joint, abnormal scapular movements can be associated with abnormal movement in at least one of these joints. Since the scapulothoracic joint is a bridge between the SC and AC joint, it can be said that abnormal

ST motion is associated with the abnormalization of one or both of the SC and AC joint kinematics. Inman et al. Observed in their study that while upward rotation of the scapula was revealed on the thorax during elevation, elevation in the SC joint and upward rotation movements in the AC joint contributed equally. When the SC joint movement decreases, the movement in the AC joint increases and tries to provide normal scapular movement on the thorax, but this situation may lead to degenerative changes. (68)

As a result of different studies, abnormal scapulothoracic kinematics were detected in the patient population. Scapular winging, decreased upward rotation, increased internal rotation, and decreased posterior tipping were observed in patients with tendonitis or impingement. (68, 78, 79). It has been found that the upper rotation of the scapula is reduced in patients with inferior glenohumeral instability. (68)

Abnormal scapular movements may be due to an imbalance in ST muscle activity. Increased upper trapezius activation and increased superior translation of the scapula were observed in patients with shoulder pathology. While the upper trapezius provides elevation and upward rotation in the scapula, the lower trapezius activates and provides the horizontal and vertical balance of the scapula. When these muscles release unbalanced force, abnormal scapular movements occur in the frozen shoulder. Strength imbalance can result in subacromial impingement, rotator cuff, and biceps tendinitis. (54)

If the level of shoulder is below normal, it again affects the position of the scapula and causes impingement. Injuries to the clavicle or scapula can alter the orientation of the scapula and cause painful conditions. Acromioclavicular joint arthrosis or detachment can alter the kinematics of the scapula by causing anomalies in the supporting role of the clavicle. (22)

Any muscle imbalance affecting the shoulder complex can alter scapular kinematics and shoulder motion symmetry. Therefore, scapular asymmetry can be associated with shoulder pain, disability, and similar symptoms. (80).

The abnormal biomechanics and physiology seen in sports injuries refer to changes in the function of the muscles that control the scapula. Injuries to the long thoracic nerve

or spinal accessory nerves cause abnormal stabilization and control by altering the function of the Serratus and Trapezius muscle. This type of nerve injuries are seen in 5% of muscle function anomalies. (22, 76)

Often, the muscles are exposed to direct trauma and there is muscle weakness or force pair imbalance or inhibition due to painful conditions around the shoulder, with muscle strain due to microtrauma. Muscle inhibition or weakness is common in GH problems due to instability, labral lesions, and arthrosis. Serratus and trapezius lower fibers are the most susceptible muscles to inhibition and are in the first phase of shoulder problems. Muscle inhibition and resultant scapular instability is a nonspecific response to the painful condition. The inhibition is seen in the disorganization of the normal pattern of the muscles around the shoulder and the reduction of muscular ability, which provides both torque releasing and stabilization of the scapula. (22)

GH inflexibility can also lead to abnormal scapular biomechanics. Posterior shoulder inflexibility due to muscle tension GH affects the fluent movement in the joint and creates a wind-up effect, pulling the scapula forward and inferior as the glenoid and arm move. This situation causes excessive protraction of the scapula on the thorax. Depending on the geometry of the upper surface of the thorax, the more the scapula protracts, the more the acromion moves around the thorax in anterior and inferior directions. The further the scapula moves inferiorly, it lowers the elevation and its ability to prevent impingement. As a result, excessive protraction causes impingement due to abnormal biomechanics. (22)

Inadequate acromial elevation may also result in impingement. Impingement as a result of acromial elevation failure due to muscle inhibition of the Serratus-Trapezius force couple is seen at the beginning of many shoulder problems. Since the muscles that cannot provide a stable connection point cannot produce enough strength, muscle strength decreases and muscle imbalance occurs. (22)

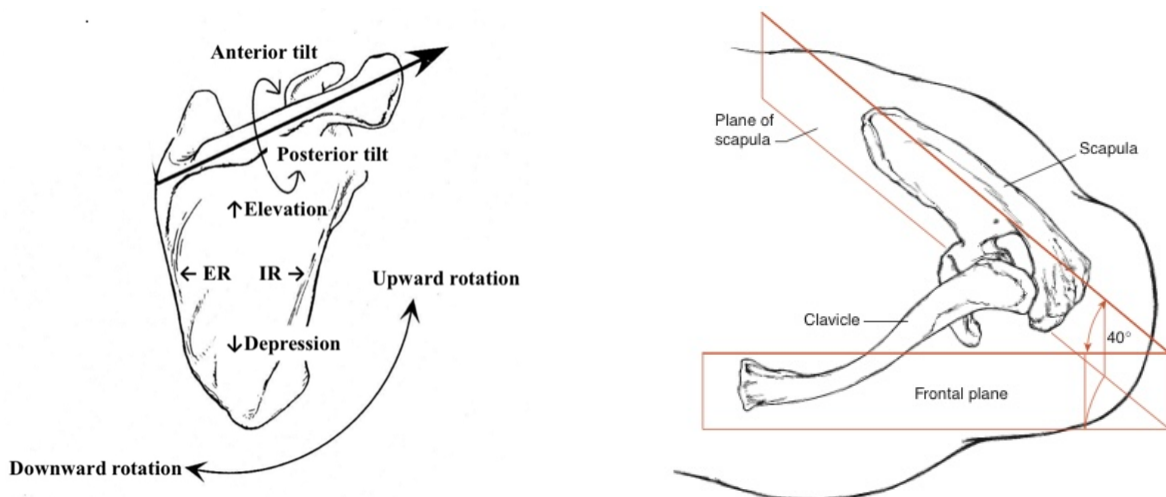


Figure 2.8. Functions and the Plane of Scapula[15]

The most important anomaly in abnormal scapular biomechanics is the loss of connection in the kinetic chain. If there is a deficiency in the movement and position of the scapula, the great forces produced in the lower extremity cannot be transmitted to the upper extremity. This situation negatively affects the maximum force transmitted to the hand. More distal connections are activated at a higher level to compensate for the loss of strength produced in the proximal, but their functions are damaged because they are not suitable for generating large forces. (22)

Changes in scapular motion, position, and kinematics are defined as scapular dyskinesia. (81). In general, they are all dysfunctional movements that damage the shoulder function. (23). During elevation, the scapulohumeral rhythm should be soft. Another definition of scapular dyskinesia is that this movement is asymmetrical when compared to both scapulae. (82). Dyskinesia is seen in 68-100% of shoulder problems. It is seen in 68% of rotator cuff anomalies, 94% in labral tears and 100% in GH instability problems. (76). There are three types of dyskinesia in the literature. (82). Type 1 is characterized by the protrusion on the inferior medial scapular edge. In Type 2, a protrusion is observed on the entire medial edge and this situation causes abnormal rotation in the vertical axis. In Type 3, the scapula is in superior translation and its superior medial edge is protruding.

Dyskinesia can occur as a result of an injury or it can be seen independent of trauma. There are clinical signs of protrusion of the medial or inferior edge of the scapula, earlier scapular elevation during elevation, and rapid downward rotation when lowering the arm. The scapula can have many causes: arthrosis of the AC joint, joint-related causes such as instability, bony structures such as thoracic kyphosis, clavicle fracture, and neurological causes due to injuries in the long thoracic or spinal accessory nerves. (23).

The mechanism that causes dyskinesia is mostly due to soft tissue, such as intrinsic muscle pathology or normal muscle activation inhibition. The reduced flexibility of the short head of the pectoralis minor or biceps pulls the coracoid process, causing protraction of the anterior tilt and scapula. (23,76). However, regardless of the cause of the dyskinesia, it results in the protraction of the scapula while resting or in motion on the shoulder. Protraction is not a desirable movement for shoulder function because it reduces the subacromial area and causes many shoulder pathologies and reduced rotator cuff force. (23)

In the evaluation of dyskinesia, the measurement is made according to a fixed point in the spine by comparing it with the contralateral side in 3 different positions of the scapula with the Lateral Scapular Shift Test. (76). With this test, scapular asymmetry can be measured in 3 different axes and varying loads. (77). Scapular position is evaluated when the upper extremity is at 0°, 45°, and 90° in abduction. Measurement is made on the spine from the inferior angles of both scapulas to the corresponding thoracic spinous process. It is designed to measure the ability of scapular stabilizers to control the scapula under varying loads. The problematic side has a longer scapular distance than the other side. This hypomobility is the result of scapular asymmetry and dysfunction. (83).

Abnormal scapular movements such as excessive scapular elevation and increased upward rotation during elevation are compensatory mechanisms developed against restricted glenohumeral movement due to adhesion. When the glenohumeral joint mobility is limited, the humerus pulls the scapula outwards earlier in elevation. At the same time, trapezoidal activity increased in the frozen shoulder. Excessive scapular

elevation and upward rotation, which develops compensatory to restricted GH movement, arises due to increased trapezius activity. Abnormal scapular motion and scapulohumeral rhythm may be associated with an imbalance of force generation of the upper and lower trapezoidal fibers along humeral elevation. (54).

Similarly, Rundquist and Ludewig found in their study in 2005 that in patients with frozen shoulder, overhead activities were performed by increasing scapular movement. Increased scapular movement is to compensate for the limited GH movement. (78)

2.2. Adhesive Capsulitis

2.2.1. Terminology

The adhesive capsulitis defined under the changing headings such as dull shoulder, capsulitis, pericapsulitis, periarthrititis and adherent bursitis is not yet fully understood in the literature and is a pathology in the terminology. (84). The most general definition is the pain and limitation in the active and passive movement that occurs in the shoulder joint as a result of the stiffness of the non-contractile structures in the glenohumeral joint. (16).

Adhesive capsulitis is defined as an idiopathic musculoskeletal problem, which is characterized as decrease in all of the shoulder joint movements and developing with adherence at the humeral head. (2,84).

In the literature, it was first described in 1872 as skapulohumeral periarthritis. (16, 85). In 1934, it was first defined by Codman and identified as frozen shoulder syndrome. Codman described this pathology as a difficult pathology to describe, treat and explain. (86). The same pathology has entered the literature by Neviaser as Adhesive Capsulitis in 1945. Neviaser stated that the definition of adhesive capsulitis was more accurate as fibrous, inflammation and capsular contracture were associated with the frozen shoulder (16, 86).

2.2.2.Epidemiology

Adhesive Castulitis is seen by 2-5% in the overall population. When the primary and secondary is separately, the primary is seen between 2-5% and secondary is between 4-38%. (87).

It is more common on the non-dominant side. (88). The impact of the dominant side is seen in 30% of cases. More frequently in seen in women, adhesive capsulitis affects women who are more than 50-70 years of age. (89). Adhesive Castulit is not common on the contralateral side. (85).

2.2.3. Risk factors

Risk factors of AC include diabetes, hyperthyroid, Parkinson and ischemic heart disease. A clear conclusion of genetic predisposition in the literature has not yet been reached. Again, several studies refer to the relationship between Primary Adhesive Capsulitis and Dupuytren. (2).

Among all risk factors, the most common is the relation between diabetes and adhesive capsulitis. The risk is higher in women who have diabetes than men who have diabetes. (90). It is more difficult to get good results after conservative treatment in patients with diabetes who have bilateral adhesive capsulitis. (91,92).

The history of shoulder, chest or cervical spine surgery is one of the risk factors of adhesive capsulitis. (93).

2.2.4. Classification

Adhesive Capsulitis is classified as Primary and Secondary. Primary adhesive capsulitis is idiopathic which causes global capsular inflammation and fibrous formation without any other lesions. It is also seen painful and progressive loss of active and passive movement.

The secondary is similar to the primary in terms of development, but it occurs due to intrinsic and extrinsic reason. Rotator cuff problems, bursitis and tendinitis are some of the intrinsic reasons as trauma is the most seen extrinsic reason. (4,94).

Zuckerman has divided the secondary adhesive capsulitis in 3 subgroups as a classification of adhesive capsulitis. In addition to intrinsic and extrinsic reasons, he identified the systemic secondary adhesive capsulitis and defined its reason as systemic connective tissue diseases. (16)

2.2.5. Clinical phases

Neviaser has described arthroscopically adhesive capsulitis stages in 1962. Hannafin and Chiaia examined the pathology in 4 phases based on the arthroscopic findings of Neviaser. (95)

Phase 1: The duration of symptoms varies from 0-3 months. The patient feels pain during the active and passive joint movement. Flexion, abduction, internal-external rotation movements are limited. In the evaluation, while the patient is under anesthesia, the range of motion is observed as full or close to the full range. In arthroscopic examination, glenohumeral synovitis is observed in anterosuperior capsule. In addition, hypertrophic and hypervascular synovite and normal capsule are observed.

Phase 2 - Freezing Phase: The duration of symptoms starts up from 3 months to 9 months. There is a complaint of chronic pain in active and passive joint movements. The marked limitation is observed in the movements in the first phase. The range of motion under anesthesia is the same as the patient is awake. In arthroscopic examination, it is observed that the capsule becomes more tight and the synovitis is more. Hypertrophic and hypervascular synovite is seen along with perivascular and subcinovial scar.

Phase 3 - Frozen Phase: The symptoms are between 9 months and 15 months. The patient feels minimal pain except the end point of the range of motion. The limitation is obvious and the last point is rigid in joint movements. The joint movement under anesthesia is the same as the patient is awake. When arthroscopically examined, it does not appear to be

hypervascular; The capsular volume has decreased and the capsule is thickened. Also there is intense scar formation under the capsule.

Phase 4 - Thawing Phase: The symptoms that last between 15-24 months are included in this phase. Pain is minimal. The range of motion is improving. (4,16).

2.2.6.Pathogenesis

The etiology and pathophysiology of adhesive capsulitis is still not fully understood. The studies done until today are limited in this sense; However, it is supported by some studies that various biological factors, mechanical stress etc. factors play a role. (6).

Studies conducted in recent years confirm the hypothesis that the pathological changes underlying adhesive capsulitis and causing the adhesive capsulitis inflammatory and fibrotic are synovial inflammation and accompanying capsular fibrosis. Cytokinesis has also been observed to accompany these processes. Cytokinesis is involved in the repair of many musculoskeletal problems and its continuous production results in the formation of fibrous tissue. Rodeo et al.proved in their study that cytokinesis was involved in the inflammatory and fibrotic stages of adhesive capsulitis in the samples taken from patients with primary and secondary adhesive capsulitis. Cytokineses such as transforming growth factor B, platelet derived growth factor, interleukin 1 B and tumor necrosis factor a have been observed in the stage of synovial hyperplasia and capsular fibrosis. (4, 6). However, there is still no consensus on how these two processes were triggered in the first place. (4).

The active fibroblastic process that takes place in adhesive capsulitis is similarly observed in Dupuytren's disease. It has been found that the risk of developing frozen shoulder and Dupuytren is higher in cases of gastric cancer treated with a synthetic matrix metalloproteinase inhibitor. This has shown that abnormal matrix metalloproteinase inhibitor release may be associated with pathogenesis. (6)

Studies investigating the relationship between diabetes and adhesive capsulitis are due to excessive glucose concentration; It was concluded that the faster collagen glycosylation

and cross-linking mechanisms in the shoulder capsule that developed against this situation restricted the shoulder joint movement. These mechanisms are thought to support the contracture in Dupuytren and trigger finger findings in diabetic patients. (6).

2.2.7. Clinical Findings

In idiopathic primary adhesive capsulitis, sudden onset pain, progressive limitation in all directions of the glenohumeral joint and loss of at least 50% in external rotation are the main clinical findings. Pain lasts longer than 4 weeks and is severe. At the same time, all these symptoms progress and begin to negatively affect sleep quality. (96, 97). Capsular pattern in adhesive capsulitis pathology is external rotation, abduction and internal rotation, respectively. (98).

Adhesive capsulitis gives different findings in its own phases. In phase 1, the patient complains of pain in the deltoid insertion. This pain increases with movement. The patient often complains of night pain and cannot lie on the affected arm. Movement is restricted, but this limitation ends when the pain complaint is relieved by intra-articular injection. In Phase 2, pain complaints begin to increase, especially at night. Limitation begins to progress in forward flexion, abduction and rotations, even if intra-articular injection is made. In Phase 3, the patient's complaint becomes not pain but limitation. The pain continues more minimally, especially at night. Injection for the joint cannot provide improvement in limitation as in Phase 2. In the last phase, the pain is minimal and the range of motion gradually increases. (86).

Although each phase is different in adhesive capsulitis, pain and limitation of movement are seen in all phases and all these phases do not always follow each other step by step. If the pain and increased limitation can last up to 2 years, 10% of the patients may not reach normal range of motion at all. (99).

Reeves stated that the healing process in adhesive capsulitis, which he divided into 3 phases clinically, was related to the duration of the painful phase. The longer the painful period lasts, the longer the thawing phase takes. Nevertheless, maximum improvement is observed between 1 and 4 years from the onset of symptoms. Codman, on the other hand,

states the expected recovery time as an average of 2-3 years. (100). Different studies suggest that 20% to 50% of patients diagnosed with adhesive capsulitis continue to have pain and limitation of movement for more than 3 years. (101). Similarly, Simmonds observed that pain and limitation persisted after 3 years in a study in 21 patients with adhesive capsulitis. (102). In another study, it was found that 40% of the patients still had symptoms after 3 years and 15% left permanent disability. (89). As a result of their prospective study, Binder et al. Found that 90% and 40% of normal range of motion could not be achieved, respectively, as a result of the evaluation performed 6 months and 3 years after diagnosis. (87).

2.2.8. Assessment Methods

2.2.8.1. Laboratory Tests

Since the relation between adhesive capsulitis and diabetes is known, glucose test can be applied to the patient who does not have diabetes diagnosis. If an autoimmune condition is suspected, it may be ordered additionally. The erythrocyte sedimentation rate and C-reactive protein levels may be high in patients with adhesive capsulitis, but these tests are not sensitive or specific. (99).

2.2.8.2. Imaging

Radiographic findings are mostly normal in patients with adhesive capsulitis. Capsular and coracohumeral ligament thickening, synovial hypertrophy and scar tissue formation in the rotator gap are frequently observed on MRI imaging. While edema in the joint capsule is often encountered in the early stages of adhesive capsulitis, capsular thickening increases as the phases progress. (93).

Plain Radiography

It is used to distinguish primary adhesive capsulitis from glenohumeral arthritis or calcific tendinosis diagnoses.

Arthrography

It is used to detect many findings characterized in adhesive capsulitis. The glenohumeral joint volume less than 10ml suggests adhesive capsulitis. Today,

conventional arthrography has left its place to MRI and MRA in the evaluation of adhesive capsulitis.

Magnetic Resonance Imaging / Arthrography

All phases of pathology can be evaluated with shoulder MRI. It is particularly useful in cases of adhesive capsulitis that cause less symptoms and can be confused with other pathologies such as rotator cuff tear and bursitis.

Ultrasound

It gives similar results to MRI and MRA. Compared to MRI, ultrasound is a shorter, more economical method and allows the diagnosis of patients with implants that are not suitable for MRI. (89).

2.2.9. Treatment

Most patients diagnosed with adhesive capsulitis are treated with a multidisciplinary approach without the need for surgery. However, since it is more difficult to respond to conservative treatment in secondary adhesive capsulitis, interventional treatment approaches are preferred earlier. (91).

2.2.9.1. Surgical

It is preferred when permanent and widespread functional limitations occur and there is no response to conservative treatment. (91)

Distension arthrography

It is a method that does not require general anesthesia. For this reason, it is preferred as an easier and more convenient alternative to operations such as manipulation or capsular release under anesthesia. (91)

Manipulation under anesthesia

It can be used alone or in conjunction with steroid injection and / or arthroscopic capsular release. Due to the risk of humeral fracture, it is not preferred in the elderly and

patients diagnosed with osteoporosis. It is often supplemented with steroid injections and physical therapy to maintain range of motion. (91)

Arthroscopic capsular release

It is a surgical method that is frequently used in the treatment of adhesive capsulitis. Initially, the glenohumeral joint is examined arthroscopically and checked for any other accompanying pathology. Subsequently, the contracted structures in the rotator gap are loosened. Afterwards, the patient is directed to physical therapy in order to maintain the joint range of motion provided. (91). Patients experience more rapid and distinct improvement in range of motion than other methods. (86)

Open capsular release

The indications for open capsular release are few and this method is rarely used. It is preferred in patients who cannot obtain results from arthroscopic release and closed manipulation methods. (86)

2.2.9.2. Non-Surgical

Patient education, use of painkillers, physical therapy or intra-articular steroid injection are frequently preferred conservative treatment methods instead of surgery. All these methods are preferred because they are non-invasive, economical and contain minimum risks. Since the main purpose of adhesive capsulitis is to reduce pain, especially in the early period, it is aimed to increase the patient's participation in the treatment by controlling the pain with the use of painkillers, patient education and active exercises. (91)

Intra-articular steroid injection

It is used to help reduce inflammation. In a randomized controlled study with 93 patients, two groups who received a rehabilitation program under the guidance of a physiotherapist alone and additional intra-articular injection were compared and better results were obtained in the injected group. (91).

The effectiveness of this method, which is an alternative to oral treatment, takes place widely in the literature. As a result of the study conducted by Rizk et al., It was found that steroid injection had a faster effect on decreasing pain symptoms, but this effect is temporary and disappears within 2-3 weeks. In their study with 42 patients, Bulgen et al. Divided the patients into 4 groups: the group that received intra-articular injection, the group that was manipulated by the physiotherapist, the group that received cold therapy, and the group that did not receive any treatment. In the first 4 weeks, a better improvement was achieved in the limitations in the injection group compared to the other groups. However, no difference was found between the groups after 6 weeks. (86).

Intra-articular injection is more effective when applied before significant capsular contracture develops in phases 1 and 2. It provides a quicker effect on pain reduction compared to placebo. (86)

In contrast to shoulder mobility and stretching exercises alone, intra-articular steroid injection and combined exercises are more effective in the development of pain and movement in the short term (4-6 weeks). (87).

Patient education

Patient education plays a major role in planning rehabilitation in adhesive capsulitis. Since the patient will be exposed to severe pain symptoms at the beginning of the pathology, it is important to inform the patient about the pathology and its phases and what to expect gradually, in order to overcome the patient's fear. Activity modification is taught to the patient, allowing the patient to continue his / her functional painless range of motion. Thus, immobilization is prevented. (87)

NSAID use

Despite its widespread use, the effectiveness of oral nonsteroidal anti-inflammatory drugs in the treatment of adhesive capsulitis is limited in the literature. (99). The effectiveness of some NSAIDs against each other was investigated, but no superiority was found in both groups because the pain was reduced. (86)

Exercise

In adhesive capsulitis stages 1 and 2, while resting is recommended to reduce the pain due to inflammation, it is also important to create an exercise program at the pain margin to maintain range of motion. After practices aimed at reducing pain, an exercise program at the limit of pain should be created both in the clinic and as a home program in order to prevent limitation. (16)

The mobility of the scapula is of great importance in the shoulder joint structure. Therefore, scapular mobilization techniques may be preferred, especially in the medial and superomedial parts where tension is high. (16)

Studies have shown that there is thickening in both the anterior and posterior capsules in the frozen shoulder, but thickening is mostly in the posterior capsule. In cases where the posterior capsule is tense, since the humerus and scapula move as a whole, when the glenohumeral joint mobility is achieved without providing scapular relaxation, the lateral movement of the scapula occurs during the movement. For this reason, anterior and posterior capsule stretching exercises should be added both manually to the treatment program in the clinic and to the patient's home program. (16)

One of the conditions that negatively affects the normal movement pattern of the scapula in the shoulder mechanics is the tension of the minor pectoral muscle. Again, loosening of this muscle is important in the patient and should be included in the rehabilitation program, both manually in the clinic and actively in the home program. (16)

All these stretches should be applied at the level of pain that the patient can tolerate and initially with low intensity for a short time. Since the tissue is in the remodeling stage in this process, it is strengthened by the synthesis of collagen and the increase of extracellular materials with intermittent loads thanks to stretching. (16)

According to the pain tolerance of the patient, the Codman exercise, which provides joint mobilization by increasing the joint release and the painless movement arc of the

shoulder, is added to the exercise program in the directions of flexion, abduction and circumduction. (4)

In order to increase the range of motion, shoulder flexion and abduction performed by using the ball and trunk flexion at the edge of the table, flexion and abduction exercises on the finger ladder are included in the rehabilitation program. (16)

In order to increase the use of the arm in daily life activities, the Wand exercise is given in the directions of flexion, abduction, extension, internal and external rotation as an active assistive exercise. At the last point of the movement, the patient is asked to keep his arm unaided at this point, and it is aimed to increase the range of motion with active repetitive contractions. (16)

When the pain decreases and the range of motion reaches the desired level, it is aimed to increase the muscle strength. In this phase, it is important to strengthen the muscles around the scapula and to reduce the increased upper trapezius activation in elevation. For this purpose, scapular retraction exercises in elbow flexion and extension are taught without activating the upper part of the trapezius. (16)

While determining the exercise program in the light of all these exercises, the patient should be taught that 1 set, 10 repetitions a day, and 30 seconds between exercise transitions should be given. (103).

When the flexibility of the posterior joint capsule decreases, the humeral center of rotation is displaced. This situation is one of the causes of shoulder pain. Many studies state that posterior capsule shortness is one of the mechanisms that cause shoulder injury. Especially the importance of stretching at the last degree of range of motion is emphasized. With the cross stretching exercise given for posterior capsule stretching, an increase in active internal rotation angle was observed in the patients in the study group after 1 week. The total elevation angle is increased with the anterior capsule stretching exercise. According to all these results, it can be concluded that when anterior and

posterior capsule stretching exercises are applied in adhesive capsulitis, an increase in total elevation will be achieved. (104)

Physiotherapy

Increasing range of motion and preventing capsular contracture, especially in advanced phases, it is the most preferred method for. Light stretching and active movement along the painless angle play an important role in the treatment of adhesive capsulitis. (86)

It is a whole that includes various modalities such as physiotherapy, osteopathy and laser therapy, ultrasound. With a rehabilitation program that includes passive mobilization and capsular stretching for 6-12 weeks, improvement in range of motion is expected in the patient. However, this program is not suitable for patients with acute and painful inflammatory phase. In many studies, it has been found that mobilization applied with heating agents has positive results as it changes the viscoelastic properties of the connective tissue. For this purpose, ultrasound and short wave diathermy techniques are also used. In a study, the shortwave diathermy activities applied with stretching exercise and stretching exercise were compared and it was concluded that shortwave diathermy application with stretching exercise was more beneficial in pain and disability. (91)

Electrotherapy agents such as hot-pack application and transcutaneous electrical nerve stimulation (TENS) are also included to the treatment as they enhance the effect of exercises and manual applications. The application of hot-pack Before or during the exercise or manual therapy increases The muscle extensibility. This is due to the decrease in muscle viscosity and neuromuscular-mediated relaxation. Especially TENS application results in pain reduction and improvement in range of motion. (95).

Rehabilitation should be planned by combining shortwave diathermy, ultrasound or electrical stimulation with mobility and stretching exercises in patients with adhesive capsulitis to reduce pain and increase range of motion. (87)

Joint mobilization

Although many studies have investigated the effect of joint mobilization in patients with adhesive capsulitis and found that it is effective, the superiority of mobilization compared to other applications has not been proven. In his study of a group of patients with adhesive capsulitis, Nicholson formed two groups: joint mobilization - active exercise and only exercise group. After 4 weeks of treatment, range of motion increased and pain decreased in both groups. The only difference is that passive abduction improved better in the mobilization group. The glenohumeral joint should be applied directly to improve joint mobilization and pain and range of motion. (87). Johnson et al. Investigated the effect of mobilization in their studies on patients with a diagnosis of frozen shoulder and found that mobilization in the posterior direction increased the range of motion more than anteriorly. (104).

Mulligan

Developed by Brian Mulligan, the Mulligan concept is a concept of manual therapy techniques that are often used to reduce pain in peripheral joints in musculoskeletal problems. The technique of mobilization with motion involves the active movement of the patient simultaneously with the physical therapist's practice of manual gliding in the painful joint. (98). The principle of this mobilization is based on analyzing and correcting any minor positional errors in the joint. (103, 105). Correct alignment is tried to be reinforced with a movement in addition to the active movement of the patient (106). If the active movement is painless, the desired result is achieved with the sliding movement. (103, 105). This technique is applied painlessly and repeatedly with additional overpressure for a successful result. Thus, good results can be obtained even in the first session (109).

In addition to mobilization with movement, it focuses on the principles of assisted sliding, physiological movement, pain-free or immediate effect with reduced pain, and overpressure. With this technique, getting better results in pain reduction is provided by painless passive overpressure application at the end of joint range of motion. (103).

Studies have measured its effectiveness in pain and range of motion. While the humeral head is centered in the glenoid fossa in a patient without pathology during shoulder motion, a superior or anterior translation of the humeral head is observed in the presence of pathology. And this over-translation results in pain and loss of function. It is thought that the posterior sliding technique with movement mobilization will provide painless movement by correcting this erroneous position. In a cadaver study conducted by Hsu et al in 2000, they found that the glenohumeral abduction angle improved with the anterior posterior sliding movement they applied along the abduction angle. (107).

The Mulligan technique, which can be applied active or passively, aims to correct the positional error by producing a synchronized hypoalgesic effect and changing the function of the central nervous system during and after the application. This results in a rapid and total pain relief. (108).

Brian Mulligan defined positional joint error as a malposition between the articular joint surfaces that is the cause of the patient's symptoms (109). Mobilization by movement corrects minor positional errors in the joint. According to this hypothesis, positional errors often cause pain and joint limitations. (105,110). And with correction of positional error, the symptoms disappear (109).

Nervous system stimulation during implementation of the Mulligan concept can be considered as a complementary explanation of pain reduction. These physiological effects mostly occur on the side where the technique is applied. (109).

Mulligan mobilization gives tactile and compressive stimulation to soft tissue. The afferent activity resulting from this stimulation affects the inhibitory nociceptor spinal cord neurons in the motor neuron pool, so the patient provides repetitive and painless movement. This helps to close the wrong spinal cord circuit that occurs in the patient and normal level of nociception is reestablished (111).

In the mobilization technique with movement aimed at painless movement in the peripheral joints, the mobilization directions consist of internal-external lateral shift,

internal-external rotation, and anteroposterior-posteroanterior shifts. (109). In the painful shoulder joint, the shift applied in the mobilization technique with movement is in the posterior or posterolateral direction. While the technique is being applied, the patient is in a sitting position. The physiotherapist stands on the non-painful side of the patient. While the physiotherapist places the thenar region of his hand anterior to the humeral head of the patient, he stabilizes the scapula with the other hand. It performs the posterolateral sliding movement without putting pressure on the coracoid process by hand in the humerus. During this maneuver, the patient is asked to raise his arm up to the painful point in the scapular plane. With 3 sets of 10 repetitions, the patient moves actively and there is a delay of 30 seconds between sets. (98,103, 107).

Mulligan technique is indicated if it provides free and painless movement in the affected joint during application. The direction of the applied force must be perpendicular to the plane of motion, except in some exceptional cases. (105-121).

The most important points in the Mulligan concept are the active participation of the patient and the elimination of pain during the application. With these features, the Mulligan technique also ensures its safety. In addition, to date, this technique has not been found to have a side effect. (109).

Function development and pain reduction after the mobile mobilization technique may be due to increased active movement with this technique. Active movement increases the participation of extra proprioceptive tissues such as the Golgi tendon organ, which is activated by tendon tension. However, there was no significant difference in terms of increased range of motion in the long term. (103). As a result of the studies of Teys et al. In 2006, the Mulligan technique provided rapid and distinct ROM development and pain reduction in the painful and restricted shoulder joint. (107)

In a systematic review consisting of randomized controlled trials, the effectiveness of different manual techniques were evaluated in musculoskeletal disorders of the shoulder, and it was found that the mobilization technique was useful in the short term in shoulder problems. (103)

In the study conducted by Doner et al in 2013, the instant and 3-month effectiveness of the Mulligan technique in patients with adhesive capsulitis was examined and it was concluded that the Mulligan technique was more effective than conventional stretching. (10)

In the study conducted by Yang et al. In 2007, mobility and functional skill increase in the joint was observed with the development of scapulohumeral rhythm after the mobilization technique. (98).

Again, in a similar study, Mulligan and conventional treatment were compared; It has been found to be more effective in the development of pain and range of motion. In addition, functional skills were better developed in the Mulligan group compared to DASH. (106).

Proprioceptive Neuromuscular Facilitation (PNF)

Proprioceptive Neuromuscular Facilitation is described as to ease the responses of the neuromuscular mechanism by the stimulation of the proprioceptors. This technique is focused on the principle that the physiological movements in the human body have rotational and oblique characteristics and the greater response comes with the maximum resistance. The purpose is to improve the ability of the posture and movement by using hand contact, visual and verbal stimulus. (116)

PNF targets to develop the voluntary control at the central level. Herman Kabat used the information of neurophysiology, motor learning and motor behavior while forming PNF technique. In 1948 Kabat and Knott emphasized on the maximum resistance as the first principles of PNF. More motor neurons are stimulated with maximum resistance. (116)

In 1956, Kabat introduced another mechanism which is the importance of sense in the creation of movement. Skeletal muscles, muscle, tendon and joint receptors on the ligaments and joints send the information of muscle function, posture and movement the central nervous system. They are the muscle spindles, golgi tendon organs, the fascia

of muscles and joints and the other receptors on the connective tissue. These receptors are sensitive to pressure and stretching. The facilitation of these receptors increases the number of stimulated neurons. (116)

The stimulation of muscle spindle facilitates the synergistic muscle and inhibits the antagonist muscle. The golgi tendon organs are located on the tendons and stimulated with the stretching. The golgi tendon inhibits the target muscle and its synergistic muscle but activates the antagonist muscle. This mechanism contributes the reduction of muscle tone by otogenic inhibition. The other receptor called Pacinian corpuscles. They are located on the tendon, joints and periost, under the fascia of the muscle and subcutaneous tissue. The Pacinian corpuscles are sensitive to pressure. (116)

The PNF patterns are gross movement patterns and underlie all the techniques. The gross movement is one of the the characteristics of normal motor function. According to Beevor, the brain controls the movement as a whole not the muscles individually. (116)

The PNF patterns occur with the combination of the movements on three planes:

1. Flexion and extension on sagittal plane
2. Abduction - adduction on extremities and lateral flexion on trunk on frontal plane
3. Rotation on transverse plane

Autogenic inhibition, reciprocal inhibition, stress relaxation and the gate control theory are the four physiological mechanisms underlie the increase in ROM. (112,113). In a condition like sense of stretching or muscle contraction, these mechanisms occur in the golgi tendon organs in the target muscle or in the antagonist muscle reflexively.

a. Autogenic Inhibition : When the muscle is contracted or stretched, the inhibitory signals are sent from the golgi tendon organs of the same muscle and it is concluded as a decrease in excitability. Ib afferent fibers located in the golgi tendon organs are activated and signals are sent from afferent fibres to the spinal cord. Without this stimulus, the inhibitory interneurons in the spinal cord are activated. These interneurons decrease the nerves' excitability and muscles' efferent motor drive. (113). The target muscle relaxes

in this way. The body use that mechanism as a self-regulatory mechanism and protects structures. The ROM is increased with the advantage of viscoelastic characteristics of musculotendinous units, so that the muscle can elongate.

b. Reciprocal Inhibition : When the opposing muscle is contracted for maintaining the maximum contraction force, the target muscle relaxes. The neural activity decreases and the the inhibition proprioceptive structures in the target muscle increases so there is a relaxation in the target muscle. (112). Ia afferent fibers enter the spinal cord and give off collateral branches. Then the alpha motorneurons on the golgi tendon organs of the target muscle are signalled. This mechanism creates an inhibitory and also relaxing effect for the target muscle. (113). By this mechanism, it is prevented that the target muscle and the antagonist muscle work against one another. The interneuron which innervates the alpha motorneuron results in the decrease of the neural activity of target muscle so the target muscle can stretch more. (112).

c. Stress Relaxation : Muscles and tendons which form musculotendinous unit have viscoelastic characteristics. It means that MTU is resistant to stress and can return to its original form after the stress is removed. If there is a constant stretch in MTU, stress relaxation mechanism appears. This mechanism protects the muscle from tearing by decreasing the passive torque. (113,114).

d. The Gate Control Theory : Peripheral pain receptors are connected to non-myelinated or small-myelinated afferent fibers. But pressure receptors are connected to larger myelinated afferent ones. If both of them are synchronously stimulated, the pressure afferent fibers reach to the spine before the pain fibers do.(114). When the large fibers transmit stimulation, the pain signals are inhibited in the dorsal horn. (115). With the PNF technique when the muscle is stretched beyond its active ROM, the participant resist against the stretch. Then the target muscle is stretched more and a large force is produced. The body detects the large force and the golgi tendon organs are activated to inhibit the force and protect from injury. If this protocol is consistent, the golgi tendons adjust that large force and allow muscle to produce to generate more force. Both the decrease in the

golgi tendon organs inhibition and the increase in the ROM, the muscle can be strengthened. (114).

The Techniques of PNF

The PNF techniques developed by Kabat and Knott are divided into two groups:

1. Facilitation Techniques

- a. Rhythmic initiation
- b. Repeated stretch
- c. Replication
- d. Combination of isotonic
- e. Dynamic reversal
- f. Stabilizing reversal
- g. Rhythmic stabilization

2. Inhibition Techniques (116)

- a. Contract-relax
- b. Hold-relax

Rhythmic initiation is to move the extremities in a planned ROM rhythmically and passively. It is mostly used during the PNF application to teach the movement patterns. This technique also improves the sense of movement and coordination.

Repeated stretch technique is based on the concept that the repeated stimulation of the central nervous system decreases the synaptic resistance and simplifies the impulses transition and the isometric contraction against the resistance is more effective than the isotonic contractions. It is useful for increasing the ROM and strength and improving the voluntary movement skills.

For a successful movement pattern, it is important for the patient to learn what will happen at the end of the movement. Replication technique is based on the isometric and repeated isotonic contractions that facilitates the time of learning any functional activity.

The aims of this technique are to learn the completed movement position to the patient, increase the endurance and correct the muscle imbalance.

Combination of isotonic technique is a sequence of concentric, eccentric contractions and stabilization without any relaxation. It enhances the strength and coordination of movement.

Dynamic reversal is combined of sequential isotonic contractions of agonist and antagonist muscles without any relaxation. It improves the active ROM, increase the strength, endurance and coordination.

Stabilizing reversal is a technique that includes stabilizing contractions from different directions with the amount of resistance which prevents the movement occurs. The aim is to generate the response of dynamic stabilization. It enhances stabilization and balance, increase the strength and agonist-antagonist muscle coordination.

Rhythmic stabilization has the consecutive isometric contractions of agonist and antagonist muscles. One co-contraction occurs because of using isometric contractions only. With this technique, active and passive ROM is increased, strength, stabilization and balance are improved and pain is decreased.

Contract-relax technique includes the isotonic and isometric contractions at the limitation point. The aim is to increase the passive ROM.

Hold-relax is a relaxation technique which is based on the isometric contractions against the maximum resistance. With the extremity in the agonist pattern, the patient is told to do isometric contraction against to maximum resistance for 5-8 seconds with no movement at the limitation point. It is important not to see any movement during the contraction. After the maximum isometric contraction, the patient is told to relax actively. It is controlled actively or passively by the therapist to see if there is any increase in the movement in the agonist direction. With the increase in ROM, the technique is repeated

a few times at the new limitation points. To increase the passive ROM and decrease the pain are the aims of this technique.



3.MATERIAL AND METHOD

3.1. Subjects

Our research, which was planned as a prospective randomized control, was conducted in Sportomed Suadiye Clinic between June 2019 and August 2020.

In the power analysis, the alpha significance level (Type I error) was taken as $\alpha=0.05$, and the power value we wanted to obtain (Type II error) was taken as $\beta=0.80$. The effect width was taken as $|\rho|=0.80$, which is a value that accepts a high degree of difference according to Cohen's d standards (for studies with 2 groups) (this value is calculated based on the values in the article "EVALUATION OF MULLIGAN'S TECHNIQUE FOR ADHESIVE CAPSULITIS OF THE SHOULDER". placed). As a result of these, the number of people to be included in the study was determined as 42 in total. In other words, there are 42 people in total, 21 people in the Mulligan group and 21 people in the PNF group.

A total of 42 patients who came to our clinic, diagnosed with adhesive capsulitis, had complaints of at least 3 months or more, and accepted to participate in the study were included in the study. These patients 28 woman 14 were male and PNF group was $62,33\pm$ years while MULLIGAN group was 63 ± 52 years..

3.1.1. Inclusion criteria

- A complaint of shoulder pain for at least 3 months or more
- Phase 2-3, unilateral Adhesive Capsulitis
- At least one of the external rotation movements in abduction, flexion and 0° abduction
- Painful and limited active and passive ROM in one of them (more than 50% limitation compared to the unaffected side) Night pain on the affected side that prevents sleep
- Maximum 100 elevation in the anterior shoulder area

3.1.2. Exclusion criteria

- Accompanying neck pain and radiculopathy
- Infection or malignancy in the shoulder area
- Previous surgery on the shoulder joint

- Rheumatological problems
- Rotator cuff rupture
- Fracture, instability, dislocation and subluxation

The study protocol was approved by the Marmara University Faculty of Health Sciences Non-Interventional Ethics Committee on 30.05.2019 with protocol number 67. The aim and protocol of the study were explained to the patients before participating in the study. Patients gave written consent to voluntarily participate in the study's test protocols.

3.1.3. Flow of Research

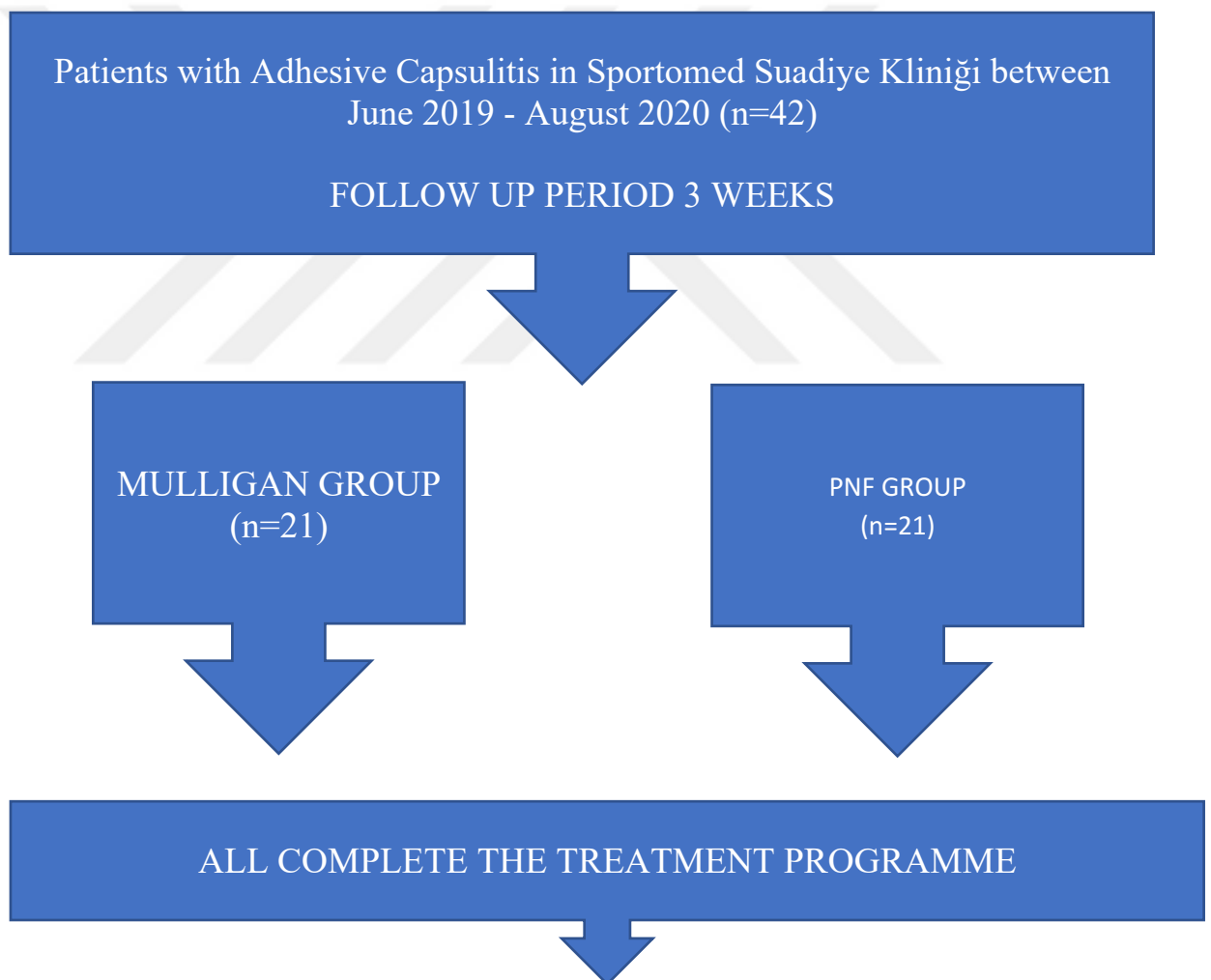


Figure 3.1. Flow Chart Diagram

3.1.4. Study Protocol

Two groups were created using the randomization method by giving random numbers among the patients with adhesive capsulitis who just started treatment with randomization method. 42 patients diagnosed with adhesive capsulitis were divided into two groups: the group to be applied the Mulligan concept ($n = 21$) and the group to apply the PNF technique ($n = 21$).

Conventional treatment including hot-pack application and TENS current for 20 minutes was applied to both groups before Mulligan and PNF applications. While the patients in the first group, Mulligan group, were applied Posterolateral glide technique in addition to conventional treatment; The Hold-relax method was applied to the patients in the PNF group. The treatment program was applied to the patients in both groups for a total of 3 weeks, 5 days a week.

In the treatment, both groups were taught an exercise program consisting of Codman exercise, wand exercises and anterior-posterior capsule stretching exercises. The patients included in our study were evaluated by the same physiotherapist pre and post the treatment program of 15 sessions.

The evaluation consisted of the following parts:

- ✓ Sociodemographic questionnaire
- ✓ Evaluation of joint range of motion
- ✓ Evaluation of shortness for pectoralis major-minor, teres major, latissimus dorsi, rhomboid major-minor muscle groups
- ✓ Shoulder Pain and Disability Index (SPADI)
- ✓ Arm, Shoulder and Hand Problems Index (DASH)
- ✓ Lateral scapular sliding test
- ✓ Pittsburgh Sleep Quality Test

3.2. Evaluations

3.2.1. Sociodemographic questionnaire

Participants were asked to fill out a sociodemographic questionnaire including age, height, weight, gender, dominant side, whether they had a surgical operation on the shoulder joint, the presence of shoulder fractures, subluxation and rotator cuff tears, and chronic diseases.

3.2.2. Evaluation of joint range of motion

In the supine position, flexion, abduction, internal and external rotation measurements were made with a universal goniometer. Shoulder flexion and abduction were written between 0-180 ° and rotation between 0-90 ° (10).

For flexion, the pivot point in the elbow extension was the great tubercle of the humerus, and the moving arm was measured parallel to the midline of the humerus by asking the patient to raise his arm. For abduction, the patient was measured by asking the patient to open his arm sideways, parallel to the anterior midline of the humerus, with the patient's arms in the supine position on the side of the body, the pivot point of the goniometer as the acromion. Internal and external rotation was measured in the supine position, with the shoulder in 90 ° abduction and the elbow in 90 ° flexion. The goniometer pivot point was placed as the olecranon and the moving arm was at the midpoint of the ulna with the radial, parallel to the 3rd metacarpal, and the patient was asked to perform the movements (117).



Figure 3.2. Evaluation of shoulder external rotation and abduction with universal goniometry

3.2.3. Evaluation of shortness for pectoralis major-minor, teres major, latissimus dorsi, rhomboid major-minor muscle groups



Figure 3.3. Evaluation of Muscle Tightness

For the evaluation of the shortness of the pectoral muscles, the patient lies on the back with the knees slightly flexed. He clamps his hands at the back of the neck and frees

his elbows in this position. If not, the pectoral muscles are short. Shortness can also be recorded by measuring the distance between the lateral epicondyle of the humerus and the bed with a tape measure. For the adductor and internal rotator muscles, the patient is asked to raise his arms over his head in the same position, with the elbows in extension. The evaluation of shortness can be made by measuring the distance between the lateral epicondyle of the humerus and the bed (117).

3.2.4. Shoulder pain and disability index

5 questions of this index, which consists of 13 questions in total, measure pain and 8 questions measure disability. The patient scores each question on a scale of 0-10. The higher the score in the pain and disability sections, the higher the pain intensity and disability are evaluated (118). In our study, we used this test in our native language.

3.2.5. Arm, shoulder and hand problems questionnaire

This questionnaire is used to evaluate physical disability and symptoms in upper extremity problems. It consists of 3 parts. The first part, consisting of 30 questions, determines the patient's function / symptom score. The second part evaluates the patient's disability in business life, while the third part evaluates the patient group engaged in sports or music. Patients answer the questions according to the 5-point Likert system. Scores between 0 and 100 are determined for each section. The higher the score, the higher the disability (119). In our study, we used this test in our native language.

3.2.6. Lateral scapular slip test

It is done to evaluate dyskinesia. It evaluates the position of the scapula in the 0-45-90 degree abduction positions of the shoulder. It is applied in 3 different positions, with arms on both sides of the body in neutral position, hands at hip level with shoulder 45 ° abduction and internal rotation, and 90 ° shoulder abduction at maximum internal rotation. Bilaterally, the lower end of the scapula and the closest spinose process in the horizontal plane are measured, and differences over 1 cm are evaluated as positive (9).



Figure 3.4. Evaluation of scapular dyskinesis at 45 degrees

3.2.7. Pittsburgh sleep quality index

It is an evaluation consisting of 7 sub-categories and a total of 19 questions, given a score of 0-3. It includes sub-categories such as subjective sleep quality, sleep delay, sleep duration, use of sleeping pills. These 7 subcategories are grouped together to determine a global score between 0-21. High score corresponds to worse sleep quality (120). In our study, we used this test in our native language.

3.3 Treatment

Table 3.1. Treatment Programme of Both Groups

MULLIGAN GROUP	PNF GROUP
20 minutes hot-pack + TENS of 100 Hz, 0,05-0,07 ms	20 minutes hot-pack + TENS of 100 Hz, 0,05-0,07 ms
Home-exercise programme including Codman exercises, Wand exercises and anterior-posterior capsule stretching exercises.	Home-exercise programme including Codman exercises, Wand exercises and anterior-posterior capsule stretching exercises.
Posterolateral gliding technique 30 times, 3 sets of 10 repetitions with 30 seconds of rest between sets.	Hold-relax technique with isometric contractions lasting 5-8 seconds against maximum resistance.

Conventional treatment including hot-pack application for 20 minutes and TENS current of 100 Hz, 0.05-0.07 ms were applied to both groups before PNF and Mulligan applications. In the treatment, both groups were taught the following exercises, both in the clinic and as a home program:

Codman exercise: drawing front-back right-left lines and clockwise-counter-clockwise circles 1 * 10

Wand exercises: flexion, abduction and internal rotation 1 * 10

Anterior-posterior capsule stretching exercises 1 * 5



Figure 3.5. Home-exercise programme including Wand, Codman and stretching exercises

Patients were randomly divided into two groups as Mulligan and PNF groups, and a total of 15 sessions of treatment were applied 5 days a week for 3 weeks. The hold-relax technique in the upper extremity in the PNF group and the posterolateral glide technique in the Mulligan group were applied by the researcher.

While the Posterolateral Glide technique was applied to the Mulligan group, the physiotherapist stood on the unaffected side of the patient. One hand was placed posteriorly on the scapula to stabilize the scapula, while the other was placed anterior to the humeral head. A posterior gliding force was applied to the humeral head. While the force was being applied, the patient was asked to raise his arm up to the level where he started to feel pain. This application was repeated 30 times, 3 sets of 10 repetitions, with 30 seconds of rest between sets.

In the PNF Hold-Relax technique, which increases the passive range of motion and reduces pain with isometric contractions lasting 5-8 seconds against maximum resistance in the PNF group, the physiotherapist will have the affected arm of the patient in the opposite hip shoulder extension / adduction / internal rotation, elbow extension, forearm

pronation posture. positioned in the way. The patient was asked to raise his hand over his head. The patient tried to expose this movement by shoulder flexion / abduction / external rotation. Meanwhile, the physiotherapist supported the patient's arm with his other hand.



Figure 3.6. PNF Hold-Relax Technique (left), Mulligan Posterolateral Glide Technique (right)

3.4. Statistical analysis

The statistical analysis of the study was made using "SPSS for IBM Version 22.0" statistical package program. The compliance of the variables to normal distribution was examined using the Kolmogorov-Smirnov test. Averages of variables; arithmetic mean $\pm$ standard deviations ($X \pm SD$) were shown. The statistics of the pre-treatment and post-treatment findings within the groups were done by "t test for dependent groups (Significance Test of the Difference Between Two Spouses)". The differences between groups pre and post the treatment were examined with "t test for independent groups (Significance Test of the Difference Between Two Means)" and the differences were

revealed. In determining the significance level of statistical differences, $p < 0.05$ was taken and expressed with the * sign.



4.RESULTS

The study included Adhesive Capsulitis diagnosed patients (n=42, 28F/14M) who referred to Suadiye Sportomed Fizik Tedavi ve Rehabilitasyon Merkezi, İstanbul, Turkey by a Medical doctor between June 2019 and January 2020.

The group in which the Mulligan Concept is applied will be defined as group 1 and the Group in which the PNF Technique is applied will be defined as Group 2.

Table 4.1. Physical Features of Participants

	Treatment Protocol	N	Mean $\pm$ SD	t	p
Age	PNF	21	62.333 $\pm$ 10.823	-0.377	0.708
	MULLIGAN	21	63.524 $\pm$ 9.616		
Height (m)	PNF	21	1.64 $\pm$ 0.107	-0.908	0.369
	MULLIGAN	21	1.669 $\pm$ 0.101		
Weight (kg)	PNF	21	70.143 $\pm$ 11.105	-0.18	0.858
	MULLIGAN	21	70.857 $\pm$ 14.43		
BMI (kg/m²)	PNF	21	26.058 $\pm$ 3.351	0.556	0.581
	MULLIGAN	21	25.385 $\pm$ 4.417		

p<0,05 Independent Samples T Test*

A total of 42 people participated in the study and 21 of these 42 were treated with PNF treatment method and the other 21 were treated with MULLIGAN method. The mean age of Group 2 was 62.33 and the mean age of Group 1 was 63.52 and their standard deviations were 10.8 and 9.6. Since the p value is greater than 0.05, there is no significant differences between the groups by age.

The mean height of PNF and MULLIGAN are 1.64 and 1.669, respectively. Standard deviations are 0.107 and 0.101. Since the p value is greater than 0.05, there is no significant division among the treatment groups in terms of height. The mean weight of Group 2 and Group 1 are 70,143 and 70,857 respectively. Standard deviations are 11.105

and 14.43. Since the p value was greater than 0.05, it was not significant differences between the treatment groups according to weight.

The mean of BMI values of Group 2 are 26.05 and 25.385 are respectively. Standard deviations are 3.351 and 4.417. Since the p value is greater than 0.05, there is no significant differences between the treatment groups according to BMI. According to the results, homogeneity was achieved in the participating treatment groups.

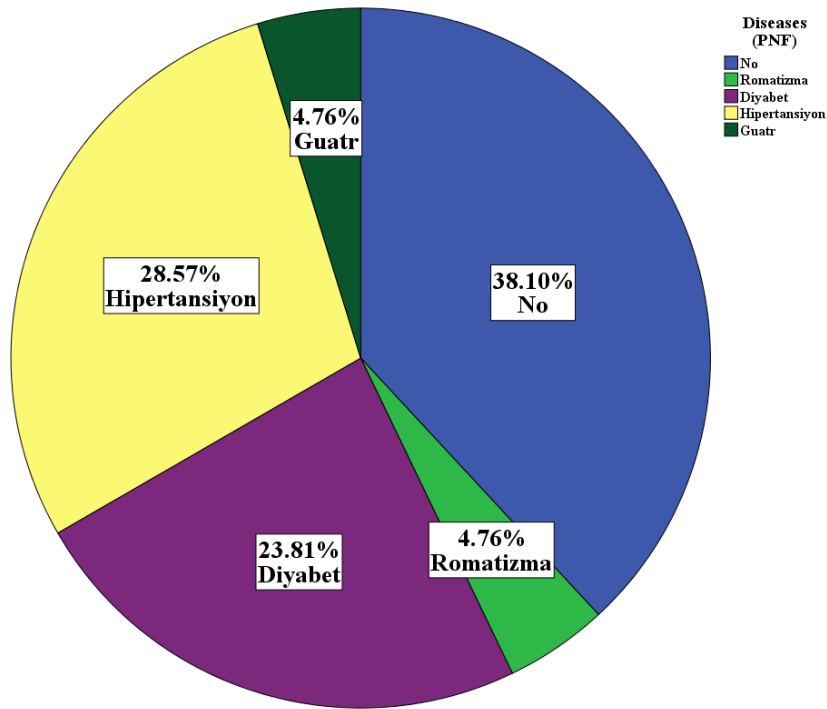
Table 4.2. The frequencies of the Characteristic Features of Participants

		PNF		MULLIGAN		χ^2	p
		N	%	N	%		
Gender	Female	14	66.70%	14	66.70%	0.000	1.000
	Male	7	33.30%	7	33.30%		
Affected Side	Right	11	52.40%	11	52.40%	0.000	1.000
	Left	10	47.60%	10	47.60%		
Dominant	Right	17	81.00%	15	71.40%	0.525	0.469
	Left	4	19.00%	6	28.60%		

p<0,05 Chi-Square Test*

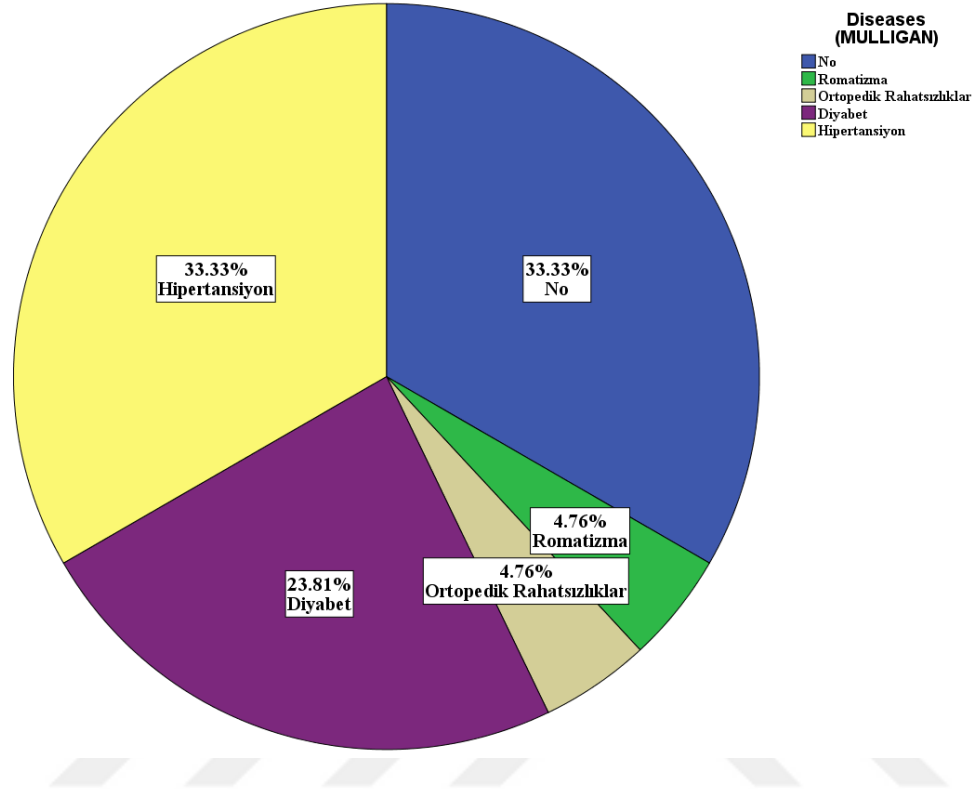
66.7% of the patients in the Group 2 were female and 33.3% were male. The proportion of patients in the group 1 is also the same. Since the p value is greater than 0.05, there is no significant difference between the treatment groups in terms of gender. The proportion of patients in the Group 2, whose affected side is right, is 52.4%, and the rate of those who are left is 47.6%. The proportion of patients in the Group 1 is also the same. Since the p value is greater than 0.05, there is no significant difference between the treatment groups according to the affected side. The dominant side of the patients in the Group 2 is 81% for the right side and 19% for the left side. The dominant side of the patients in the group 1 was 71.4% for the right side and 28.6% for the left side. Since the p value is greater than 0.05, there is no significant difference between the treatment groups according to the dominant side. According to the above results, homogeneity was achieved in the treatment groups participating in the study.

Graph 4.1. The distribution of the chronical diseases of Group 2



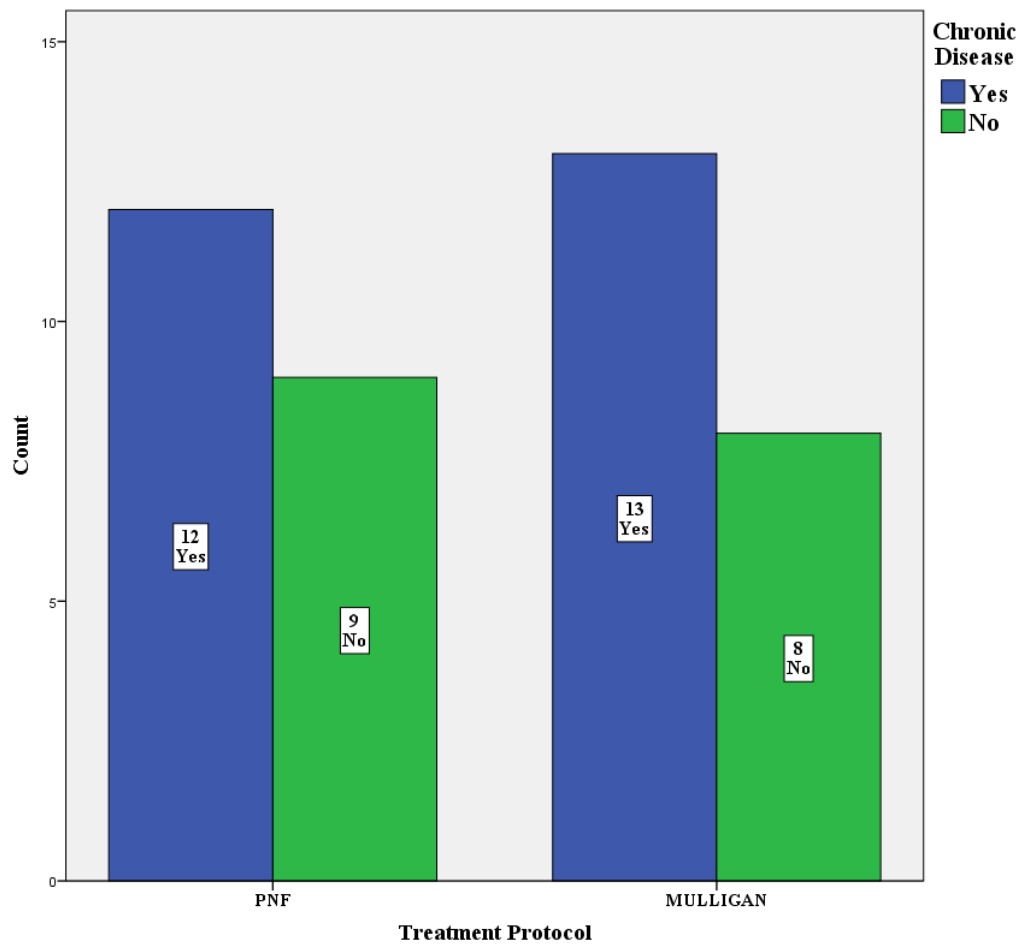
In group 2 participants, 28.57% have hypertension, 23.81% diabetes, 4.76% rheumatism and 4.76% guatr disease. The remaining 38.1% have no disease.

Graph 4.2. The distribution of the chronical diseases of Group 1



Of 21 people in Group 1, 33.33% have hypertension, 23.81% diabetes, 4.76% rheumatism and 4.76% orthopedic disorders. There is no disease in the remaining.

Graph 4.3. Chronical disease distribution according to the treatment groups



20 of the patients of Group 2 have chronic disease, 9 of them do not have any chronic disease. 13 of the patients group 1 have chronic disease, 9 of them do not have any chronic disease.

Table 4.3. Comparison of Flexion and Abduction Evaluation of Group 2 Pre and post the Treatment

	N	Mean $\pm$ SD	t	p
Flexion (Pre)	21	84.381 $\pm$ 17.848	-8.78	0.001*
Flexion (Post)	21	131.905 $\pm$ 30.227		
Abduction (Pre)	21	69.286 $\pm$ 22.599	-8.306	0.001*
Abduction (Post)	21	112.857 $\pm$ 29.35		

p < 0,05* Paired Samples T Tes

The p coefficients of the flexion and abduction tests of the Group 2 patients pre and post the treatment were less than 0.05. In this case, there is a significant difference between these variables pre and post treatment. Namely, PNF treatment was effective in flexion and abduction tests. While Flexion average value was 84,381, this value increased to 131,905 after treatment. In the abduction test, while the average treatment was 69,286, this value increased to 112,857 after the treatment.

Table 4.4. Comparison of Flexion and Abduction Evaluation of Group 1 Pre and post the Treatment

	N	Mean $\pm$ SD	t	p
Flexion (Pre)	21	87.238 $\pm$ 16.513	-11.661	0.001*
Flexion (Post)	21	144.619 $\pm$ 17.987		
Abduction (Pre)	21	71.191 $\pm$ 17.671	-10.665	0.001*
Abduction (Post)	21	123.571 $\pm$ 24.246		

p < 0,05* Paired Samples T Test

The p coefficients of the flexion and abduction tests of the patients treated with Mulligan pre and post the treatment were less than 0.05. In this case, there is a significant difference in these variables between pre and post treatment. In other words, Mulligan treatment was effective in flexion and abduction tests. While Flexion average value was 87,238 before treatment, this value increased to 144,619 after treatment. In the abduction

test, it was 71.191 before the treatment, while this value increased to 123.571 after the treatment.

Table 4.5. Comparison of Internal and External Rotation Evaluation of Group 2 Pre and post the Treatment

	N	Mean $\pm$ SD	z	p
Internal Rotation (Pre)	21	35.952 $\pm$ 26.202	-3.858	0.001*
Internal Rotation (Post)	21	51.191 $\pm$ 23.287		
External Rotation (Pre)	21	24.857 $\pm$ 20.759	-4.027	0.001*
External Rotation (Post)	21	43 $\pm$ 21.483		

p<0,05* Wilcoxon Test

The p coefficients of pre-treatment and post-treatment values of the internal and external rotation tests of the patients treated with PNF were found to be less than 0.05. In this case, there is a significant difference in these variables between pre and post treatment. Namely, PNF treatment was effective in internal and external rotation tests. While the mean internal rotation value was 35,952 before the treatment, this value increased to 51,191 after the treatment. In the external rotation test, the average was 24,857 before the treatment, while this value increased to 43 after the treatment.

Table 4.6. Comparison of Internal and External Rotation Evaluation of Group 1 Pre and post the Treatment

	N	Mean $\pm$ SD	z	p
Internal Rotation (Pre)	21	19.286 $\pm$ 13.81	-3.833	0.001*
Internal Rotation (Post)	21	41.191 $\pm$ 16.726		
External Rotation (Pre)	21	18.143 $\pm$ 14.729	-3.93	0.001*
External Rotation (Post)	21	35.476 $\pm$ 16.875		

p<0,05* Wilcoxon Test

The p coefficients of the pre-treatment and post-treatment values of the internal and external rotation tests of the patients treated with Mulligan were found to be less than

0.05. In this case, there is a significant difference in these variables between pre and post treatment. In other words, Mulligan treatment was effective in internal and external rotation tests. While the mean internal rotation value was 19,286 before the treatment, this value increased to 41,191 after the treatment. In the external rotation test, the average was 18,143 before the treatment, while this value increased to 35,476 after the treatment.

Table 4.7. The Comparison of Adductor and Pectoral Tightness Evaluation of Group 2 Pre and post the Treatment

	N	Mean ± SD	t	p
Adductor Tightness (Pre)	21	26.381 ± 6.932	8.179	0.001*
Adductor Tightness (Post)	21	16.714 ± 6.302		
Pectoral Tightness (Pre)	21	26.81 ± 7.801	6.438	0.001*
Pectoral Tightness (Post)	21	15.81 ± 6.258		
<i>p<0,05* Paired Samples T Test</i>				

The p coefficients of the pre-post-treatment values of the adductor tightness and pectoral tightness tests of the patients who were treated with PNF were less than 0.05. In this case, there is a significant difference in these variables between pre and post treatment. Namely, PNF treatment was effective in adductor tightness and pectoral tightness tests. While the average value of adductor tightness was 26.381 before the treatment, this value decreased to 16.814 after the treatment. In the pectoral tightness test, the average was 26.81 before the treatment, while this value decreased to 15.81 after the treatment.

Table 4.8. The Comparison of Adductor and Pectoral Tightness Evaluation of Group 1 Pre and post the Treatment

	N	Mean $\pm$ SD	t	p
Adductor Tightness (Pre)	21	25.619 $\pm$ 5.191	8.54	0.001*
Adductor Tightness (Post)	21	14.429 $\pm$ 6.313		
Pectoral Tightness (Pre)	21	24.714 $\pm$ 4.649	7.101	0.001*
Pectoral Tightness (Post)	21	14.667 $\pm$ 5.276		
<i>p<0,05* Paired Samples T Test</i>				

The p coefficients of the pre-post-treatment values of the adductor tightness and pectoral tightness tests of the patients treated with Mulligan were less than 0.05. In this case, there is a significant difference in these variables between pre and post treatment. In other words, Mulligan treatment was effective in adductor tightness and pectoral tightness tests. While the average value of adductor tightness was 25.619 before treatment, this value decreased to 14.429 after treatment. In the pectoral tightness test, while the average was 24,714 before treatment, this value decreased to 14,667 after the treatment.

Table 4.9. The Comparison of SPADI Pain - SPADI Disability - SPADI Total Evalaluation of Group 2 Pre and post the Treatment

	N	Mean ± SD	t	p
SPADI Pain (Pre)	21	33.095 ± 6.999	9.738	0.001*
SPADI Pain (Post)	21	16.238 ± 6.745		
SPADI Disability (Pre)	21	46.333 ± 10.608	10.663	0.001*
SPADI Disability (Post)	21	20.571 ± 9.892		
SPADI Total (Pre)	21	79.429 ± 16.234	11.301	0.001*
SPADI Total (Post)	21	36.81 ± 15.59		

p<0,05 Paired Samples T Test*

p coefficients of the pre-post-treatment values of SPADI pain, SPADI disability and SPADI total tests of the patients treated with PNF were found to be less than 0.05. In this case, there is a significant difference in these variables between pre and post treatment. Namely, PNF treatment was effective in SPADI pain, SPADI disability and SPADI total tests. While the mean value of SPADI pain was 33.095 before the treatment, this value decreased to 16.238 after the treatment. In the SPADI disability test, the average was 46.333 before the treatment, while this value decreased to 20.571 after the treatment. In the SPADI total test, the average was 79.429 before the treatment, while this value decreased to 36.81 after the treatment.

Table 4.10. The Comparison of SPADI Pain - SPADI Disability - SPADI Total Evalaluation of Group 1 Pre and post the Treatment

	N	Mean $\pm$ SD	t	p
SPADI Pain (Pre)	21	38.381 $\pm$ 7.599	8.878	0.001*
SPADI Pain (Post)	21	19.571 $\pm$ 9.791		
SPADI Disability (Pre)	21	54.571 $\pm$ 10.712	10.917	0.001*
SPADI Disability (Post)	21	28.048 $\pm$ 14.299		
SPADI Total (Pre)	21	92.952 $\pm$ 17.451	10.375	0.001*
SPADI Total (Post)	21	47.619 $\pm$ 23.237		

p<0,05 Paired Samples T Test*

The p coefficients of the SPADI pain, SPADI disability and SPADI total tests of the patients who were treated with MULLIGAN pre and post the treatment were found to be less than 0.05. In this case, there is a significant difference in these variables between pre and post treatment. In other words, MULLIGAN treatment was effective in SPADI pain, SPADI disability and SPADI total tests. While the average value of SPADI pain was 38.381 before the treatment, this value decreased to 19.571 after the treatment. In the SPADI disability test, the average was 54.571 before the treatment, while this value decreased to 28.048 after the treatment. In the SPADI total test, the average was 92.952 before the treatment, while this value decreased to 47.619 after the treatment.

Table 4.11. The Comparison of Pittsburgh Evaluation of Group 2 Pre and post the Treatment

	N	Mean $\pm$ SD	t	p
Pittsburgh (Pre)	21	13.81 $\pm$ 8.146	4.04	0.001*
Pittsburgh (Post)	21	8.667 $\pm$ 5.247		

p<0,05 Paired Samples T Test*

The p coefficient of the pre-post treatment values of the Pittsburgh test of the patients treated with PNF was less than 0.05. In this case, there is a significant difference in this variable between pre and post treatment. So, PNF treatment was effective in pittsburgh test. While Pittsburgh average value was 13.81 before treatment, this value decreased to 8.667 after treatment.

Table 4.12. The Comparison of Pittsburgh Evaluation of Group 1 Pre and post the Treatment

	N	Mean ± SD	t	p
Pittsburgh (Pre)	21	17.381 ± 5.509	5.132	0.001*
Pittsburgh (Post)	21	11.381 ± 6.095		

p<0,05 Paired Samples T Test*

The p coefficient of the pre-post treatment values of the Pittsburgh test of the patients treated with Mulligan was less than 0.05. In this case, there is a significant difference in this variable between pre and post treatment. So, Mulligan treatment was effective in the pittsburgh test. While Pittsburgh average value was 17,381 before treatment, this value decreased to 11,381 after treatment.

Table 4.13. The Comparison of DASH Evaluation of Group 2 Pre and post the Treatment

	N	Mean ± SD	t	p
DASH (Pre)	21	85.857 ± 16.638	11.89	0.001*
DASH (Post)	21	49.667 ± 9.967		

p<0,05 Paired Samples T Test*

The p coefficient of the pre-post-treatment values of the DASH test of the patients treated with PNF was less than 0.05. In this case, there is a significant difference in this variable between pre and post treatment. Namely, PNF treatment was effective in the DASH test. While the average value of DASH was 85.857 before the treatment, this value decreased to 49.667 after the treatment.

Table 4.14. The Comparison of DASH Evaluation of Group 1 Pre and post the Treatment

	N	Mean $\pm$ SD	t	p
DASH (Pre)	21	92.381 $\pm$ 22.951	7.837	0.001*
DASH (Post)	21	56 $\pm$ 18.48		
<i>p<0,05* Paired Samples T Test</i>				

The p coefficient of the pre-post treatment values of the DASH test of the patients treated with Mulligan was less than 0.05. In this case, there is a significant difference in this variable between pre and post treatment. In other words, Mulligan treatment was effective in the DASH test. While the mean value of DASH was 92,381 before the treatment, this value decreased to 56 after the treatment.

Table 4.15. Comparison of the Post treatment Efficacy Inter Groups

		Treatment Protocol	N	Mean $\pm$ SD	t	p
Flexion (Difference)		PNF	21	47.524 $\pm$ 24.804	-1.348	0.185
		MULLIGAN	21	57.381 $\pm$ 22.549		
Abduction (Difference)		PNF	21	43.571 $\pm$ 24.039	-1.226	0.227
		MULLIGAN	21	52.381 $\pm$ 22.507		
Internal Rotation (Difference)		PNF	21	15.238 $\pm$ 11.233	-1.616	0.114
		MULLIGAN	21	21.905 $\pm$ 15.205		
External Rotation (Difference)		PNF	21	18.143 $\pm$ 12.587	0.272	0.787
		MULLIGAN	21	17.143 $\pm$ 11.244		
Adductor Tightness (Difference)		PNF	21	9.905 $\pm$ 5.309	-0.735	0.467
		MULLIGAN	21	11.191 $\pm$ 6.005		
Pectoral Tightness (Difference)		PNF	21	11 $\pm$ 7.829	0.429	0.67
		MULLIGAN	21	10.048 $\pm$ 6.484		
SPADI Pain (Difference)		PNF	21	16.857 $\pm$ 7.933	-0.763	0.45
		MULLIGAN	21	18.952 $\pm$ 9.765		
SPADI Disability (Difference)		PNF	21	25.762 $\pm$ 11.072	-0.18	0.858
		MULLIGAN	21	26.381 $\pm$ 11.187		
SPADI Total (Difference)		PNF	21	42.619 $\pm$ 17.281	-0.47	0.641
		MULLIGAN	21	45.333 $\pm$ 20.023		
Pittsburgh (Difference)		PNF	21	5.238 $\pm$ 5.744	-0.567	0.574
		MULLIGAN	21	6.191 $\pm$ 5.125		
DASH (Difference)		PNF	21	36.191 $\pm$ 13.949	-0.034	0.973
		MULLIGAN	21	36.381 $\pm$ 21.273		
<i>p<0,05* Independent Samples T Test</i>						

All of the p values calculated to examine the effects of the test results according to the treatment methods were higher than 0.05. In this case, the results of the tests according to the treatment methods do not show a significant difference. When looking at the average values of the tests, although there are different values according to the treatment methods, this difference is not statistically significant. That is, statistically, Mulligan and PNF treatment methods have no superiority over each other.

Table 4.16. The Comparison of Scapular Dyskinesis a 0-45-90 degrees of PNF Group Pre and post the Treatment

		Pre		Post		λ^2	p
		N	%	N	%		
Scapular	+	9	42.90%	2	9.50%	6.035	0.014*
Dyskinesis 0	-	12	57.10%	19	90.50%		
Scapular	+	18	85.70%	6	28.60%	14.000	0.001*
Dyskinesis 45	-	3	14.30%	15	71.40%		
Scapular	+	18	85.70%	12	57.10%	4.200	0.04*
Dyskinesis 90	-	3	14.30%	9	42.90%		
<i>p<0,05* Chi-Square Test</i>							

The p coefficients of the pre-post-treatment values of the scapular dyskinesis 0-45-90 tests of the patients treated with PNF were less than 0.05. In this case, there is a significant difference in these variables between pre and post treatment. Namely, PNF treatment was effective in scapular dyskinesis 0-45-90 tests. In the scapular dyskinesis 0 test, the + 'ratio before treatment was 42.9% and the -' ratio was 57.1%, while the + 'ratio decreased to 9.5% after the treatment, while the -' ratio increased to 90.5%. In the scapular dyskinesis 45 test, the + 'ratio before treatment was 85.7% and the -' ratio was 14.3%, while the + 'ratio decreased to 28.6% after the treatment, while the -' ratio increased to 71.4%. In the scapular dyskinesis 90 test, the pre-treatment oranı + 'ratio was 85.7% and the -' ratio was 14.3%, while the + 'ratio decreased to 57.1% after the treatment, while the -' ratio increased to 42.9%.

Table 4.17. The Comparison of Scapular Dyskinesis a 0-45-90 degrees of Group 1 Pre and post the Treatment

		Pre		Post		λ^2	p
		N	%	N	%		
Scapular Dyskinesis 0	+	6	28.60 %	8	38.10 %	0.429	0.513
	-	15	71.40 %	13	61.90 %		
Scapular Dyskinesis 45	+	19	90.50 %	3	14.30 %	24.43 6	0.001 *
	-	2	9.50 %	18	85.70 %		
Scapular Dyskinesis 90	+	12	57.10 %	11	52.40 %	0.096	0.757
	-	9	42.90 %	10	47.60 %		
<i>p<0,05* Chi-Square Test</i>							

Among the p coefficients of the pre-treatment values of the scapular dyskinesis 0-45-90 tests of the patients treated with Mulligan, only the coefficient of the scapular dyskinesis 45 test was less than 0.05. In this case, there is only a significant difference in this variable between pre and post treatment. So, Mulligan treatment was effective in the scapular dyskinesis 45 test. In the scapular dyskinesis 45 test, the pre-treatment + 'ratio was 90.5% and the -' ratio was 9.5%, while the + 'ratio decreased to 14.3% after the treatment and the -' ratio increased to 85.7%. In scapular dyskinesis 0 and 90 tests, Mulligan treatment could not achieve a significant effect, since the P coefficient was higher than 0.05.

Table 4.18. The Comparison of the Evaluation of Pittsburgh 5h and DASH 29 of Group 2 Pre and post the Treatment

		Pre		Post		λ^2	p
		N	%	N	%		
Pittsburgh 5H	None	3	14.30%	10	47.60%	26	0.001*
	Less than 1	2	9.50%	11	52.40%		
	1-2 times	8	38.10%	0	0.00%		
	More than 3	8	38.10%	0	0.00%		
DASH 29	No difficulty	1	4.80%	17	81.00%	27.765	0.001*
	Mild difficulty	4	19.00%	3	14.30%		
	Moderate difficulty	9	42.90%	1	4.80%		
	Extreme difficulty	4	19.00%	0	0.00%		
	There is so much difficulty	3	14.30%	0	0.00%		

$p < 0,05$ * *Chi-Square Test*

p coefficients of the pre-post-treatment values of the Pittsburgh 5h and DASH 29 tests of the patients treated with PNF were less than 0.05. In this case, there is a significant difference in these variables between pre and post treatment. Namely, PNF treatment was effective in pittsburgh 5h and DASH 29 tests. In Pittsburgh 5h test, pre-treatment "None" rate was 14.3, "less than 1" rate was 9.5%, "1-2 times" and "more than 3" rates were 38.1%, after treatment "None" rate was 47.6%, " Less than 1 "rate increased to 52.4%, others dropped to 0%. In DASH 29 test, pre-treatment "No difficulty" rate was 4.8, "Mild difficulty" and "Extreme difficulty" rate was 19%, "Moderate difficulty" rate was 42.9%, "There is so much difficulty" rate was 14.3%, after treatment "No difficulty". its rate increased to 81%. "Mild difficulty" rate dropped to 14.3%, "medium difficulty" rate to 4.8%, others to 0%.

Table 4.19. The Comparison of the Evaluation of Pittsburgh 5h and DASH 29 of Group 1 Pre and post the Treatment

		Before		After		χ^2	p
		N	%	N	%		
Pittsburgh 5H	None	0	0.00%	5	23.80%	19.804	0.001*
	Less than 1	0	0.00%	8	38.10%		
	1-2 times	11	52.40%	6	28.60%		
	More than 3	10	47.60%	2	9.50%		
DASH 29	No difficulty	1	4.80%	10	47.60%	28.097	0.001*
	Mild difficulty	2	9.50%	10	47.60%		
	Moderate difficulty	9	42.90%	1	4.80%		
	Extreme difficulty	4	19.00%	0	0.00%		
	There is so much difficulty	5	23.80%	0	0.00%		

p<0,05 Chi-Square Test*

p coefficients of the pre-post treatment values of Mulligan treatment pittsburgh 5h and DASH 29 tests were less than 0.05. In this case, there is a significant difference between these variables pre and post treatment. So, Mulligan treatment was effective in pittsburgh 5h and DASH 29 tests. In the Pittsburgh 5h test, the pre-treatment rate of "none" was 0, "less than 1" rate was 0%, "1-2 times" rate was 52.4%, and "more than 3" rate was 47.6% after treatment, "none" rate was 23.80%. "Less than 1" ratio increased to 38.1%. The rate of "1-2 times" fell to 28.6% and the rate of "more than 3" to 9.5%. In DASH 29 test, pre-treatment "No difficulty" rate was 4.8%, "Mild difficulty" rate was 9.5%, "Moderate difficulty" rate was 42.9%, "Extreme difficulty" rate was 19%, "There is so much difficulty" rate was 23.8% after treatment. The rate of "No difficulty" and "Mild difficulty" increased to 47.6%. The rate of "medium difficulty" decreased to 4.8% and the others to 0%

5. DISCUSSION

The main outcome of this study that, both Mulligan technique and PNF technique in addition to conventional physical therapy are effective for the symptoms of adhesive capsulitis such as limitation in ROM, tightness of adductor and pectoral muscles, pain, quality of life and sleep quality. Consistent with our hypotheses we found that both of the treatments had good impacts on the symptoms of our patients. However, there was not any significant differences and we did not find any superiority between Mulligan and PNF for the same symptoms.

In a study conducted with 100 patients diagnosed with adhesive capsulitis in 2003, the clinical profiles of individuals were evaluated. In this study, unlike our study, it was concluded that diabetes is the most common and associated chronic disease with a rate of 27% in patients diagnosed with adhesive capsulitis. When we examined the participants in our study as two different groups, the hypertension rate in both treatment groups was found to be 28.57% for the pnf group and 33.33% for the mulligan group, respectively. Again, according to our study result, the highest mean after hypertension belongs to diabetes (90).

There is significant differences between pre and post treatment on the findings of our patients for flexion, abduction, internal and external rotation range of motions. Although there is no superiority of two treatments. Based on the average values, it can be said that Mulligan is more effective than PNF in the development of flexion, abduction and internal rotation ROM. Likewise, the result of external rotation measured after 15 sessions of treatment was higher in PNF group. In 2012 Gong et al., investigated the effects of Gong's mobilization and anteroposterior gliding on the shoulder medial rotation ROM. In their study, the participants were 40 healthy male and female college students whose medial rotation ROM were limited to 45 degrees or less, but who had no musculoskeletal or nervous system or pain that limits their ADL. They found that both Gong's mobilization and anteroposterior gliding had positive effects on medial rotation ROM but Gong's was more effective. They explained the superiority of Gong's because it is an end-range mobilization and keeps the shoulder in normal position. (122). It can be in relation with that in Mulligan group there were lower external rotation ROM than PNF

group. Mulligan only aims to reveal painless movement by correcting the positional faults. (105).

PNF that includes four mechanisms as autogenic inhibition, reciprocal inhibition, stress relaxation and the gate control theory is one of the treatments for decreasing pain and improving function. (116). Balçı et al., conducted a study in 2016, they divided 53 patients who were diagnosed with adhesive capsulitis into three groups and applied scapular PNF exercises to one group, classical exercises and physiotherapy modalities to one group and only physiotherap modalities to one group. The effects of these applications on pain, ROM, shoulder function and scapular dyskinesis were evaluated. They found significant differences in shoulder ROM in all three groups. But shoulder flexion and abduction results had no significant differences among the groups. Also VAS results showed no significant differences between groups. The assessment of scapular dyskinesis did not show any improvements either. PNF provides reciprocal activation in agonistic and antagonistic muscles, allowing the target movement to be released. (9). On the other hand, Mulligan is a manual treatment technique that uses a glide and a force that is perpendicular to the plane of movement and aims the injured joint to move without pain. (105). Although there was no statistically significant difference between the two treatment groups in our study, the mean ROM increase in Mulligan group was higher than PNF group except for external rotation. In the evaluation of pain and shoulder function, SPADI pain and disability sections were calculated separately and two treatments were compared. Again there was no significant difference but both results were better in Mulligan group. It can be in relation with the characteristic of Mulligan that is painless completion of the movement under the guidance of a physiotherapist. Contrary to the result in this study, when the scapular dyskinesia was evaluated, all measurements made at 0-45-90 degrees showed positive results in PNF group, while an improvement was observed in Mulligan group only at 45 degrees.

In a study in 2016, Dilip et al., 40 subjects diagnosed with frozen shoulder were divided into two groups, Gong's mobilization was applied to one group and Mulligan mobilization was applied to one group. At the end of the 10-sessions of treatment period, pain was assessed with VAS and internal rotation ROM was evaluated. It was found that

both treatments were effective in pain relief and improvement of internal rotation ROM, but Gong's mobilization had a higher percentage. (13). In our study, Mulligan had higher percentage of improvement in ROM, shoulder function and pain relief. Also we had longer treatment duration that is 15 sessions as it is said in Manuel Concept.

Much of the literature suggested manuel therapy techniques to improve pain, quality of life, range of motion and shoulder function in the case of adhesive capsulitis. However, there is a gap in the literature which manuel therapy technique is more effective and easy to use in the clinics. In the light of our results, we would like to point to symptoms of adhesive cspulitis that adversely affects the patients'life can be relieved by manuel techniques in addition to conventional therapy such as Mulligan technique.

The limitations of our study :

- ✓ We did not have a control group to compare both manuel therapy groups.
- ✓ Manuel treatments give better results in the early period, but we did not compare results of the early period in this study.

6. CONCLUSION AND SUGGESTIONS

- ✓ The symptoms of pain, limitation in ROM, shoulder function in patients diagnosed with adhesive capsulitis can be improved with manual therapy techniques in addition to conventional treatment.
- ✓ There is no significant differences between both treatment groups. The mean of improvements of ROM was higher in Mulligan except for external rotation. It may be suggested using Mulligan for better results in ROM development.
- ✓ Both the treatment techniques are stimulus for contractile tissue, the tightness of adductor and pectoral muscles were better at the end of the treatment. While better results were obtained for adductor muscles in Mulligan group, flexibility in pectoral muscles was better in PNF Group.
- ✓ It is important to apply manual therapy in addition to conventional treatment in improving the quality of life that is impaired with limitation of movement and related pain.
- ✓ Scapular movement is of great importance in shoulder function. It should be evaluated and included in the treatment plan of adhesive capsulitis. In our study, we can say that PNF should be added to the scapular dyskinesia-focused treatment since the results were better in the angles of evaluation.
- ✓ We did not have follow-up results such as 2 weeks, 1 month after treatment to compare the results of both treatments. In a study that was conducted in 2016 compared the effectiveness of using 2 different manual techniques for adhesive capsulitis and observed that symptoms still improved during 2-4 weeks post treatment. This can be given as a recommendation for future studies.

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8.APPENDIX

8.1. Informed Written Consent

BİLGİLENDİRİLMİŞ ONAM FORMU

Araştırmanın Adı: Adeziv Kapsülitli Olgularda Konvansiyonel Tedaviye Ek Olarak Uygulanan Mulligan Konsepti ve PNF (Proprioseptif Nöromusküler Fasilitasyon) Tekniğinin Etkilerinin Karşılaştırılması

Sayın Katılımcı,

Yukarıda adı yazılı araştırmaya katılmak üzere davet edilmiş bulunmaktasınız. Bu araştırmada yer almayı kabul etmeden önce, araştırmanın ne amaçla yapılmak istendiğini anlamanız ve bu bilgilendirme sonucunda kararınızı vermeniz gerekmektedir. Aşağıdaki bilgileri lütfen dikkatlice okuyunuz, sorularınız olursa sorunuz ve açık yanıtlar isteyiniz.

Bu araştırma ile donuk omuz tanılı hastalarda konvansiyonel tedaviye ek olarak uygulanan iki farklı tekniğin ağrı, eklem hareket açıklığı ve uyku kalitesine etkilerinin araştırılması amaçlanmıştır. Bu araştırma, iki tekniğin tedavi edici etkilerinin birbirlerine üstünlüğü konusunda da yarar sağlayacaktır.

Seansınız, 20 dakikalık ağrınızı azaltmaya yönelik elektroterapi uygulaması ile başlayacaktır. Elektroterapi ardından yine ağrınızı azaltmak ve hareket açıklığınızı artırmayı amaçlayan manuel tedavi yönteminin fizyoterapistiniz eşliğinde yapılması ile devam edecektir. Manuel tedavi ardından klinikte size öğretilen egzersizlerinizi yapmanız istenecektir.

Araştırma için Sportomed'den izin alınmıştır. Araştırmaya sizin dışınızda 41 kişi katılacaktır. Sizden bu çalışmada seanslarınıza eksiksiz gelmeniz ve ev egzersiz programlarınızı belirlenen şekilde eksiksiz yapmanız istenecektir. Bu işlem 30 dakikanızı alacaktır. Bunun size ve yakınlarınıza hiçbir zararı olmayacaktır. Çalışmaya katılmakla parasal yük altına girmeyeceksiniz ve size de herhangi bir ödeme yapılmayacaktır.

Bu arařtırmaya katılıp katılmamakta t m yle  zg rs n z. Gerek duyduėunuz t m bilgileri istemeye ve doėru, a ık, anlařılır bilgi almaya hakkınız vardır. Arařtırmaya katılmayı istemezseniz burada size verilen hizmet olumlu veya olumsuz řekilde etkilenmeyecektir. Gerekli g rd ė  takdirde arařtırmanın herhangi bir kısmında katılımcı arařtırmadan  ıkabilir, arařtırmacı  alıřmayı sonlandırabilir. Arařtırmanın t m ařamalarında kimlik bilgileriniz gizli tutulacaktır. Arařtırma kapsamında elde edilen bilgiler bilimsel ama larla kullanılabilir gizlilik kurallarına uyulmak kaydıyla sunulabilir ve yayınlanabilir.

Yukarıda yer alan ve arařtırmaya bařlanmadan  nce katılımcılara verilmesi gereken bilgileri i eren metni okudum (ya da s zl  olarak dinledim). Arařtırma kapsamında elde edilen řahsıma ait bilgilerin bilimsel ama larla kullanılmasını, gizlilik kurallarına uyulmak kaydıyla sunulmasını ve yayınlanmasını, hi bir baskı ve zorlama altında kalmaksızın, kendi  zg r irademle kabul ettiėimi beyan ederim

 mza/Tarih :

 mza/Tarih :

Katılımcının adı soyadı :
soyadı :

Sorumlu Arařtırmacının adı

Prof.Dr. Feryal SUBAŐI
Fzt. Pelin AKDOėAN

8.2. Structured Questionnaire

ADEZİV KAPSÜLİT TANILI BİREYLERDE GENEL SAĞLIK DURUM VE YAŞAM KALİTELERİNİN DEĞERLENDİRİLMESİ

Tarih : / /

Hasta Adı Soyadı :

Telefon :

Adres :

.....

.....

1. Doğum Tarihi : / /

2. Cinsiyet : E() K()

3. Mesleği : Şu anda çalıştığı iş :

4. Boy :

5. Vücut Ağırlığı :

6. BMI :

7. Devamlı / düzenli olarak ilaç kullanmasını gerektiren kronik hastalık var mı ?

() Evet () Hayır

8. Kronik hastalık veya hastalıkları var ise hangi hastalıklar

() Romatizma () Ortopedik Hastalıklar () Diyabet () Hipertansiyon

() Kalp Hastalıkları () Damar Hastalıkları () Kanser () Travma

() Guatr () Hormon Bozuklukları () Nörolojik Problemler () Epilepsi () Diğer

9. Dominant Taraf : Sağ() Sol ()

10. Daha önce omuz ekleminde cerrahi geçirdiniz mi ? () Evet () Hayır

11. Ağrılı tarafta kırık, subluksasyon veya rotator kuf yırtığı tanısı var mı ?

() Evet () Hayır



8.3. Shoulder Pain and Disability Index

Shoulder Pain and Disability Index (SPADI)

Please place a mark on the line that best represents your experience during the last week attributable to your shoulder problem.

Pain scale

How severe is your pain?

Circle the number that best describes your pain where: 0 = no pain and 10 = the worst pain imaginable.

At its worst?	0	1	2	3	4	5	6	7	8	9	10
When lying on the involved side?	0	1	2	3	4	5	6	7	8	9	10
Reaching for something on a high shelf?	0	1	2	3	4	5	6	7	8	9	10
Touching the back of your neck?	0	1	2	3	4	5	6	7	8	9	10
Pushing with the involved arm?	0	1	2	3	4	5	6	7	8	9	10

Disability scale

How much difficulty do you have?

Circle the number that best describes your experience where: 0 = no difficulty and 10 = so difficult it requires help.

Washing your hair?	0	1	2	3	4	5	6	7	8	9	10
Washing your back?	0	1	2	3	4	5	6	7	8	9	10
Putting on an undershirt or jumper?	0	1	2	3	4	5	6	7	8	9	10
Putting on a shirt that buttons down the front?	0	1	2	3	4	5	6	7	8	9	10
Putting on your pants?	0	1	2	3	4	5	6	7	8	9	10
Placing an object on a high shelf?	0	1	2	3	4	5	6	7	8	9	10
Carrying a heavy object of 10 pounds (4.5 kilograms)	0	1	2	3	4	5	6	7	8	9	10
Removing something from your back pocket?	0	1	2	3	4	5	6	7	8	9	10

8.4. Arm, Shoulder and Hand Problems Questionnaire

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1. Open a tight or new jar.	1	2	3	4	5
2. Write.	1	2	3	4	5
3. Turn a key.	1	2	3	4	5
4. Prepare a meal.	1	2	3	4	5
5. Push open a heavy door.	1	2	3	4	5
6. Place an object on a shelf above your head.	1	2	3	4	5
7. Do heavy household chores (e.g., wash walls, wash floors).	1	2	3	4	5
8. Garden or do yard work.	1	2	3	4	5
9. Make a bed.	1	2	3	4	5
10. Carry a shopping bag or briefcase.	1	2	3	4	5
11. Carry a heavy object (over 10 lbs).	1	2	3	4	5
12. Change a lightbulb overhead.	1	2	3	4	5
13. Wash or blow dry your hair.	1	2	3	4	5
14. Wash your back.	1	2	3	4	5
15. Put on a pullover sweater.	1	2	3	4	5
16. Use a knife to cut food.	1	2	3	4	5
17. Recreational activities which require little effort (e.g., cardplaying, knitting, etc.).	1	2	3	4	5
18. Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.).	1	2	3	4	5
19. Recreational activities in which you move your arm freely (e.g., playing frisbee, badminton, etc.).	1	2	3	4	5
20. Manage transportation needs (getting from one place to another).	1	2	3	4	5
21. Sexual activities.	1	2	3	4	5
21. Sexual activities.	1	2	3	4	5

	NOT AT ALL	SLIGHTLY	MODERATELY	QUITE A BIT	EXTREMELY
22. During the past week, to what extent has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups? (circle number)	1	2	3	4	5

	NOT LIMITED AT ALL	SLIGHTLY LIMITED	MODERATELY LIMITED	VERY LIMITED	UNABLE
23. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem? (circle number)	1	2	3	4	5

Please rate the severity of the following symptoms in the last week. (circle number)

	NONE	MILD	MODERATE	SEVERE	EXTREME
24. Arm, shoulder or hand pain.	1	2	3	4	5
25. Arm, shoulder or hand pain when you performed any specific activity.	1	2	3	4	5
26. Tingling (pins and needles) in your arm, shoulder or hand.	1	2	3	4	5
27. Weakness in your arm, shoulder or hand.	1	2	3	4	5
28. Stiffness in your arm, shoulder or hand.	1	2	3	4	5

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	SO MUCH DIFFICULTY THAT I CAN'T SLEEP
29. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? (circle number)	1	2	3	4	5

	STRONGLY DISAGREE	DISAGREE	NEITHER AGREE NOR DISAGREE	AGREE	STRONGLY AGREE
30. I feel less capable, less confident or less useful because of my arm, shoulder or hand problem. (circle number)	1	2	3	4	5

8.5. Pittsburgh Sleep Quality Index

PITTSBURGH SLEEP QUALITY INDEX (PSQI)

INSTRUCTIONS: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, when have you usually gone to bed at night?
USUAL BED TIME _____
2. During the past month, how long (in minutes) has it usually take you to fall asleep each night?
NUMBER OF MINUTES _____
3. During the past month, when have you usually gotten up in the morning?
USUAL GETTING UP TIME _____
4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spend in bed.)
HOURS OF SLEEP PER NIGHT _____

INSTRUCTIONS: For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you...

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
(a) ...cannot get to sleep within 30 minutes	☐	☐	☐	☐
(b) ...wake up in the middle of the night or early morning	☐	☐	☐	☐
(c) ...have to get up to use the bathroom	☐	☐	☐	☐
(d) ...cannot breathe comfortably	☐	☐	☐	☐
(e) ...cough or snore loudly	☐	☐	☐	☐
(f) ...feel too cold	☐	☐	☐	☐
(g) ...feel too hot	☐	☐	☐	☐
(h) ...had bad dreams	☐	☐	☐	☐
(i) ...have pain	☐	☐	☐	☐
(j) Other reason(s), please describe				

How often during the past month have you had trouble sleeping because of this?

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
	☐	☐	☐	☐

	Very good	Fairly good	Fairly bad	very bad
6. During the past month, how would you rate your sleep quality overall?	☐	☐	☐	☐
	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
7. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?	☐	☐	☐	☐
8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?	☐	☐	☐	☐
	No problem at all	Only a very slight problem	Somewhat of a problem	A very big problem
9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?	☐	☐	☐	☐
	No bed partner or roommate	Partner/ roommate in other room	Partner in same room, but not same bed	Partner in same bed
10. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?	☐	☐	☐	☐

If you have a roommate or bed partner, ask him/her how often in the past month you have had...

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
(a) ...loud snoring	☐	☐	☐	☐
(b) ...long pauses between breaths while asleep	☐	☐	☐	☐
(c) ...legs twitching or jerking while you sleep	☐	☐	☐	☐
(d) ...episodes of disorientation or confusion during sleep	☐	☐	☐	☐
(e) Other restlessness while you sleep; please describe	☐	☐	☐	☐

8.6. Permission Letter From the Institution

20.05.2019

Araştırmacı Pelin AKDOĞAN'ın yüksek lisans çalışması olarak belirlenen "Adeziv Kapsülitli Olgularda Konvansiyonel Tedaviye Ek Olarak Uygulanan Mulligan Konsepti ve PNF (Proprioseptif Nöromusküler Fasilitasiyon) Tekniğinin Etkilerinin Karşılaştırılması" başlıklı çalışmasını kurumumuz Suadiye Sportomed'de gerçekleştirmesi uygundur.

SPORTOMED
GİZLİLİK HİZMETLERİ VE TİC. A.Ş.
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No: 471/3 - Kadıköy / İSTANBUL
Etiler Köyü 5/3 - 33050/123 Tic. Sic. No: 2810
Mersis No: 07910100000000000000

MURAT MENDERES ÇAĞLAR
FİZYOTERAPİST

8.7. Ethical Committee Approval


T.C.
MARMARA ÜNİVERSİTESİ
Sağlık Bilimleri Fakültesi
Girişimsel Olmayan Etik Kurulu

PROJENİN ADI : “ Adeziv Kapsülitli Olgularda Konvansiyonel Tedaviye Ek Olarak Uygulanan Mulligan Konsepti Ve PNF (Proprioseptif Nöromusküler Fasilitasyon) Tekniğinin Etkilerinin Karşılaştırılması

PROJENİN YÜRÜTÜCÜSÜ : Prof. Dr. Feryal SUBAŞI

PROJEDEKİ ARAŞTIRICILAR : Pelin AKDOĞAN

ONAY TARİHİ VE SAYISI : 30.05.2019/67

Sayın: Prof. Dr. Feryal SUBAŞI

“67” protokol numaralı “Adeziv Kapsülitli Olgularda Konvansiyonel Tedaviye Ek Olarak Uygulanan Mulligan Konsepti Ve PNF (Proprioseptif Nöromusküler Fasilitasyon) Tekniğinin Etkilerinin Karşılaştırılması” isimli projeniz Fakültemiz Etik Kurulu tarafından incelenmiş oy birliği ile etik yönden uygun olduğuna karar verilmiştir.

Prof. Dr. M. GökdenİZ
Etik Kurul Başkanı

Prof. Dr. Mehveş TARIM

Prof. Dr. Ayşen GARGILI

Doç. Dr. M. Emin ALŞAHİN

Doç. Dr. Ş. Burak BEKAROĞLU

Doç. Dr. Zübeyir SARI

Doç. Dr. Hediye KADIOĞLU

Doç. Dr. Meltem BAL

Doç. Dr. Saim EROL

Doç. Dr. Ayşe YILDIZ

Dr. Öğr. Üyesi Murat D. ÇEKİN

Dr. Öğr. Üyesi Burcu ÇALIK

Dr. Öğr. Üyesi Ayşe KARAKOÇ

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